

**Lehman Brothers**

**Consolidated Supervised Entity Market and Credit Risk Review**

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## Acronyms in Lehman Consolidated Supervised Entity Market and Credit Risk Review

ABS	Asset Backed Securities
ALS	Aurora Loan Service
ARM	Adjustable-Rate Mortgages
BMA	Bond Market Association
CAO	Chief Administrative Officer
CAS	Credit Approval System
CDO	Collateralized Debt Obligation
CDS	Credit Default Swaps
CE	Current Exposure
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CLO	Collateralized Loan Obligations
CMBS	Commercial Mortgage Backed Securities
CMO	Collateralized Mortgage Obligations
CRM	Credit Risk Management
CRO	Chief Risk Officer
CSA	Collateral Support Agreements
CSE	Consolidated Supervised Entity
CVA	Credit Valuation Adjustment
CWS	Credit Work Station
DQCG	Data Quality Control Group
EAD	Exposure At Default
EE	Expected Exposure
ELP	Estimated Loss Potential
EMG/HF	Emerging Market Firms And Hedge Funds
EPE	Effective Potential Exposure
EPPE	Effective Peak Potential Exposure
FX	Foreign Exchange
GCS	Global Clearing Services
GMG	Global Margin Group
GREG	Global Real Estate Group
HistSim	Historical Simulation
HYCC	High Yield Commitment Committee
IB	Investment Banking
ICR	Internal Credit Rating
IO	Interest-Only
LBO	Leveraged Buy-Outs
LGD	Loss Given Default
LTV	Loan-to-Value
MACs	Material Adverse Clauses
MIS	Capital Markets Technology Group
MMD	Municipal Market Data
MPE	Maximum Potential Exposure

MRA	Marginal Risk Appetite
MRM	Market Risk Management
NAV	Net Asset Values
NIM	Net Interest Margin
NPC	New Products Committee
NPE	Net Potential Exposure
OAS	Option-Adjusted Spread
OEC	Operating Exposures Committee
OPSRA	Office Of Prudential Supervision And Risk Analysis
P&L	Profit And Loss
PC	Product Control
PD	Probabilities Of Default
PE	Potential Exposure
PPE	Peak Potential Exposure
PTG	Principal Transaction Group
QR	Quantitative Research
QRM	Quantitative Risk Management
RA	Risk Appetite
RMD	Risk Management Department
ROTE	Return On Tangible Equity
TBA	To-Be-Announced Market
TMG	Transaction Management Group
VaR	Value-At-Risk
VCV	Variance-Covariance
VoD	Value-On-Default
WLT	Whole Loan Tracking System

## Scope and Methodology of Review

Pursuant to Lehman Brothers' (Lehman) application to become a Consolidated Supervised Entity (CSE), staff of the Office of Prudential Supervision and Risk Analysis (OPSRA)<sup>1</sup> reviewed the independent risk management function at Lehman. We met with members of the Risk Management Department (RMD), trading desk heads, financial controllers, model research heads, and others.<sup>2</sup> The bulk of the field work and analysis was done during May and June of 2005.<sup>3</sup>

The review consisted of on-site interactions with Lehman staff and off-site review and analysis of reports, documents and presentations submitted pursuant to this review.<sup>4</sup> The on-site meetings generally covered one or more topics: (i) business unit risk taking and risk controls; (ii) aggregate risk metrics and the independent risk control function; and/or (iii) control processes supporting risk management. In total, we spent 23 days on-site meeting with Lehman staff, and participated in several follow-up conference calls.

During the review, we sought to assess the adequacy of the independent risk management function and to establish a supervisory framework by which to monitor and gauge risk management developments in the future. For market risk, we focused on businesses generating material or difficult to capture exposures, including interest rate trading, credit trading, mortgages, municipals, equity volatility, real estate, and risk arbitrage. We reviewed processes surrounding the primary market risk component of RA, value-at-risk (VaR), and looked at the calculations behind event risk, another component of RA that will be discussed in greater detail in the following sections. In addition, we focused on the control processes surrounding these and other market risk metrics (e.g., price verification and profit and loss reconciliation). For credit risk, we focused on the risk management of the business areas with the most material counterparty credit exposure. These include the leveraged lending business, which provides relatively large unsecured financing packages to non-investment grade counterparties, the OTC derivatives and securities financing areas, which generate "current" (i.e., unsecured) as well as "potential" credit exposures to a variety of counterparty types, prime brokerage, which provides overcollateralized (i.e., secured) financing to hedge funds, and the warehouse lending business, which finances large pools of whole loans for residential mortgage originators. We examined the Potential Exposure (PE) methodology, a primary tool used to manage and limit counterparty credit risk, and a key input into the credit component of the risk appetite calculation, as well as the overall estimation of the counterparty risk appetite usage. In addition, we focused on the credit department's processes for assessing counterparty credit quality and permissioning risk taking.

One feature of the risk management function at Lehman should be noted up front: unlike at its peer firms, market and credit risk are managed in an integrated fashion, through their aggregation into a single measure called Risk Appetite (RA). This

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<sup>1</sup> The market risk review team consisted of Lori Bettinger, Mike Hsu, and P.C. Venkatesh, with assistance from Matt Comstock in the Net Capital Group. The credit risk review team consisted of Michelle Danis and Steve Spurry.

<sup>2</sup> Our primary contact at Lehman was Madelyn Antoncic, the Chief Risk Officer. For a list of Lehman staff contacted as part of this review process, see Appendix B.

<sup>3</sup> For the past two years, Lehman's market and credit risk departments have met with OPSRA staff under the auspices of the Derivatives Policy Group to present monthly risk information and commentary.

<sup>4</sup> See Appendix A for a catalogue of work papers related to this review.

<sup>6</sup> These deals are discussed in detail in Section III.e.i.

model achieves many of the same goals, such as the efficient allocation of resources, of the economic capital models at its peer firms. Given the integration of market and credit risk, it is difficult to clearly delineate a discussion of market risk management from a discussion of credit risk management, and for this reason both departments are assessed jointly in one document.

At Lehman, much of the focus of senior risk management is on the pipeline of financing deals that make up a large portion of their risk. These deals generate market risk, resulting from the process of selling securities into the market, as well as credit risk, resulting from loan positions retained by Lehman.<sup>6</sup> They also generate significant operational risk (e.g., legal and reputational) and are heavily scrutinized by senior management. The departments work together closely, and in the case of some businesses (e.g., prime brokerage and warehouse lending) jointly manage the risks. This high-level aggregation of risks provide some clear benefits, yet also raises issues surrounding the aggregation process and the assumptions underlying it. Lehman's approach to aggregating and managing risk is discussed in more detail below.

In addition to the standard market and credit risk review topics, we also looked at the integration of market and credit risk management. Nowhere is this integration more evident than in the Quantitative Risk Management (QRM) group. QRM is responsible for independently reviewing and approving the pricing models used across the firm. It is also responsible for the overall architecture of the risk systems, implementation and maintenance of the risk models and generation of risk reports. Within QRM, the Credit Risk Analytics department shares responsibility with Credit Risk Management (CRM) for the development, maintenance and operation of the risk quantification methodologies for credit risk, including Maximum Potential Exposure (MPE) and credit risk inputs for RA and Risk Equity. Similarly, the Market Risk Analytics department shares responsibility with Market Risk Management (MRM) for the development, maintenance and operation of the risk quantification methodologies supporting market risk, including VaR, stress tests, scenario analyses, and RA and Risk Equity.

This review did not focus on operational control issues nor conduct any systems or transactions testing. Rather, OPSRA directed its efforts to gain a broad understanding of Lehman's risk management infrastructure in order to be able to carry out prudential supervision on an ongoing basis. Overall, the risk management function at Lehman is robust and market and credit risks are adequately measured, monitored and managed given the firm's current overall risk profile. Lehman's standards for the measurement of market and credit risk exposures comply with the requirements of the Basel Standards and are consistent with the CSE rule.

This report is organized as follows. The first section provides a discussion of Lehman's risk management infrastructure, highlighting the formal governance structure, the RA framework, and aggregate risk limits. The second section describes and assesses Lehman's market risk management, models and methodologies for measuring risk, businesses generating significant market risk, and control processes around market risk metrics. The third section describes and assesses Lehman's credit risk profile and the processes in place for managing and controlling credit risk, including tools for credit risk management, limits and permissioning, technology systems, and businesses generating significant credit risk. The fourth section looks at RA in detail, including a discussion of its components, the aggregation process, and the framework's limitations. The final section highlights areas warranting ongoing scrutiny and our conclusions.

## I. Risk Management Infrastructure

### a. Formal Governance Structure

RMD has approximately 190 employees and is responsible for the risk management function at Lehman. RMD is independent of Lehman's business units and is headed by a Chief Risk Officer (CRO) who is a member of Lehman's Management Committee<sup>7</sup> and reports directly to the firm's Chief Administrative Officer (CAO), a member of the Executive Committee.<sup>8</sup> The CAO reports to the Chairman and Chief Executive Officer (CEO) and, ultimately, to the firm's Board of Directors. RMD consists of five divisions: MRM, CRM, QRM, Sovereign Risk Management and Operational Risk Management.

Lehman's policies and procedures identify three core functions of RMD. First, the group must understand risks material to the firm, at both a business unit and aggregate firm level. Accordingly, the group has developed metrics to measure and aggregate risks across products and businesses. Second, RMD must ensure that appropriate limits are in place for all transactions and exposures. For example, RMD uses RA to establish these limits at a business and firmwide level. Third, RMD risk manages the firm against "catastrophic" loss. To this end, RMD measures and monitors "tail risk" for trading positions, and deal risk for large transactions.

In addition to RMD, senior management oversight committees have responsibility for ensuring that the firm understands and approves the risks being incurred by various businesses and transactions. The following section highlights four of those committees.

The Risk Committee meets weekly to review exposures and position concentrations (both market and credit). The committee consists of the Executive Committee, the CRO and the Chief Financial Officer (CFO). The committee discusses the firm's top market and credit risks, relying on metrics such as RA; VaR; counterparty credit risk exposures by region, role, product, and top sectors; large exposures and commitments. The CRO communicates with the Executive Committee regularly and provides reports as necessary.<sup>9</sup>

The Operating Exposures Committee (OEC) was formed in 1996 at the CEO's request. The Chief Legal Officer chairs the committee and reports directly to the CEO. Members of OEC are Executive Committee members and senior managers from control functions such as tax and finance, including the CRO. The committee meets monthly. OEC's mission is to protect the franchise and ensure that the firm has implemented an appropriate set of internal controls. OEC examines all activities that expose Lehman to market, credit, operational, technological, documentation and legal risk. It attempts to identify and anticipate areas and issues that leave the firm most vulnerable to losses and sponsors appropriate measures to address those areas and issues. To accomplish its mission, OEC may review any group, department or division where there is the potential for the firm to lose money. Issues that OEC has addressed or continues to address

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<sup>7</sup> The Management Committee includes all major business unit operating heads and is responsible for the operations of, and coordination among, the global business units, including the establishment of near-term strategic objectives.

<sup>8</sup> The Executive Committee is comprised of the most senior members of Lehman and is ultimately responsible for its leadership and strategic direction. The Committee generally meets twice weekly, but will meet more frequently, if necessary. The Committee reviews and approves all major decisions that impact Lehman.

<sup>9</sup> Other risk committees include Investments, Bridge Loan, New Products and Country Risk Committees.

include fraud prevention and continuous audit monitoring, derivatives documentation, client account documentation, business continuity planning, mortgage origination business and infrastructure control, and money laundering prevention, among others. In addition to identifying vulnerabilities, OEC attempts to play a proactive role by providing a forum for addressing issues before they become problems.

The New Products Committee (NPC) determines if Lehman will commit to market a new product or enter into a new business. The NPC is intended to provide a forum for the business units to present new products or businesses to relevant areas of the firm to assess potential risks (including legal, regulatory, market, credit, and operational risks); ensure that the appropriate infrastructure is in place to trade the products or engage in the business; and approve, disapprove or recommend enhancements related to managing risks associated with the new products or businesses. The Chief Legal Officer chairs the NPC. It is comprised of senior managers from control functions, including Compliance, Corporate Audit, Corporate Strategy, Market and Credit Risk Management, Financial Control, Information Technology, Legal, Operations, Product Control (PC), Tax, Transaction Management and Treasury. The CAOs of various business divisions, such as Equities and Fixed Income, may participate in reviews of products that their respective divisions sponsor.

Lehman also has both a firmwide Commitment Committee and divisional commitment committees that perform a number of functions. Prior to bringing the deal to the Commitment Committee, the appropriate divisional commitment committee (equity, high yield, or high grade) considers the profitability and limit usage of a particular transaction. These committees have primary responsibility for determining whether a transaction offers an attractive return on equity and whether it fits within cash capital, RA, credit and single transaction limits. Once a transaction has been approved by a divisional commitment committee, it must then obtain approval from the firmwide Commitment Committee. The firmwide Commitment Committee seeks to address risks that are incurred as a result of capital markets deals, such as acquisition financing and underwritings, areas in which Lehman has a dominant presence. These transactions, such as high yield debt underwritings, can expose the firm to significant amounts of risk. This committee ensures that a particular transaction fits within Lehman's funding and risk frameworks, with particular attention to any reputational risk a deal may incur. The firmwide Commitment Committee determines if due diligence on a transaction has been thorough, the firm is protected on relevant legal issues, the firm is comfortable doing business with the client (i.e., reputational issues) and the syndication strategy is clear.

#### b. Risk Appetite Framework

The RA metric embodies the integrated risk management philosophy discussed above. Unlike its peer firms, Lehman utilizes this firmwide risk metric to capture market, event and credit risk in a single number for purposes of limit setting and senior management reporting.

Lehman's firmwide RA limit is calculated through a process which considers the budget for the firm, projected revenues for a down year, and minimally-acceptable return on tangible (book) equity (ROTE). In this way, the firm's RA limit is constructed from the bottom up, rather than through high-level discussions of loss tolerance, as is often the case for VaR and PE limits.<sup>10</sup> The broad objective is to arrive at a number – the RA limit

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<sup>10</sup> For instance, in setting a firmwide VaR limit, a senior management committee at other firms utilizing a more conventional approach may seek to set the limit directly by considering the dollar amount it is comfortable with losing one out of every 100 trading days, which is what a 99<sup>th</sup> percentile VaR metric is

– which reflects Lehman’s capacity to take risk, based on a one year horizon and 95<sup>th</sup> percentile loss assumption.

In practice, the firmwide RA limit is calculated by the controllers in January, after the Board has signed off on the year’s budget. Beginning with the firm’s baseline revenue, which is a function of the business units’ expected revenues in a normal operating environment, the controllers adjust downward to account for a simultaneous slowdown in customer flow, proprietary trading and banking activities (e.g. origination and mergers and acquisition advisory). The resulting figure represents what the firm can expect to make, even under prolonged adverse market conditions. For 2005, the baseline net revenue was \$12.7 billion. Of this, \$10.4 billion was derived from customer flow and \$2.3 billion from principal investments, private equity and real estate. To simulate a downturn in the market, a -10% revenue shortfall was applied to the customer flow revenues and \$0.6 billion was deducted from the \$2.3 billion.<sup>11</sup> Thus, should the market environment in 2005 turn sour, the firm could be expected to generate at least \$11.1 billion of revenue.

These revenues are offset by expense projections. While most expenses can be assumed to decline in rough proportion to a fall in revenues, compensation-related expenses are assumed to be sticky, reflecting the fact that some headcount must be maintained to protect the franchise in the medium to long term. Moreover, the firm assumes that to protect the franchise it must generate earnings sufficient to maintain for shareholders a minimally acceptable ROTE. This return has been set at 10%. Thus, a portion of the firm’s revenues essentially cannot be put at risk, in order to maintain the viability of the franchise. For 2005, these combined constraints translated into \$8.9 billion. The difference between the \$11.1 billion of revenues the firm can expect to receive (even in a bad year) and the \$8.9 billion of revenues which the firm cannot put at risk in order to cover projected expenses is \$2.1 billion, which represents how much the firm can risk (i.e., lose) without jeopardizing the franchise. In other words, the difference represents the firm’s RA limit: \$2.1 billion.

Two aspects of this calculation are worth pointing out. First, from a senior management perspective, this figure has great intuitive appeal. It encapsulates, in dollar terms, how much total risk the firm can take. Moreover, it is generated based on business considerations (revenues, expenses, ROTE, etc.), rather than on statistical metrics like VaR, which can be difficult for non-risk managers to link to the business activities of the firm. Second, the limit establishes a binding constraint on risk-taking. At Lehman the aggregate RA limit is, by design, not meant to be exceeded under any conditions, as an excession would indicate that the franchise was at risk.

In contrast to the RA limits, which express the firm’s risk capacity, RA exposures reflect the risks being taken by the businesses, i.e., risk *usage*. RA exposures are an amalgamation of three types of risk: market risk, event risk, and credit risk. Each component is calculated separately, largely by transforming existing metrics like VaR

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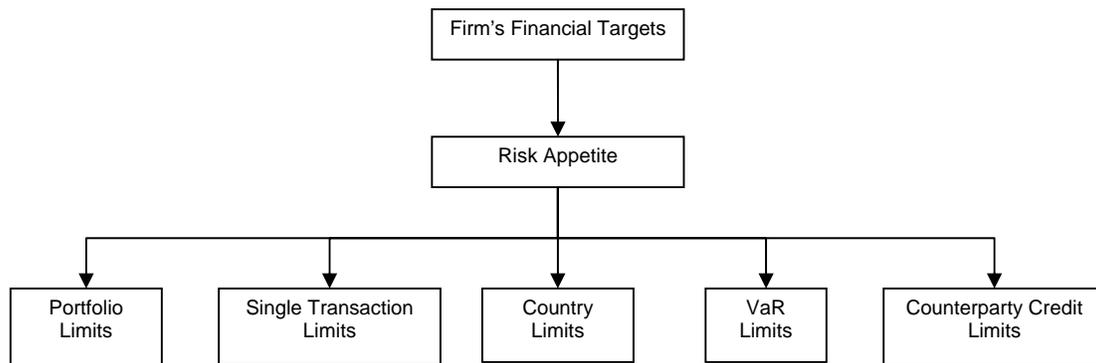
designed to capture. This determination of comfort level is, by its nature, subjective. In addition, at times these limits may be set at relatively low levels, in order to act as “speed bumps” that would trigger discussion if they were to be breached. By contrast, under Lehman’s approach, the firm’s risk tolerance proceeds along more tightly defined criteria, with little apparent subjectivity around the final number itself. Under this latter approach, the number which falls out of the calculation is less a reflection of management’s subjective “comfort level” and more a binding constraint.

<sup>11</sup> The 10% adjustment to baseline projected customer flow revenues is based upon the firm’s revenue history during its existence as a public company, with a focus on the down years. The firm has never experienced a revenue shortfall of this magnitude, thus the adjustment has been deemed to be sufficiently conservative. The \$0.6 billion deduction from the principal investments component reflects what the firm believes it needs to represent the inherent volatility of this revenue stream.

and PE, and then aggregated according to certain correlation assumptions, described below. A central idea behind the RA exposure number is that a dollar of risk is equivalent to all other dollars of risk, no matter the source. To get to a point where this holds true, the existing measures of market, event and credit risk must first be standardized and put on an apples-to-apples basis with each other. By matching these to the one year, 95<sup>th</sup> percentile assumption underlying the RA limit, risk usage and risk capacity can be compared meaningfully.<sup>12</sup>

c. Aggregate Risk Limits

Lehman’s risk management framework is multi-tiered. The primary firm limits live within the RA framework. As mentioned above, the Executive Committee sets the overall RA limit at a firmwide level and at the division level (e.g. fixed income or equities). RMD, in conjunction with the business heads, sets limits for the businesses. As mentioned in a prior footnote, many firms have their own limits intended to act as a sort of speed bump that prompts discussion with risk management prior to putting on a risky position. At Lehman, RA limits are considered to be hard; that is, they are non-negotiable except in extremely limited situations. If the firmwide RA limit were to be breached, the CRO would immediately notify the CAO and the Risk Committee. If a business level breach occurred, the market risk manager would discuss this with the traders, the desk head, the head of MRM, and the CRO. The CRO, in consultation with the division head, may either allow the excess for an agreed period of time in support of a specific strategy (this type of approval is generally granted only ex-ante), agree to revise the limit if such a change is warranted, or instruct the business to reduce its profile so as to be within the original limit.



Lehman also sets risk limits for the firm on a more granular basis, such as VaR, counterparty credit limits, and country limits.<sup>13</sup> In addition, Lehman is in the process of developing single transaction limits, which would cap the size of individual deals.<sup>14</sup> The

<sup>12</sup> It is worth noting that at many firms, stress tests are thought of as more extreme, yet less likely, occurrences, for which probabilities cannot be assigned. At Lehman, however, event risks are deemed probabilistic for RA aggregation purposes, despite the fact that they appear designed to capture these risks in the same manner as peer firms' stress tests.

<sup>13</sup> VaR limits are discussed in more detail in Section xx. Counterparty credit and country limits are discussed in more detail in Section III.c.

<sup>14</sup> These limits do not apply to large derivative deals.

purpose of these limits is to minimize headline risk, where Lehman would receive negative press about an outsized loss that might raise questions about its internal risk management processes. A deal will still have to pass through the requisite approval processes, such as formal committee approval. In addition, a deal may fall within VaR and RA limits, but still be considered too big under the single transaction limits. These limits have not yet been rolled out in a formal manner, but the business units are currently operating as if the limits are in place.

Single transactions are limited to \$200 million in potential quarterly pre-tax losses and to an overall deal size of 15% of tangible equity (equivalent to \$1.8 billion). However, with “bells and whistles” such as material adverse clauses (MACs) and pricing flexibility, potential quarterly pre-tax losses and transaction sizes can be larger. RMD has developed a calculator that determines the maximum loss, looking at factors such as place in the capital structure, volatility, event risk, pricing flexibility, business or market MACs. In addition, deals that will take longer to close are penalized within the calculation. Both RMD and the businesses have access to the same calculator, the idea being that it will allow the bankers to proactively structure a deal with the risk mitigants that will ensure the deal is within the limits. A banker will input the size of a deal’s tranches into the calculator, which will give the maximum loss figure. The calculator inputs, mentioned above, are input into the model by risk management. The model incorporates both VaR and event risk at a 99.5% confidence level. As mentioned previously, RMD at Lehman focuses much of its attention on these large deals generating concentrated exposures.

RMD and the affected business units have worked together to develop this framework, leading to acceptance of the limit by the businesses. For example, the high yield leveraged loan group pointed out that a leveraged buyout which is a total revamping of a company’s structure has a lower probability of default in the first year than a comparable company that has just received a cash infusion. Thus, the probability of default was adjusted in the calculator accordingly. However, in areas such as syndication market visibility, MRM is unwilling to adjust the parameters.

The various risk limits set at the senior management level cascade down to the business units and, ultimately, to the trading desks. Both business unit and RMD personnel then monitor usage against those limits. Limit excessions (of RA, VaR, or counterparty exposures, for example) are reported to appropriate supervisory personnel and escalated to senior management, if necessary. In some cases, desk heads may set their own limits based on alternative risk measures (e.g. gamma or delta), but these limits are entirely owned by the businesses units rather than RMD.

## II. Market Risk Overview

This section will discuss the structure and responsibilities of MRM, as well as the metrics used to capture and convey market risk at Lehman.<sup>15</sup> It will then describe the businesses generating significant amounts of market risk, and how the department seeks to capture the risks associated with these businesses. In addition, OPSRA looked at businesses generating significant event risk, which is discussed in further

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<sup>15</sup> Unless otherwise specified by term “market risk component” in this section of the report, the term “market risk” will be used to refer to risk arising from potential changes to various risk factors, and generally captured by VaR. It does not refer to the market risk component of RA, although the market risk component of VaR is directly derived from the daily VaR measure used by MRM.

detail later in this section. Based on these criteria, OPSRA looked at interest rates, credit trading, mortgage trading, municipals, equity volatility, real estate, and risk arbitrage.

a. Structure of Market Risk Management

MRM is responsible for developing and implementing Lehman's market risk management policies and procedures; determining market risk measurement methodologies in conjunction with QRM; monitoring, reporting and analyzing the aggregate market risk of the firm's trading exposures; and administering market risk limits. The Global Head of MRM is based in New York and reports to the CRO. Under the head of MRM, there are risk managers aligned by businesses: a head of real estate, two global heads of interest rate products, a head of equities, and a head of investment management. The heads of collateralized lending report jointly to the head of market risk and the head of credit risk. MRM has teams in the firm's regional trading centers of New York, London, and Tokyo. In addition to the risk managers aligned by business, there are regional heads: a head of European risk management, and a head of Asian risk management. The heads of Asian and European risk management report to the regional CEOs for administrative purposes.

MRM is governed by the Market Risk Policies & Procedures, which are reviewed annually concurrently with the budgeting process, or more often if necessary. MRM is responsible for measuring, monitoring, and reporting VaR, VaR backtesting, stress testing, scenario analysis, and event risk.

Market risk managers physically sit on the trading floors which they cover, and meet daily with the appropriate business unit management.<sup>16</sup> The risk managers are consulted by desk heads prior to large and unusual transactions. While the daily processes vary depending on the product covered, in general a risk manager's day begins with market monitoring and a prior day recap. All of the risk managers' responsibilities are geared towards ensuring that there is a coherent and consistent story being reflected in the data, and reporting that story up through the chain of command. He or she will look at the prior day risk capture through position data, sensitivities, and stress matrices. VaR and risk reports will be generated at desk and aggregate levels, and managers will usually perform a "sanity check" with product control, the middle office, and the traders. In the morning, each risk manager must sign off on the VaR calculation for their business. Without these sign-offs, firmwide VaR cannot be calculated. The risk manager will also provide commentary on major exposures, trades, and market events. Throughout the day, the risk manager monitors the market and intraday risk, and any large and unusual transactions. At the end of the day, the risk manager may provide an additional recap. In addition to these responsibilities which are common to many product areas, some risk managers create daily customized risk reports. In the equity proprietary business, for example, risk management prepares daily limit transaction reports and daily fund managers name overlap and exposure reports at the behest of the business.

The weekly process involves risk aggregation with regard to major sensitivities, and major trade or exposure details. On a monthly basis, the risk manager will comment on VaR or RA changes, as well as discuss the risk with the business head. Lehman stated that informal interaction with business heads occurs on a daily basis. For example, the risk manager for U.S. rates attends an end of day meeting held by the

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<sup>16</sup>OPSRA visited with the head market risk managers at their desks on the trading floor, and the risk managers described and demonstrated their specific daily processes.

business head of interest rates and liquid proprietary trading, where the desk heads give a quick summary on their day's positions, and any notable market movement.<sup>17</sup>

Risk managers prepare daily updates for the head of MRM and the CRO. On a weekly basis, the senior risk managers contribute to a "top line risk report" that is prepared by the head of MRM. This report is then given to the CRO, who presents it to the Executive Committee during a weekly meeting. This report discusses changes in RA, changes to material exposures (e.g. interest rate and foreign exchange (FX) positions), and businesses currently having notable risks. There is also discussion of new trades and positions that have had a material impact on risk, and investment grade and non-investment grade large exposures on a name by name basis. The report that OPSRA reviewed also had a lengthy discussion of principal transactions within the real estate business. MRM also contributes to the Firmwide Risk Snapshot, a one-page report which shows RA and VaR usage by business. It breaks out the top market risks, and large exposure highlights.

While market risk managers monitor overall RA usage for their respective businesses, on a day-to-day basis, they tend to focus on the specific RA component (market or event risk) driving RA usage. In the case of the more liquid businesses, such as equity derivatives and interest rates, RA is driven primarily by VaR, or the market risk component. Therefore, the risk managers for those businesses focus their daily processes on VaR drivers and overall usage. In areas such as real estate, the majority of RA is driven by the event risk component, and it is monitored accordingly. This approach seems appropriate in that it allows risk managers to focus on the metric that best captures a particular business' risks.

Market risk managers also have responsibility for reporting limit breaches, both for VaR and RA. The overall VaR limit is a function of the market risk component of RA, and the division level VaR limits are set by MRM in conjunction with the business heads. While, as mentioned previously, RA limits are considered to be "hard," there tends to be a bit more flexibility around VaR limits, although not at the divisional level. Within a division, however, MRM may approve an overage within one business as long as the division is within its overall limits. As mentioned previously, the CRO and senior business management are made aware of limit overages by risk managers via emails throughout the day. Risk managers include varying degrees of analysis and commentary with the limit breach notification. This flexibility allows managers to respond in a manner consistent with the materiality of the breach, but risks inconsistency in the overall limit breach process. In some cases, senior business management will engage in a dialogue to seek more detailed explanation for the increase in risk. While this provides an audit trail of sorts for limit breaches and management follow-up, the manual nature of this activity means that senior business management is informed of limit excessions only to the extent that risk managers affirmatively report them. Many of Lehman's peer firms use limit processes that are more automated, or have plans to migrate to such systems.

At the highest level, risk managers rely on a technology platform called LehmanRisk to measure aggregate risk-taking by the business units, to store and report relevant risk data, and to otherwise assist them in their analyses of the risk profile of the firm. LehmanRisk calculates RA, VaR, event risk, and aggregate sensitivities and stress matrices for a variety of products and exposures at multiple levels of the firm hierarchy. This information is accessible to risk managers through a web-based interface. In

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<sup>17</sup> OPSRA attended this end-of-day meeting for interest rates, where the business head, his desk heads (e.g. Treasuries, pass-through mortgages, agencies), and the market risk manager for the rates business were in attendance. OPSRA spoke with the business head after the meeting to understand how he viewed his interactions with his MRM counterpart.

calculating the aggregate risk exposures, LehmanRisk leverages off of data in the front office trading and aggregation systems – e.g., position greeks, spread sensitivities and stress matrices. Accordingly, as discussed later in this document, the controls around that data, such as PC-led price verification, are critically important to the robustness of the aggregate risk calculations done for VaR, event risk and RA.

Risk managers also may look directly to the various systems built and used by the business units themselves to provide more granular information on changing risk exposures. For instance, the front office trading systems for mortgages feed into and support a system called RAMP, which aggregates exposure sensitivities to various yield and spread curves and provides a host of other information to its users, primarily the trading desk heads.<sup>18</sup> A similar risk aggregation system exists for rates trading, dubbed IRIS. The finer granularity and higher dimensionality of the exposure information available through these systems provides risk managers with the means to investigate in detail the drivers of any higher level risk changes as evidenced through LehmanRisk. It also provides another set of metrics by which to reconcile changes in aggregate measured risk.

Much of the detailed work from a modeling perspective occurs in the front office systems. Recall, LehmanRisk focuses exclusively on risk aggregation. By contrast, the risk sensitivities which LehmanRisk depends upon are calculated in the front office systems such as RAMP and IRIS. Thus, the model validation process discussed later in this report serves an important role in ensuring the robustness of the risk measurement data eventually calculated and reported by LehmanRisk.

Currently, there is no risk tool to conduct real-time “what if” analysis on large transactions, as is the case at several peer firms. Rather, MRM conducts an ad hoc customized risk analysis for large transactions warranting further review.

#### b. Models and Methodologies for Measuring Risk

As mentioned previously, MRM relies on various metrics to assess the risk in the business areas. For some businesses, such as equities and interest rates, the risk manager’s primary metric is VaR, as the risks tend to be readily captured through the VaR system. In other businesses, such as real estate, the risk managers tend to focus on event risk, which captures the risks not picked up by VaR. Event risk measures the potential loss associated with occurrences which are not captured in market risk. It seeks to measure stress and “gap risks” which go beyond potential market risk losses.

While the exposure characteristics of positions and portfolios can be captured by risk factor-specific sensitivities, such as the Greeks and measures of the incremental impact of a widening of spreads across the curve<sup>19</sup>, calculating a meaningful aggregate risk measure requires some means of taking into account the correlations and dependencies between all of the relevant risk factors and aggregating risk across businesses with exposures to different risk factors. VaR is able to address these aggregation needs. Mathematically, VaR corresponds to a percentile loss of the forecast distribution of a portfolio’s profit and loss (P&L). Conceptually, VaR attempts to answer the question, “What is the maximum amount that can be expected to be lost with

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<sup>18</sup> The market risk manager responsible for mortgages demonstrated to OPSRA how he uses RAMP in his process of risk assessment.

<sup>19</sup> These sensitivities to parallel shifts in the yield curves are found in businesses such as interest rates and credit trading. They are referred to by different nomenclatures, from “DV01” in interest rates to “spread01” in credit. Both are measures of sensitivity to a one basis point parallel change in the appropriate underlying metric across the curve. In this report, these types of risk measures will be referred to as curve sensitivities.

a certain degree of certainty over a given time horizon?" Lehman calculates VaR for a one-day horizon to a 95<sup>th</sup> percentile confidence level.

#### i. Introduction to VaR

Very broadly, there are three central steps to designing a VaR model. The first step involves mapping the firm's positions to risk factors. Examples of risk factors include equity indices, interest rates, corporate spreads, implied volatilities, and option-adjusted spreads. The mapping expresses positional P&L as a function of movements in these factors. The second step involves generating the distribution of risk factor movements that will be applied to estimate the portfolio P&L distribution (using the above mappings). This process must generate simultaneous movements in all risk factors so as to preserve the correlation structure across factors – i.e., a joint risk factor distribution must be generated. There are three broad approaches to modeling this joint distribution: Historical Simulation (HistSim), Monte Carlo simulation, and a Variance-Covariance (VCV) approach. The third step involves taking the risk factor distribution generated and applying a revaluation approach to quantify the P&L impact from each joint risk factor realization.

Lehman utilizes a HistSim approach to calculating the 1-day 95<sup>th</sup> percentile VaR for the firm as a whole, for each division and the business units within the divisions. The HistSim approach relies directly upon historical data to establish the joint distribution of risk factors and hence correlation among risk factors, which in turn serve as the inputs for estimating the portfolio P&L distribution.<sup>20</sup> In broad terms, the portfolio is repriced on each historical date, and each day's P&L is saved, weighted with a decay factor to emphasize recent history, and then rank ordered to form a distribution of gains and losses. The VaR metric then simply reflects a percentile loss from this distribution. To capture specific risk, Lehman either directly maps to name-specific risk factors, for most equities, or utilizes a Monte Carlo method, for bonds.

In calculating a HistSim VaR, the following are critical: (a) the revaluations of the positions in the portfolio (based upon the movements in risk factors) must be robust, especially if the portfolio has non-linear positions, e.g., options; (b) the mapping of positions to risk factors must be robust, especially for securitization-related positions which are backed by customized collateral pools; and (c) the historical times series data upon which the revaluations are based must be robust and sufficiently granular to permit capture of all of the material risk in the portfolio.

#### ii. Revaluation

To calculate the changes in position values and thus portfolio P&L, those positions must be revalued as a function of the changes in risk factors. The revaluation techniques utilized by Lehman's VaR model attempt to capture: (1) linear risks; (2) non-linear risks; and (3) issue-specific risks.

Linear risks are measured by calculating the local sensitivities of positions to certain risk factors, and then multiplying those sensitivities by historical movements in the corresponding risk factors. This yields the hypothetical P&L effect of risk factor movements on the portfolio. For instance, if an equity position has a delta of +\$100, a

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<sup>20</sup> In other words, the past is assumed to be an indicator of the future, and no other statistical assumptions are imposed. By contrast, under the Monte Carlo approach, individual and joint distributions are specified by the VaR modeler, i.e., parameterized, though they may be calibrated using historical data. Under the VCV approach, all of the distributions are assumed to be a distribution with fat tails, such as a joint normal.

\$2 decrease in the price level of that equity would correspond to a \$200 loss. Similarly, if a cash government bond position has a spread sensitivity of \$1,000 per basis point, a 5 basis point rise in rates would correspond to a \$5,000 gain. In short, the magnitude of the P&L is approximated as a linear function of the movement(s) in the underlying risk factor(s).

Of course, many instruments exhibit non-linear price dynamics. For example, options prices generally do not change linearly with changes in the prices of the underlying assets. In these cases, using only local sensitivity measures to calculate the P&L distribution for VaR could introduce significant estimation error. In addition, many derivatives positions are sensitive to the non-linear co-movements of multiple risk factors, so-called cross-partial effects.<sup>21</sup> Thus, even if one were able to capture the non-linear sensitivity of a position or portfolio to one risk factor, the cross-partial effect exerted by another risk factor could result in further estimation error. Lehman addresses both the non-linear and the cross-partial effects through the use of stress matrices. With a stress matrix, a number of stress points for two risk factors are specified and revaluations are done at each intersection. For instance, for equity options Lehman uses stress matrices consisting of eleven price points and five volatility points. For interest rate derivatives, the stress matrix has eleven parallel shifts in the yield curve and nine parallel shifts in the volatility curve. At each intersection the position or portfolio is fully revalued.<sup>22</sup> Once full revaluations are completed for all of the intersection points of the stress matrix, the matrix serves as a look-up table for the VaR calculation. When the actual historical moves in the various risk factors fall between the grid points, the non-linear P&L for that day is estimated using an interpolation technique. This stress matrix approach provides a shortcut to full revaluation for each position for each historical day's movements in risk factors, thus saving considerable computation time presumably without sacrificing too much accuracy. The number of points on each axis of the grid, as well as their spacing, should be evaluated in light of the portfolio for appropriateness.

Where stress matrices are used, all revaluations are done in the using the front office calculators, which are not owned by MRM. This makes the VaR calculation in the risk system more manageable and straightforward, since only multiplication and addition are required to interpolate in between grid values during the VaR calculation. The truly computationally demanding hard work occurs through the revaluations. With mortgage products, for instance, this calculation is done only once per week because of the computational burden.

Not all convex, or non-linear, exposures get stress matrix treatment. For instance, in high grade credit, much of the risk is linear. However, for the products in the book generating non-linear risks (e.g. emerging market positions), full repricing through stress matrices is done only for positions with "significant" convexity. All other positions use linear approximations. OPSRA will be following up with MRM to understand how convexity is determined to be "significant" versus determining that the use of linear approximations is sufficient, particularly in books with a higher proportion of non-linear instruments. In addition, OPSRA will discuss how MRM assesses whether the linear character of a portfolio has changed over time.

Issue-specific risk is discussed in the next section on mapping. In basic terms, where positions are mapped to indices for VaR calculation purposes, the risk is that

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<sup>21</sup> For example, equity options exhibit non-linear sensitivity to both the price of the underlying asset (gamma) and the implied volatility (vega).

<sup>22</sup> For instance, given a -5% shock in the price of the underlier and a +2 point shock in implied volatility, the position under consideration may yield a loss of \$30.

those positions will only be partially explained by movements in the indices – the unexplained portion of risk is issue-specific risk and is captured through the means described below.

### iii. Mapping

All positions must get mapped to a set of risk factors. Under HistSim, these risk factors must have sufficiently robust and complete histories of observations to be useful. These observations may come from external sources, such as Bloomberg, or from internal marks, such as credit correlations, which are subject to scrutiny and review by product controllers. Alternatively, the risk factors utilized may be synthetically created where the historical risk factor time series are weak or non-existent. For example, in the case of municipal bonds, a special index was created to provide a meaningful time series to which particular positions can be mapped. In the calculation of firmwide VaR, Lehman utilizes approximately 12,000 risk factors in its VaR calculation – 9,000 for equities and 3,000 for fixed income. In general, a high number of risk factors facilitates more granular risk capture, especially where basis exposures may be significant.

Nearly all name-specific equity exposures are mapped directly to name-specific time series. This obviates the need to calculate issue-specific risk for equities since the mappings are on a name-to-name basis, which effectively captures both the systematic and idiosyncratic components of risk.

For high grade and high yield bonds, however, several mapping approximations are utilized. For instance, in the high grade bond space, the risk factors are segmented by industry sector, credit rating, tenor, and currency. A distinct time series corresponds to each combination of those four attributes. Thus, each investment grade corporate bond, for instance, is mapped to an attribute-specific, but not name-specific, time series. To the extent that the mapped time series is unable to explain the risk (variance) of the position, the unexplained variance is considered issue-specific risk. That variance is used to specify a distribution (mean zero, variance X) from which a Monte Carlo simulation draws to estimate the issue-specific risk arising from that position on any given day in the HistSim P&L distribution. This internal creation of issuer-specific risk effectively adds another 10,000 risk factors to the VaR calculation. Because of the high number of unique bond instruments and the limited time series data on each, this method requires that positions' issue-specific risk be proxied by that exhibited in each attribute-specific index. This introduces some approximation error. Other challenges include dealing with ratings migrations, particularly by big names (like General Motors) which may disproportionately affect index levels and estimates of index volatility and issue-specific risk.

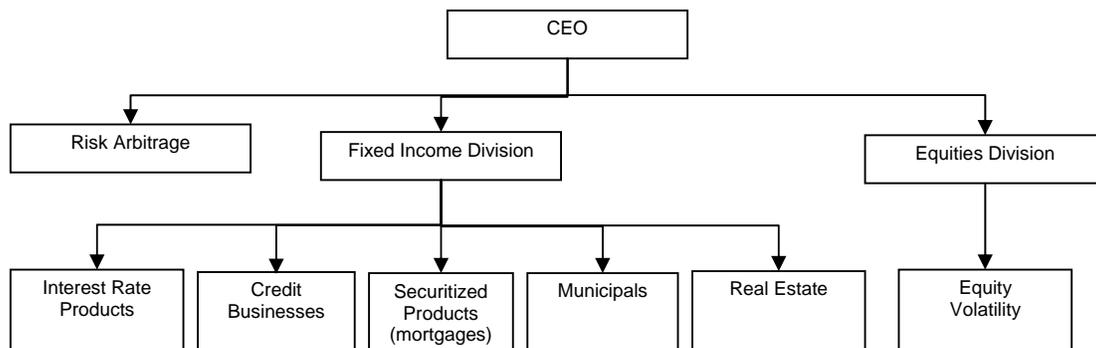
### iv. Historical time series

The integrity of Lehman's HistSim VaR calculation relies upon quality time series data for each risk factor. Ensuring and maintaining that quality requires significant resources given the large number and specialized nature of many of them. Lehman has a group within QRM called the Data Quality Control Group (DQCG), which is responsible for the integrity of the historical data. This group has one dedicated full time QRM employee, who has a PhD. He is assisted by market risk managers who are charged with responsibility for specific time series. DQCG is responsible for checking the data and working with MRM when irregularities arise. Given the number of data series used by Lehman, ensuring data quality is a time-intensive task, and QRM is in the process of developing a new set of reports to monitor the historical database. With only one person

dedicated full time to maintaining the quality of the time series data used in VaR, Lehman sits at the lower end of the spectrum of resources allocated to that important control. OPSRA will continue to discuss the issue of data quality with QRM.

c. Businesses Generating Significant Market Risk

The following sections describe businesses which have material and/or complex market risk profiles. OPSRA met with the heads of each business to discuss the range of products and activities that fell within their jurisdiction. Also present at the meetings were members of MRM and product control, who explained the specific control processes around each business. The chart below shows how the businesses discussed are organized at a divisional level.



i. Interest Rate Products and Liquid Markets Proprietary

Business Overview

This business is one of the largest within the fixed income division, which is the key driver of Lehman’s RA usage. There is a client-focused flow business, where risk is incurred while facilitating trades, and a proprietary business. Interest rate products, the flow portion of the business, has a global RA limit of \$300 million, and liquid markets proprietary trading has a limit of \$100 million. As of 2/28/05, RA usage in rates was \$347 million, and in liquid markets proprietary was \$121 million.<sup>23</sup> Both businesses are predominantly in the United States, but also have significant presences in Europe and Asia. As both lines of business are run by the same business head, they exhibit similar characteristics and will be discussed in tandem.

Lehman trades in two product groups within the flow business: governments and derivatives. Trading activity centers on facilitating clients’ requests to increase or hedge exposure to interest rates across the globe and related risk factors such as volatility and inflation. Within the liquid market proprietary group, there is foreign exchange as well as interest rate trading.

One area of note within the flow business is fund derivatives, a topic that occupied a significant amount of time during discussions between Lehman and OPSRA. The notional size of this business is \$5.7 billion, with just over 200 trades. Within this line of business, centered mainly in Europe, Lehman creates principal-protected hedge fund

<sup>23</sup> All RA usage numbers in the discussion of businesses are as of 2/28/05. As noted in the discussion on limits, excessions are permitted within a division as long as the division is not breaching its overall limit.

linked structured notes, which allow leveraged investment into hedge funds. The primary risk in this space is gap risk, where the business would find itself unable to rebalance its portfolio quickly enough. Other risks in this area include systemic event risk, fraud risk, market risk such as rate, equity and volatility risk, legal risk, operational risk, and reputational risk. The group manages these risk through due diligence at the fund of funds or individual manager level, diversification across underlying funds and products, and gap options. Gap options, generally sold by insurance companies, protect again a discontinuous market move. The fund derivatives business will be an area of focus for OPSRA following the formal CSE review.

Recently, within the flow business, Lehman executed its largest trade in 11 years – an inflation linked interest rate swap with a sovereign. As part of the CSE review, OPSRA was walked through the trade approval and execution process. The trade was developed by Lehman's derivatives solutions group, which then proposed the trade to the sovereign. The trade was explained to senior management in the firm, as well as at all levels of the fixed income division. The factors considered were the initial rate risk, the volatility and inflation risk, the planned hedging strategy, the credit risk exposure, and lack of liquidity in the inflation derivatives market. Once approved at all levels, including by the CEO who had visited the country in person to discuss the trade, the London derivatives desk executed the trade.<sup>24</sup>

Proprietary trading consists of interest rate and foreign exchange strategies. This area tends to have fewer positions than the flow business, and they are unwound once value is captured. Within rates, Lehman trades basis spreads, swap spreads, calendar spreads, volatility arbitrage, and gamma (relative value between different types of interest rate options). Within foreign exchange, they trade foreign basis (hedged foreign exchange forward contracts versus local swaps), global curve arbitrage (sovereign yield curves through the foreign exchange markets), and cross-border arbitrage (trading off-shore versus on-shore interest rate markets). Similar to the flow business, risks within these two areas include rate risk, basis risk, volatility risk, and convexity risk. They are managed within the business by limiting traders to specific strategies, employing a dedicated risk monitor who reports directly to senior business managers, and using appropriate hedges. In addition, the group is subject to standard MRM oversight.

## Risk Management

Within this space, the key drivers for VaR are interest rates (government, agency, swaps, Eurodollar futures, and treasury futures), rates volatility, spot foreign exchange, and foreign exchange volatility. P&L distributions are calculated for every desk position using a variety of methods. For instance, the P&L distribution for cash products may be calculated using treasury on-the-run and off-the-run yield or Libor/swap yields, amongst other time series, while distributions for Treasury futures are generated using the Lehman cheapest-to-deliver model. In the interest rate derivatives space, to capture vega risk the five year into ten year USD swaption implied volatility is utilized as a reference time series for synthetically generating a sufficiently rich set of rate volatility risk factors. Non-linear components of the P&L are calculated using stress matrices, representing 11 parallel shifts of the yield curve from minus 100bp to plus 100bp and nine parallel shifts in the volatility levels from minus two volatility points to plus two volatility points. As part of Lehman's drive to capture specific risk, mapping is often quite

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<sup>24</sup> OPSRA has regularly discussed this position during the ongoing monthly risk reviews with senior members of the risk management department.

detailed. For example, Lehman maps government bond exposures to a set of fairly granular risk factors – e.g., on-the-run versus first off-the-run Treasuries and agencies, sixteen groupings for Japanese Government Bonds, thirteen yield curve shift scenarios for bond futures, etc. Inflation risk, traded mainly in the European markets, is not yet in VaR, but including this risk factor is one of MRM's priorities. Lehman's approach allows the capture of first and second order effects (the second order effects are captured through the stress matrices), but third order effects such as volatility skew, are not picked up in the VaR calculation. QRM would prefer to capture this type of third order effect, even if in an imperfect manner, in VaR rather than develop one-off supplementary risk measures.

Specific daily risk reports include spread sensitivities by bucket, currency, and underlying (e.g., treasury or agency). For agency positions, spread sensitivity by issuer is calculated. For treasury futures, MRM looks at notional and spread sensitivity by underlying bond, and by maturity. Vega is measured in terms of caps and swaptions, while foreign exchange is reported by currency spot, rates, vega, and gamma. For the weekly reports, spread sensitivity is aggregated by business and by currency.

Event risk in interest rates occurs with fund derivatives, in the form of gap risk. Fund derivatives are hedged dynamically, but markets can occasionally gap. If the desk cannot hedge in time, losses can be significant. This mainly occurs when net asset values (NAV) of funds gap downwards. There is very limited data on gaps, as by definition they are rare events. This risk does not yet show up in risk appetite. As mentioned in the earlier discussion of fund derivatives, OPSRA will be following up with Lehman to learn about this business in further detail, including the calculation of event risk charges in this space.<sup>25</sup>

## ii. Credit Businesses

### Business Overview

Lehman's High Grade and collateralized debt obligation (CDO) business consists of several different desks. High Grade has a RA limit of \$475 million, with actual usage of \$251 million. The CDO business has a limit of \$100 million, with a usage of \$62 million. Flow trading, the most active of the group, trades and makes markets in cash credit, single name credit default swaps (CDS), and index credit. The CDO desk structures and trades cash and synthetic CDOs. The hybrid capital desk trades and makes markets in corporate preferreds. The proprietary desk takes positions in credit through all of the various instruments.<sup>26</sup>

In the cash CDO space, the desk engages primarily in "primary activity" (i.e., working with top managers to issue new collateralized loan obligations (CLO) and structured finance CDOs). For example, Lehman might partner with a manager at a pension fund, and enter into an agreement whereby the manager sources assets to be inventoried for eventual distribution through a CDO structure. The process generally

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<sup>25</sup> With respect to PC, within interest rate products and liquid markets proprietary, approximately 83% of the balance sheet is considered to be Level 1, or assets with active reference markets. 16% are Level 3, and 1% are Level 4. Level 3 consists mainly of the derivatives business, where PC gets dealer quote to verify trader marks. Level 4 consists of the fund derivatives business in Europe, where it is difficult to capture volatility around prices of the underlying funds. For a full discussion of the level definitions, see the section on price verification within Control Processes.

<sup>26</sup> Currently, proprietary trading in credit is relatively small (approximately 5% of revenues), though the business head noted that this may potentially grow to about 20% in the future.

takes six to nine months. The underlying assets are generally high yield loans or asset backed securities. Upon distribution, the entire capital structure is sold to investors. In this space, the primary risk for Lehman is inventory risk.

In the synthetic CDO space, the underlying collateral is generally high grade CDS, and the products are generally bespoke or static baskets. Demand is global, with most of Lehman's market share in the U.S. and Europe. Distribution occurs through the structured credit desk. Here, the risk stems primarily from retained residual pieces, since the sourcing process is relatively straightforward. The residuals expose Lehman to various risks, such as spread volatility, liquidity risk, and correlation skew. With regard to correlations, recent stresses to the structured credit market have demonstrated the difficulties associated with risk managing the correlation skew for tranching products, and OPSRA will continue to focus on Lehman's approach to managing this risk factor.<sup>27</sup> Lehman uses a system called Scorpion, which calculates the desk's exposure to these risks through sensitivity metrics like correlation spread sensitivity, curve sensitivity, the gain or loss associated with a default assuming a specific recover rate, also known as value-on-default (VoD), and curve risk.

Interestingly, the exotics desk trades swaptions (mostly on CDX indices, occasionally on single name CDS), bond options and warrants, and recovery locks/fixed recovery CDS (instruments which reflect recovery rate assumptions in default scenarios). Though these exposures are relatively small, they are complex to model with some exposures tracked using spreadsheets.

The hybrid capital desk focuses on "subordinated product" – e.g., preferreds and subordinated debt. It leverages Lehman's origination and structuring businesses both to take relative value proprietary plays such as capital structure arbitrage and to pitch such ideas to clients. The key risks in this space include the shape of the yield curve (flat to inverted hurts demand because of call features), rates convexity, correlation with other parts of the capital structure, and relative illiquidity. The latter two risk factors can be difficult to measure and risk manage in a systematic way. To the extent that activity in this space increases, OPSRA will discuss the capture of these risks with MRM.

The proprietary desk essentially consists of two people: one capital structure arbitrage trader and one fundamental credit trader. Both use fundamental, as opposed to quantitative or statistical, trading strategies. The investment horizons are short to medium term (up to 18 months), with relatively low trading volumes. Both strategies trade across products/asset classes. As such, in addition to the greeks, VaR is one of the primary metrics used to risk manage this book. Value on default (VoD) is used to manage tail risk. Exposure to event risk such as downgrades, leveraged buy-outs (LBO), and leveraged recapitalizations must be carefully tracked. In addition, the risk of correlations coming unglued remains difficult to manage. So far, risk-taking in this space has been relatively small, but may grow in the future.

## Risk Management

On a VaR basis, the risk manager estimated that the risk breakdown by desk was approximately as follows: Synthetic CDO (20-30%), Flow (15-25%), Hybrid (20%), Proprietary (10-15%), and Cash CDO (10%).

MRM utilizes a number of metrics to risk manage exposures from the activities described above. In addition to the standard spread sensitivities, the front office

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<sup>27</sup> During a conversation with OPSRA, the CRO stated that finding increasingly sophisticated ways to deal with correlation skew was amongst the top priorities of MRM. This is a proactive measure, as Lehman did not suffer material losses during recent credit market events referenced above.

systems also calculate: (1) VoD (2) value-on-default-zero (VoD0), the gain or loss should an issuer default with a zero recovery rate assumption; (3) VoDProb, the default probability adjusted VoD (PD x VoD); and (4) Credit10%, the change in an instrument's value for a 10% change in credit spread. These metrics assist the risk managers in identifying low probability/high impact exposures or concentrations of risk that are not readily captured in VaR. Other risks include CDS basis risk, concentration risk, and correlation risk.

Perhaps the key market risk in credit trading is correlation skew. As mentioned previously, this can be difficult to capture and manage with regards to tranching products, and addressing this issue is a priority of the CRO. OPSRA will be following up with MRM as to the success of this initiative. Within exotics, trades can be one-way, leading to illiquidity in the market. In addition, single name swaptions are subject to gap risk due to the illiquidity of the market – these risks can be difficult to manage quantitatively, and instead need qualitative solutions (e.g., being selective on names traded for single name swaptions). Again, within proprietary trading, correlations continue to be a challenge. This is addressed within this area by monitoring each leg of a paired trade to watch for correlated assets beginning to “uncorrelate.”

For the event risk component of Risk Appetite, losses due to downgrades for high grade securities and losses due to defaults for high yield securities are calculated. This is discussed in greater detail later in the credit risk section of the report.<sup>28</sup>

### iii. Mortgage Trading

#### Business Overview

Pass-through mortgages and mortgage options are traded through a joint venture with interest rates and the mortgage group. Most of the traders in these more vanilla products sit within the interest rate group, and positions therefore roll up through Liquid Markets. This venture is based on the premise that the multi-trillion dollar mortgage industry is intricately tied to the rates markets, and many flow customers take interest rates positions, especially in convexity, through mortgage products. The more complex residential mortgage trading business sits within Securitized Products, which also includes commercial mortgage backed securities (CMBS), asset backed securities (ABS), and CDOs. Securitized Products rolls up into Liquid Markets as well. Mortgage trading has a RA limit of \$350 million, with usage of \$364 million.

In the structured residential mortgage space, there are four product divisions: agency collateralized mortgage obligations (CMO), prime mortgages, sub-prime mortgages, and warehouse lending. In the agency CMO space, Lehman seeks to arrange CMOs supported by selective collateral and leverage, rather than just doing high volume/low margin CMO issuance. Similarly, in the prime and sub-prime businesses, Lehman focuses on product design (securitizations and whole loan sales), by leveraging off its three mortgage origination platforms.

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<sup>28</sup> With regards to PC, nearly all of the derivatives inventory is Level 3. PC for synthetic CDOs, which are in Level 4, must rely on MarkIT Partners for credit spreads, bespoke calibrations, correlation skew adjustments, and recovery rate assumptions. MarkIT supplies raw data recovery rate and spread data on single name corporates at a number of points on the term structure, by baskets, for 11 CDO portfolios. Participating firms' controllers then use that raw data to generate spread sensitivities and base correlations for the tranches of the 11 CDOs at various maturities. Each firm sends that data back to MarkIT. MarkIT collates submissions from 23 contributors and then reports the consensus data (means, not variances). Lehman's PC use this consensus data in the price verification process.

The origination platforms form a core piece of Lehman's mortgage trading franchise. Last year, the platforms originated a total of \$62.7 billion in residential mortgages. Lehman's fully owned subsidiary Aurora Loan Service (ALS) originates prime mortgages, mostly Alt-A, through a set of correspondent mortgage originators. ALS averages around \$4 billion in originations per month and has a significant servicing portfolio of \$50 billion. The risk arising from servicing activity has several dimensions, with operational risk being the most obvious. Less clear, but often significant, is the market risk associated with this activity. This is discussed further in the "Risk Management" sub-section. The two other Lehman originators, BNC Mortgage and Finance America, originate subprime mortgages through a wholesale network and utilize third party servicing.

These platforms provide Lehman with a considerable advantage in intermediating between borrowers (mortgagees) and lenders (investors). Many of Lehman's peer firms source loans for securitization through purchases of large pools of whole loans from third-party originators, often commercial banks. As such, their primary tool for affecting the characteristics of the underlying collateral is indirectly through contact with the third party originators and eventually through pricing. At Lehman, the origination platform provides a direct mechanism to adjust the characteristics of the underlying collateral to suit investor demand. By having an early touch on the mortgage loans, Lehman can source exactly what is needed to support the securitizations and whole loan pools most in demand. Going the other way, the investor touch stemming from Lehman's strong distribution/capital markets franchise generates efficient loan pricing information for the originators. From a risk management perspective, this business model facilitates a faster and more efficiently priced pipeline, thus reducing the risk of getting stuck with unwanted loan pools or residuals. Some of Lehman's peer firms are now moving towards this type of vertically integrated model.

The pipeline nature of the prime and subprime businesses creates exposure to certain key risks. The primary risk stems from holding inventory. Changes in interest rates, housing prices, or rating agency methodologies may adversely affect the value of the loans which are being inventoried for eventual securitization or sale. In the prime space, Lehman seeks to hedge this risk using the to-be-announced (TBA) market where applicable, in an attempt to reduce the basis risk which otherwise would be incurred if Treasuries or swaps were used to hedge interest rate risk. For non-prime product, a mix of non-TBA hedges must be used, thus introducing more basis risk. In addition, Lehman often retains the risk on residual positions, including interest-only (IO) exposure and net interest margin (NIM) exposure, as well as servicing risk via ALS. In the subprime space, there is no robust TBA market (especially for ARMs and other hybrid products), thus Lehman must hedge with Treasuries and swaps and incur significant basis risk. To minimize this, the sales team tries to sell securities forward to the extent possible. The pipeline is fairly efficient, as the turnaround for a deal is generally less than 90 days.

The desk head emphasized that most of the value from the mortgage franchise resides in the intermediation/pipeline process. As such, there is not a twin "secondary trading" desk which takes discretionary proprietary bets on certain factors using loan and investor information generated by the pipeline business. Rather, the business is selective in the loans it sources—owning the originators helps here—which allows it to exploit market inefficiencies by engaging in the pipeline activity itself.

In a way, then, Lehman's model essentially substitutes operational risk for market risk. Instead of incurring market risk to generate excess returns through bets on rates or prepayments, Lehman incurs significant operational risk through the origination platforms in order to generate excess returns from the pipeline activity itself. To this

end, Lehman has a sizeable Mortgage Capital Division which focuses on managing the operational risk arising from the three originators.

As mentioned previously, an aggregation system called RAMP serves as the centralized infrastructure which supports the monitoring of mortgage trading risk exposures on a highly granular basis. The various front office trading systems feed into RAMP, which captures all desk positions and trades (real-time), computes all sensitivities and aggregates exposures (daily), and calculates the stress matrices used for non-linear risk measurement purposes (weekly). RAMP feeds into the risk systems used to calculate VaR, event risk, and Risk Appetite.

In addition to providing the standard sensitivities, RAMP also captures model risk. It provides “model” versus “trader” calculations for option adjusted durations and 10-year equivalent exposures by trade, by trader, by desk, by product, etc., and calculates the difference between the two. Finally, RAMP is also used to produce customized risk reports, e.g., for the hybrid pipelines.

### Risk Management

Within MRM, the VaR calculation sources the curve sensitivities from RAMP by the following risk factors: rate risk across four points on the yield curve, rates volatility, option adjusted spreads, and mortgage current coupon spreads over Treasuries.

Given the size of Lehman’s mortgage business, the mapping of mortgage exposures deserves specific discussion. Mortgage positions – e.g., in residential whole loans, mortgage backed securities (passthroughs), CMOs, and mortgage derivatives – expose the firm to various types of risk, most notably to interest rates, rate volatility, and convexity (prepayments). The mapping of interest rate and rate volatility exposures follows fairly standard methods. However, other mapping decisions are not so straightforward. For example, say Lehman senses investor demand for pools of Alt-A hybrids from the Mid-Atlantic region. The inventory which gets built up for eventual securitization exposes Lehman to market risk, and leads to the question of which benchmarks should the exposure get mapped to for VaR purposes. An insufficiently specific benchmark may lead to a misstatement of risk, especially when hedging activities are factored in. Prepayment risks can also pose a dilemma. The primary metric for prepayment risk, option-adjusted spread (OAS), is dependent on extensive modeling and at the desk level is finely calibrated to the underlying collateral. For VaR purposes, of course, the prepayment risk component must be mapped to a time series. This requires an assignment algorithm, conceptually similar in some respects to the bucketing by attributes for corporate bonds, whereby positions are mapped to OAS time series, such as a government agency issuance or home equity loan credit spread benchmarks.<sup>29</sup> Lehman utilizes a wide range of OAS time series, some of which are synthetically created, e.g., convexity-adjusted collateral-specific CMO OAS’s and collateral-specific non-agency OAS’s. The robustness of the VaR calculations for mortgages relies in part on the granularity, specificity and robustness of these benchmarks. Given that the greatest growth in mortgages has been in non-agency collateral – e.g., Alt-A, Jumbos, and sub-prime – OPSRA will follow-up on the quality control processes surrounding these mapping specifications and the maintenance of these time series.

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<sup>29</sup> Of course, the assignment of specific corporate bonds to particular buckets requires minimal parameterization, as the attributes such as tenor and rating are fairly obvious. By contrast, in the mortgage context, the assignment procedure is less clear cut and requires more subjective parameterization.

Sub-prime mortgage loans are also subject to default assumptions through the event risk charge. A stress is approximated by assuming a reduction (which can also be thought of as an increased haircut) in market value of the non-rated retained exposures. Lehman will stress any non-securitized residual positions currently on the books, and a portion of any whole loans. With whole loans, Lehman assumes that 4% of the capital structure qualifies as non-rated retained exposure. These residuals, or NIMs, will be subject to a 25%, or 25 basis point, charge. This is considered by MRM to be fairly punitive given the liquidity and high turnover in the market.<sup>30</sup>

#### iv. Municipals

##### Business Overview

The municipal group's activities at Lehman are a microcosm of the fixed income division in which it is housed: origination, syndication, high grade debt, high yield debt, derivatives, structured products, funding, mortgages, asset-backed, money market, and taxables. Across current and anticipated CSE firms, Lehman is the number one book runner for municipal debt (and third overall). Within municipals, 25% of revenue is driven by cash trading (high grade, high yield, and short term), 21% of the revenue is derivatives, 19% is structured products, 18% is origination, and 17% is proprietary trading (including client driven special situations). Municipals has a RA limit of \$200 million, with a usage of \$193 million.

Cash bond trading includes a wide range of products, such as general markets and long bonds (over 20 years). A unique aspect of trading municipals is that they essentially cannot be shorted, and one cannot borrow to buy the bonds, because the interest payments associated with borrowing to finance a tax-exempt position are not tax deductible. In general, each issuance tends to be unique, and therefore relatively illiquid on a stand-alone basis. The business often incurs significant basis risk. While trading the general markets, traders hedge through the use of 5, 10, and 30 year Treasury futures as well as Bond Market Association (BMA) swaps and options. In the zero coupon bond space, the market is not as active and positions tend to be smaller. The bonds trade from one to 50 years on the curve, and hedges include government futures along the curve and BMA swaps and options. Long bonds, going out 20 years or more, are all investment grade, tax-exempt, and with a coupon. They are hedged using Treasuries, municipal bond futures, LIBOR swap futures, BMA and LIBOR swaps. This business tends not to run much spread risk. The retail trading desk is relatively small, and seeks to provide liquidity for the high net worth franchise at Lehman. These trades are done in response to specific client inquiries. Lehman is very active in the high yield/taxable municipal trading sector, and is one of the primary market makers in this space. In the short term market, Lehman specializes in notes. The short term market tends to exhibit seasonality, notably in April when people pull out money to pay taxes, and again in September when corporations do the same. The municipals group also has a proprietary desk, which trades in such strategies as housing bonds and generic bonds.

The municipals derivatives group looks to help municipal issuers with asset and liability management, as well as reduce their borrowing costs. The most common derivatives used by municipal issuers are interest rate swaps, forward starting interest rate swaps, and swaptions. The tax-exempt status of municipalities makes it more efficient for them to issue floating rate debt, as inefficiencies in the market cause the

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<sup>30</sup> With respect to PC, 35% of the inventory is in Level 1. 64% is in Level 3, and 1% is classified as Level 4.

actual tax-exempt yield curve to be much higher than the implied tax-exempt yield curve at the long end of the market, making it expensive to issue fixed rate debt. The municipalities then swap out the floating rate debt in order to pay fixed. With interest rate swaps, the municipalities often receive a floating rate index. This index is generally the BMA index, a tax-exempt short term rate, or a set percentage of LIBOR. Terms range up to 40 years. The business stated that the Greeks tend to be relatively low, and do not approach limits set by the businesses to manage risk on a more micro basis. Lehman hedges these swaps in the interdealer market and sells Eurodollar futures to hedge the interest rate risk. With swaptions, clients often seek to monetize the value of the call option present in issued callable debt. The client sells a swaption to Lehman, with an exercise date equal to the callable date. To hedge, Lehman will again use the interdealer market and Eurodollar futures, and will also sell vanilla swaptions to offset the volatility risk produced by this trade. Lehman will also enter into synthetic floating rate debt swaps, where the issuer pays Lehman a variable rate such as BMA and Lehman pays a constant fixed rate. The rate risk is generally fully hedged, and these swaps tend to be more a story about counterparty credit risk.

Structured municipal derivative products include the tender option bond program, total return swaps, principal lending, and opportunistic situations. Total-return swaps are becoming increasingly common in the municipal space. Bond issuers tend to use them as synthetic refundings for existing bonds, and synthetic variable rate debt for primary market bonds, which allows issuers to achieve the economic equivalent of variable rate tax-exempt financing without many of the requirements of traditional variable rate debt. The risk focus on these tends to be in the counterparty credit space, as Lehman retains all of the credit risk on the issuer's bonds. Direct lending solutions, such as synthetic variable rate debt, allow issuers to borrow against unique forms of collateral, such as construction products. Lehman has a joint venture between the Real Estate Principal Transactions Group and the Municipal Structured Products which allows them to create customized structures.

### Risk Management

The drivers of VaR within municipals are interest rates, yield curve, swap spread curve, municipal market data (MMD) scales, BMA ratios, and swaption volatility. The municipal cash business drives most of the VaR, as it incurs basis risk by hedging municipals with Treasuries (municipals tend to lag Treasuries by a few days). In calculating the P&L vectors behind VaR, the linear components are derived from curve sensitivities, the swap spread, muni and BMA basis, and vega. The non-linear components depend on a stress matrix including interest rate and volatility moves. In addition to focusing on VaR, MRM looks at concentrations and various spread sensitivities. For the cash desk, MRM reports net interest rate risk, muni basis risk (the change in an instrument's present value due to one basis point change in the MMD muni scale), and notional concentrations on a daily basis. For derivatives, MRM reports net interest rate risk, swap spread risk, BMA basis, and vega on a daily basis. Municipal derivatives drive the counterparty charge, and the lower-rated municipals drive the event risk charge. Municipal products are subject to the following event risk: downgrade for A and above, and default for BBB and below. The municipal cash desk tends to drive the majority of event risk.

For certain positions within municipals, it is necessary to go beyond VaR and take a more qualitative perspective. A recent transaction that caused a breach of the municipal VaR limit provides an example of this type of trade. When the government sought to increase military housing stock, the Department of Defense privately placed

bonds.<sup>31</sup> Lehman approached the government about restructuring the trade to lower the cost of financing. They did this by working with the ratings agencies to develop a tranching structure, and then worked with Congress' appropriations committees to issue bonds publicly according to the results of these discussions. They were able to increase the proceeds while lowering the yield. Lehman did this by going to the holders of the older bonds and purchasing the original issuance, and underwriting a new issuance that was approximately 7% larger than the original deal. The deal took two months to restructure and then exit, during which time Lehman was fully hedged with interest rate swaps but was exposed to spread risk, benchmarked to a taxable index. As this deal caused municipals to breach its VaR limit, MRM ran marginal analysis and discussed the trade with the head of fixed income and the CRO. The head of fixed income approved the overage within fixed income, and the CRO approved the deal as it would not cause an overall fixed income VaR breach. This deal was noted on the top line risk report, which is presented weekly to the Executive Committee by the CRO.<sup>32</sup>

#### v. Equity Volatility (Equity Derivatives)

##### Business Overview

While Lehman has a significantly smaller presence in equities than in fixed income, the firm is looking to grow the business consistent with client demands. The recent decision to appoint Bart McDade, the former head of fixed incomes, as head of equities reflects this approach. Within equities, OPSRA reviewed the global volatility business. This business is allotted 50% of the RA allocation for the equity division. Equities volatility has a RA limit of \$225 million, with a usage of \$182 million.

The business trades in both listed and OTC products. Lehman is a major player in the synthetic convertible market, driven by long-only investors interested in gaining exposure to a specific sector or stock. The synthetic convertible is essentially a bond with a warrant, leaving Lehman with positions that are relatively easy to hedge.

Within equity volatility, customer driven trades contribute over 95% of the group's revenue. These trades fall into either the flow (listed options, vanilla OTCs) or structured (equity linked notes, synthetic convertibles) volatility categories. The products traded in the structured bucket tend to group around sets of customers. For example, hedge funds tend to buy synthetic convertibles, while insurance companies look to hedge their equity risk with equity swaps. While proprietary trading currently generates a small portion of the group's revenues, management hopes to build on this business and eventually have it contribute around 20% of the group's revenue. Within the proprietary business, Lehman does statistical arbitrage and trades on automated market making electronic options exchanges. Volatility arbitrage, where traders seek to capture pricing differentials between volatility levels of an index and of its component single stocks - so-called dispersion trading – formerly resided within this group but has recently been moved to the proprietary trading group within the equities division.

The equity volatility business heads noted three areas where risk management is the most challenging: capturing correlations, dispersion trades, and capturing the term structure of volatility and volatility skew. They also stated that they do not have a

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<sup>31</sup> This deal was also mentioned to OPSRA during a regular monthly risk meeting.

<sup>32</sup> With respect to PC, 51% of municipal's balance sheet is in the Level 1 category, consisting mainly of cash positions. 34% is in Level 3, consisting mainly of the derivatives positions. The remaining 15% is in Level 3. This consists mainly of interest rate swaps where options are tied to tax events – an option that is difficult to price verify.

strategic “long gamma” or “long vega” philosophy, an approach that would leave them protected against large movements in either direction. Instead, the business heads feel that they can successfully delta hedge their positions, and do not feel it necessary to adopt a strategy of paying for insurance, i.e. experiencing theta bleed in order to remain long gamma. Heavy trading in certain structured products may effectively impose a directional view, but that is usually a relatively transient phenomenon, as structured products tend to have a tangible lifespan.

## Risk Management

For MRM, overall risk exposures are measured by delta, gamma, vega, and theta. Key drivers for volatility VaR are stock prices and volatilities. Non-linear risks area captured through price/volatility stress matrices, stressing prices up and down 25%, and volatility points up and down 10%. The equity volatility group works with MRM to create a number of bespoke reports to capture less obvious risks.

This business also has an event risk component. Within equity derivatives, event risk tries to capture the discrepancy between the actual dividend and the assumed dividend used in the option pricing model (quantitative front-office programmers will price in dividends increasing at a given growth rate). The P&L impact of a 75% discrepancy for single-stock options or a 25% discrepancy for basket options in the assumed dividend used in the model is considered to be the event risk. The event risk charge makes up a significant portion of the business’ risk appetite usage.<sup>33</sup>

### vi. Global Real Estate Group

## Business Overview

The Global Real Estate Group (GREG) generally focuses on commercial real estate, including non-performing loans which are often backed by commercial real estate. The bulk of the real estate business at Lehman consists of originating and securitizing commercial real estate loans, though there is also sizeable principal investment activity and, more recently, bridge lending. Because of the absence of prepayment risk and the chunkier nature of the underlying loans, the business is much more credit-oriented than residential mortgages. The real estate group has an RA of \$500 million, with usage of \$411 million. The vast majority of risk in this business is event risk.

The pipeline business (i.e., the origination and securitization of commercial real estate loans) is the dominant business within GREG. On the origination side, this includes direct lending (fixed and floating rate commercial mortgage loans, lines of credit and term loans), conduit financing (for loans less than \$75 million), and whole loan purchases. Lehman then effectively warehouses this risk leading up to an exit, which typically takes the form of a securitization or loan syndication.<sup>34</sup> For fixed rate loan pools Lehman averages a securitization every six to eight weeks, resulting in seven to eight securitizations per year. The key risk mitigant is maintaining a short warehousing period. Lehman accomplishes this, in part, through a Large Loan Floating Rate

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<sup>33</sup> With respect to price verification, PC uses its own algorithm to determine a volatility surface. 52% of the business is considered to be Level 1, 25% is Level 3 and 23% is Level 34. Positions that have long-dated vega, with no observable point on the curve, are classified in Level 4.

<sup>34</sup> A large number of GREG staff are dedicated to commercial mortgage loan origination and underwriting. The underwriting criteria are based heavily upon rating agency credit support criteria.

Securitization Program which is a joint venture with UBS. To hedge the warehouse risk, Lehman effectively replicates a securitization with the existing inventory at any given time and hedges both the rate and spread risk. Approximately 20-30% of the spread risk is hedged using total return swaps, which are relatively expensive and short-dated. There are also plans to potentially use a Lehman CMBS default swap index product which is currently under development. OPSRA will follow up on this initiative, as the ability to effectively short CMBS may facilitate greater capacity to for this business, which is structurally long CMBS. Lehman also has a surveillance group which monitors in real time the credit conditions of the underlying collateral (defaults, vacancy rates, etc.).

In addition to the pipeline business, through the Principal Transaction Group (PTG) Lehman makes strategic equity investments in commercial real estate. Lehman has also set up commercial real estate-focused private equity fund structures with co-investors.<sup>35</sup> These equity investments are longer term (two to three years) and are relatively illiquid. For the PTG investments, the primary risk management concern revolves around cash control and recourse in the case of default. For the private equity investments, the primary risk flows from the special servicers who are retained as asset managers. As noted above, more recently Lehman has engaged in bridge equity investing where Lehman's equity investment in a property is taken out by another equity investment or debt.

On the secondary trading side, Lehman trades to facilitate customer flow, but does so primarily to glean market information, not necessarily to make markets and earn a spread or to take proprietary positions. Lehman also engages in a wide range of investment bank-type activities in this space, such as real estate investment trust IPO underwriting.

## Risk Management

Rate and spread risk are the dominant market risks in the pipeline business. Curve sensitivities are bucketed by maturity. For loan inventory, spread sensitivities are estimated and mapped against a composite CMBS time series based on recent securitizations. Concentration risk (i.e., specific or basis risk) can be quite significant given the large size of many exposures, e.g., \$500 million to a single property. This concentration risk is not captured in VaR, but is monitored by MRM. The risk manager responsible for real estate cited an example of a \$900 million exposure to a single property, and stated that in order to mitigate the concentration risk, the property was being put into three deals. This allowed the business to quickly securitize at least \$300 million of the exposure. The risk manager also explained that on average, a securitization occurs every six weeks. He cited this regular turnover as one of the primary risk mitigants for concentrated positions. For secondary CMBS securities, spread sensitivities are estimated and mapped to CMBS spread index curves bucketed by rating, maturity, etc. These metrics are calculated in the front office systems and fed up to the MRM risk systems for VaR calculation purposes as for other businesses.

The event risk for the Real Estate desk is quite high. The measured event risk was \$345 million (easily the highest of all of the desks), compared with a \$115 million market risk measure. To put these numbers in context, the total measured event risk for the firm as a whole was \$449 million. For real estate and related loans, the stress is only applied to principal transactions, and not to collateralized mortgage backed

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<sup>35</sup> In 2001, Lehman established its first real estate equity fund. The second such fund was expected to close in May 2005 (\$2.3 billion). A mezzanine loan fund was expected to closely shortly thereafter (\$1 billion).

securities. With non-performing loans, the underlying name will be stressed. The measurement is the capital value loss due to a real estate downturn, and is therefore looking at a very long-term loss. Lehman uses a "historical simulation" approach to determine the P&L impact, by revaluing each property. The market value of the property is multiplied by the historical times series of property value changes, then senior debt is subtracted (if applicable), and finally the Lehman Loan mark-to-market basis (which determines the existence of a loss) is subtracted. This results in a simulated P&L distribution for each loan. Losses across property types are aggregated within a region, assuming perfect correlation. Losses across regions are then aggregated assuming zero correlation between regions, and a joint probability distribution, similar to the methodology found in high grade credit, is used to determine overall losses at the desired confidence level. Collateral concentrations, such as malls or hotels, are not specified in the event risk stresses, even though this risk may at times be significant (e.g., with hotels after 9/11).<sup>36</sup>

#### vii. Risk Arbitrage

##### Business Overview

While Lehman takes proprietary positions within both its equities and fixed income divisions, there is also a standalone group dedicated to proprietary risk taking. While formally called Risk Arbitrage, this group has a scope beyond what its name might imply. Risk Arbitrage has been given a risk appetite of \$450 million, equivalent to the RA limit for the entire equity business. Current usage is \$278 billion. Balance sheet usage for the group is provided by the firm, i.e., there are no outside investors. The group of 31 employees is housed in a physically isolated area from Lehman's customer businesses.

Risk Arbitrage trades within six strategies, all of which utilize a research fundamentals approach: long/short fundamental equity, merger arbitrage, distressed securities, special situations (investing in companies subject to corporate restructurings, stock buybacks, bond upgrades, and earning surprises for a period of years rather than months), convertible arbitrage, and privately structured transactions (both in public entities and private equity investments). Their biggest positions are held through high yield instruments (used in more than one strategy), long/short plays, and merger arbitrage. The group moves in and out of areas opportunistically, based on market dynamics. For example, they briefly entered the credit trading space during the turmoil surrounding the downgrades of General Motors and Ford debt. This group tends to hold

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<sup>36</sup> With respect to PC, all of the positions in Real Estate are classified as Level 3 or Level 4 – i.e., there are no direct external price quotes (Level 1) for any of the positions. As such, the product controllers must interact often with the traders and servicers to verify prices. For equity investments, PC usually get monthly data (the "tape") from servicers. They compare that with interpolated spread data, information from the trading desks, etc. For loans, floating rate loans are priced off a matrix (current spread vs. loan-to-value (LTV) by property type). For fixed rate loans, prices are based upon a "mock securitization" based on Lehman's models. CMBS securities are valued using a spread matrix and Bloomberg's Yield Table function. Mezzanine and B notes are priced using a theoretical shadow rating based upon LTVs, which serves as a basis for determining the spread. Real estate investment trust letters of credit and term loans are priced similarly. Real estate price verification uses a mix of external published data (e.g., CMBS spreads) and pricing tools such as Bloomberg's yield table or internally-generated pricing grids. For exposures lower in the capital structure, PC use a "shadow rating" based on LTVs to interpolate spreads and then price using a net present value analysis. A good portion of the pricing for real estate relies upon data supplied by servicers. PC noted that last year there were 180 deals realized, providing numerous chances to "backtest" the data supplied by servicers. They feel that servicer-supplied data integrity is fairly high.

investments over a longer time horizon, leading to lower trading P&L than might be found within a flow business.

Risk Arbitrage monitors their portfolio two to three times a day on a more micro basis and seeks to manage idiosyncratic exposure, as they do not care to have general market exposures. They generally have exposure to 300-350 names at a time, and they also monitor names not yet in the book. The majority of their risk is within the equity space, and they tend to use very liquid hedges. The business heads stated that their use of options is primarily for risk management rather than leverage.

## Risk Management

Risk Arbitrage has a dedicated market risk manager who is physically located with the group, in order to facilitate maximum interactions with the business. Market risk, as measured by VaR, arises mostly from market moves in the equity and distressed high-yield spaces. The group also incurs event risk, from security downgrades for high grade, defaults for high yield, and deal break risk for merger arbitrage. To calculate the deal break risk for merger arbitrage, target and acquirer are assumed to experience the reverse of percentage price movements at the time of the deal announcement, i.e. the target price drops and the acquirer price rises. The probability of a deal break is calculated by assuming that the current target price is the expected value of the deal complete value and the deal break value. This methodology is considered by MRM to be more objective than the desk prediction. Events across different merger and arbitrage deals are assumed to be independent, and the portfolio loss distribution is calculated using a binomial probability distribution. Of these three categories, most event risk arises from defaults for high yield positions. Some securities held by Risk Arbitrage have already defaulted, and in these cases MRM looks at the uncertainty in the traded price, and the uncertainty of recovery in determining event risk. It is worth noting that this measure of event risk is biased towards long bond positions, as it does not account for bond upgrades, which would create losses if the group were to be short securities. Risk Arbitrage and MRM stated that the group currently has few short positions, but this is an area warranting further discussion.<sup>37</sup>

### d. Control Processes

#### i. Price Verification

PC performs formal price validation on a monthly basis to ensure that the inventory is marked to market and "fair valued". PC verifies market or fair value for cash instruments and listed derivatives by utilizing vendor prices, broker quotes, exchange prices or similar instruments. To the extent that valuation adjustments are required to arrive at fair value, PC is responsible for ensuring that the marking follows Lehman's formal valuation adjustment policies.

In April 2005, Lehman adopted an adapted version of FASB's fair value hierarchy. Level 1 estimates of fair value are obtained from quoted prices in active reference markets of identical assets or liabilities. Where Level 1 cannot be applied, Level 2 applies and fair value is determined by quoted prices for "similar assets or

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<sup>37</sup> With respect to PC, the employee in charge of Risk Arbitrage does not work with any other capital markets groups, so as to maintain independence. 90% of the portfolio is screen priced, or Level 1, and the rest is verified through external quotes. 1 to 2% of the portfolio consists of private equity, and PC goes to the investment management desk to get marks for these positions.

liabilities” adjusted for “objectively determinable” differences. Lehman has elected not to price verify using the Level 2 criteria. Where quoted prices on similar assets or liabilities are not available, Level 3 applies, which relies upon quote prices for similar assets or liabilities in active reference markets or model-based valuation techniques. For model-based valuations, the focus for Level 3 pricing is on the “relevance and reliability” of the inputs to the models. Those positions which cannot be valued under the Level 3 criteria then fall into Level 4, which Lehman defines as using “hypothetical market prices replicated using entity inputs as a practical expedient.” PC described several examples of products in each level. In general, PC only price verifies positions over a certain value, e.g., cash positions greater than \$1 million market value for corporate credit. This results in less than total coverage, although OPSRA was told that coverage is generally greater than 90%. Most of the coverage cut-offs are in market value terms, presumably because they are easy to set and implement.<sup>38</sup>

For each product, there is a variance threshold which serves as a trigger for more detailed and documented investigation. For example, the variance threshold for corporate credit is \$250,000 and 5% of market value. Positions which after getting independently priced verified by PC exhibit differences from the traders’ marks greater than the threshold variance get highlighted for further review and potential adjustment. Variances are discussed initially by the product controller and the individual trader. Any issues remaining unresolved are brought to the attention of the desk head, and, if necessary, to the head of PC and the head of the business.

In addition to verifying traders’ marks, PC verifies the actual positions – i.e., makes sure that the positions in a trader’s books, used to generate the risk reports, are the same as the positions in the general ledger. As the aggregate market risk metrics such as VaR are dependent on the position information provided by the front office systems, MRM depends on the accuracy of these numbers.

## ii. Profit and Loss Attribution Process

PC analytically reviews the P&L and positions on a daily basis and provides explanations for large movements. Through this process, they work in partnership with risk management to ensure accurate reporting and analysis of risk. From a market risk control perspective, the P&L explain process provides a way to check the accuracy and robustness of the pricing models and the risk sensitivities which the business units and MRM use to calculate and monitor risk. The central idea behind the P&L explain process is that P&L should be decomposable into discrete components (e.g., commissions versus principal). This permits the desks and risk managers to assess what is driving the P&L. By matching up risk sensitivities with market movements, they can estimate ex-ante the profit or loss for a desk and compare that to the “actual” P&L ex-post. Insofar there are material differences between the two, traders, risk managers, and controllers can focus on this unexplained portion. Unexplained P&L acts as a warning flag to risk managers and trading desk heads, signaling the existence of a problem such as poor capture of data, mismarking of a position by a trader, or model failure.

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<sup>38</sup> PC walked OPSRA through several examples, including the verification of the TIPS inflation book within interest rate derivatives (a Level 1 product). They also gave an example of a bond option for an emerging market sovereign (Level 3). Within equities, they demonstrated how an option considered to be Level 3 is priced, using a volatility, spot price, and dividend test. For Level 4, PC discussed the price verification of a synthetic CDO, using data from MarkIT partners, and the price verification of a single family unit development housed within the real estate group.

Daily P&L on a position by position basis for the cash businesses is calculated by the middle office. For the derivatives business, PC (rather than the middle office) owns the entire P&L process, as they tend to have employees with a skill set better suited to explaining P&L arising from derivatives. Data flows from the front-end source systems into three reporting systems (configured for different types of products): GQuest, PALS, and GEDS. Any adjustments are made in these systems, and the numbers then flow into the general ledger.

The process is divided into three parts: the trade date estimation, the trade date + 1 P&L production which has reconciliation and analysis, and reporting, where results are aggregated and disseminated to senior management.

To perform trade date estimation, traders mark-to-market inventory positions and the front end systems then generate revenue estimates. PC receives these estimates and reviews them for reasonableness relative to market movements. Large items are scrutinized more carefully to ensure that the estimations are valid. Estimates, along with PC commentary, are consolidated and distributed to senior business and finance management. For a relatively straightforward business such as equity cash trading, the estimate will be ready around 4:15 PM and is not likely to change significantly the next day.

For cash products, the trade date +1 process is primarily owned by the middle office. This is very automated, involving high volumes and heavy reliance on systems. The middle office ensures that trades are booked correctly and trader mark-to-markets are processed correctly. They will reconcile within GQuest, and PC will then review the output in order to make any necessary adjustments. Once analysis is completed, PC delivers P&L to the front office, summarizing the results within the Highlights System and distributing them to senior management. As mentioned above, for derivatives PC owns the entire P&L process. For fixed income, PC physically delivers the reports from IRIS (the engine feeding LehmanRisk) by 8:15 AM the next day. Within equities, traders view their risk from the front office systems directly. PC also uses the risk reports from IRIS to calculate spread P&L for fixed income derivatives. The middle office is responsible for the actual position reconciliation of front to back office derivatives systems. When all booking issues have been resolved, PC will make any necessary adjustments. Upon finalizing adjustments, PC compiles and explains the results using PALS and GEDS. Within both of these systems, PC can provide a risk-based explanation of P&L using the greeks (e.g., delta and gamma). PC then reconciles the risk-based P&L explain to the accounting P&L to make sure the actual results can be explained through the risk factors. They resolve any mismatches by speaking with traders, MRM, or quantitative research. As with cash products, upon completing the explain, PC delivers the final P&L (i.e., the actual accounting numbers with risk-based explanation) to the front office, where upon approval, it is input in to the Highlights System.

In addition to PC, the Capital Markets technology group (MIS) has a role in the daily P&L process. They occupy a quality control role in regards to the data, ensuring that P&L results (estimates and actual) have been fully populated by PC, checking to ensure that comment fields are populated, and reconciling estimates to actual results and obtaining explanations from PC. They also aggregate the results (both same-day estimates and trade date +1 final results) from PC and consolidate the information at a division level.<sup>39</sup>

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<sup>39</sup> Lehman PC went over several examples of P&L verification with OPSRA. The first involved a trade date equities recap, which highlighted large P&L movements and contained explanatory comments written by the controllers. PC also walked through a P&L report for municipal cash bonds. Finally, PC discussed a P&L report covering interest rate products, and then a P&L summary, from the same day, for the entire fixed income division. This allowed OPSRA to understand how P&L is aggregated up to the division level.

### iii. Model Control

The model control framework is owned by QRM, where the head of Model Control reports directly to the head of QRM. The framework is a recent initiative at Lehman and leverages off of the business units' model developers in implementing the model control framework, requiring them to perform much of the testing and validation that was previously done within QRM.

As currently structured, model control responsibilities rest with three broad groups: Business units (e.g., Quantitative Research (QR), Analytics and front office technology), QRM, and PC. The business units are central in many respects and bear the most responsibility, as the ultimate "ownership" of a model resides with the business. QR, which reports to a business head but is independent of the trading hierarchy, has the initial responsibilities: developing, implementing, testing and fully documenting the models. QR is also charged with populating and maintaining the model inventory/library and tracking model usage and compiling related statistics, functions that at other firms tend to fall under an independent model validation team such as the one in QRM. QRM stressed the importance of the peer review process, which occurs within QR, in the model control framework. The head of QR described this process as a weekly phone call within defined product areas (e.g., mortgages and interest rates). OPSRA was not able to ascertain the depth of this peer review process, and will follow up with both QR and QRM to understand how exactly the peer review fits into the framework. Most importantly, after its initial responsibilities have been fulfilled, QR has temporary approval authority for both QR-developed models as well as trader-developed bespoke spreadsheet models. In other words, trades cannot be booked on a model which does not have QR-approval. Analytics and technology (within each business) are responsible for model implementation, i.e., maintenance control of the computer code, implementing regression tests, and providing notification of code changes and releases.

A typical sequence within the Model Control framework is as follows. Initial approval comes from QR. This is considered to be "temporary" approval. Along with temporary approval, QR may place restrictions, such as limits on volumes or number of trades to be priced by the model. Additionally, PC may require valuation adjustments on temporarily approved models. A model is considered to be "fully approved" only when they have approvals from the business unit, QRM and PC. Limits may be placed at this stage as well. OPSRA was told that the time taken for a model to graduate from temporary to full approval varies considerably, according to the model's complexity. As a general rule of thumb, equity models tended to be modest variations on already approved models and quickly addressed while fixed income models were more complex and took longer. A standard documentation template is required, so that the documentation for each model must address each of the required elements.

In principle, QRM has a broad range of responsibilities with regards to the framework: model review/validation, providing guidance to PC on model-related matters, and most importantly, ultimate approval authority (along with PC). In practice, QRM's role is expected to be more limited. OPSRA understands that QRM will diligently monitor the flow and pipeline of new models approved by the businesses, and will review developer-supplied documentation for compliance with standards prescribed by the Model Control framework. QRM is unlikely to be doing detailed model review/validation, relying instead on the QR peer review process. QRM does not plan to conduct formal evaluations of each model's theoretical framework or the model assumptions, or the issues arising from the choice of a particular numerical implementation (e.g., stability/error of prices, sensitivities). Rather, it will focus on issues related to calibration and propriety of inputs. It is unclear to what extent QRM will be assessing the suitability

of a model for its intended usage. QRM may develop a metric of model risk based on the sensitivity of a model to unobservable inputs.

PC was also presented as being a key participant in the Model Control framework, via their responsibilities of price verification of model input parameters, reviewing model suitability for transactions as per model documentation and risk management guidance; and assessing and approving model valuation adjustments. PC is well-situated to detect misuses of a model. For example, if a trader chose to mark a trade using a model not approved for that trade, this may be detected when PC price-verifies the trade using the approved model for that trade. Likewise, if the trader marks to an unapproved model, and this model's sensitivities are different from that of the approved model, this may show up in the daily P&L explain.

A Model Control Committee has been formed to provide a forum for discussions of issues related to model control. It does not have approval authority. It is chaired by the business unit and members include senior representatives from QR, Analytics, QRM, PC and Technology; other guests may be invited as appropriate. The committee has scheduled meetings every month and may meet on an "extraordinary" basis as well.

During discussions with OPSRA, QRM focused on valuation models, i.e., those used by traders for marking their books and by PC during the price verification process. Other types of models/methodologies may be subject, in some form or the other, to some components of the Model Control framework. Documentation received by OPSRA indicates that the VaR and MPE methodologies will be reviewed by the model control group.

Currently, the new process is in place only for the equity division. In this area, models tend to be more compact and formulaic, with many bespoke adjustments to basic pricing models. Key aspects of the process include regular monthly Model Control Committee meetings; development of a complete and measurable model inventory and an approval process with automatic notification and full audit trail. The inventory contains details on the approval status, the volumes/risks of each model (weekly report), daily report on lists of models with temporary approval, and PC-required reserves for models with temporary approval. The Model Control Committee uses this inventory report to prioritize reviews and re-reviews. The framework is not yet formally in place for fixed income. Here, the models tend to be much more complex, especially within credit derivatives, and operate within a broader framework. Development time is significantly longer than in equities. The model validation groups are generally involved from the outset when a new fixed income model is developed, and by the time the model is complete QRM should be in a position to readily evaluate the model. In the interim, there exists a set of "primary controls" and "detection controls." The framework is meant to apply globally, consistent across legal entities, geographic regions and trading desks.

Based on OPSRA's assessment of the framework, it appears that QRM is taking a risk-based approach to model validation and that much of the independent model control process resides within PC. The head of QRM observed that the bulk of trades are booked on models that have been extensively time-tested, and associated model risk is quite low. As an example, he cited the Black-Scholes model used within equity derivatives. Lehman asserted that the proportion of "exotic" trades, booked on models where model risk might be higher, is quite low. A risk-based approach would imply that QRM spends the majority of their time on the models generating the greatest amount of calculation risk and linked to the most material exposures, measured either by VaR or RA usage. That said, it is unclear how models that may be less material in terms of generating high measures of risk, but incur significant amounts of model risk (e.g. by incorporating inputs such as correlation skew that are difficult to capture and subsequently validate), are prioritized for review. In addition, there is minimal

documentation formalizing their approach, and there are no measures, such as risk-based model ratings, that would also lend a degree of formality to the process. OPSRA will continue its discussions with QRM about the new model control framework, and its ability to develop a system that ensures models used for pricing products within Equities and Fixed Income are validated in a thorough and timely fashion.

### III. Credit risk management

#### a. Overview of Businesses Generating Credit Risk

This section of the report discusses the risk infrastructure surrounding CRM. This includes two of the more important tools used by CRM, the MPE metric and the Internal Credit Rating (ICR) scorecards; the limit and permissioning procedures; and credit systems. This section also details businesses with significant credit risk. Lehman's credit-risk generating activities include a large and sometimes chunky leveraged lending business, smaller but significant relationship and warehouse lending businesses, a broad OTC derivatives and financing business, and a growing prime brokerage franchise.

The Leveraged Finance business is a significant source of Lehman's overall credit risk. The group offers clients without ratings or with debt ratings at loan closing of BB+ or below financing solutions including high yield bond, leveraged loan, bridge financing and/or mezzanine debt products. In 2004, Lehman was ranked seventh in the league tables for US leveraged loan book runners with a volume of \$13.0 billion on 62 deals. This area commands a significant amount of attention from the CRO and from senior management of the firm due to the large and lumpy nature of the transactions.

More recently, Lehman has moved into the investment grade loan space in response to clients' desires to consolidate investment banking relationships within one firm. They are now a major player in this loan market. One of the products Lehman offers is loans to investment grade clients that are generally unprofitable on a standalone basis in order to perpetuate an existing relationship or to strengthen a growing relationship. These loans typically take the form of commercial paper backstops or general revolvers. Currently, Lehman has 264 loans outstanding to 145 clients with \$10.7 billion committed and \$1.1 billion drawn.

Lehman's warehouse lending business provides short-term secured financing to residential mortgage banking counterparties to finance originations or acquisitions of residential mortgage loans. Although this business is profitable on a standalone basis, these facilities are generally extended in order to promote other activities, namely to ensure a source of underlying whole loans for the securitization business. Lehman currently has warehouse lending facilities with 14 counterparties representing total commitments of \$4.6 billion, with roughly 50-60% of the total commitments funded at any given time.

The OTC Derivatives, Securities Lending, and Repos businesses include a wide breadth of underlying products that generate credit risk. The counterparty current exposure (CE) as of 2/25/05 across products was \$24.4 billion. The largest single product category generating CE was Fixed Income Derivatives, with a CE of \$7.4 billion.<sup>40</sup> Large current exposures were also generated in Equity Finance<sup>41</sup> with a CE of

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<sup>40</sup> This includes Plain Vanilla Swaps, Exotic Swaps, Default Swaps, Fixed Income Options, Corporate Bond Options, Total Return Swaps, FX, EMG Options, and CDO trades.

<sup>41</sup> This includes Stock Borrow vs Stock/Cash Lending trades.

\$6.2 billion, and in Fixed Income Finance<sup>42</sup> with a CE of \$3.2 billion. Other products generating current exposure include Foreign Exchange Derivatives (CE \$1.0 billion), Equity Derivatives (CE \$590 million), and Forward/Outright trades where the underlying can be convertible bonds, corporate bonds, equities, euros, EMG securities, governments, or mortgage backed securities (CE \$410 million).<sup>43</sup> In addition to CE, these products generate significant potential exposure as discussed below.

The prime brokerage businesses, which provides securities lending services and extends secured financing (via margin loans) to hedge funds, is also a material source of credit risk. While these activities are fully collateralized on a daily basis, this business does create potential exposure stemming from the possibility that daily market movements will eat through the equity in the counterparty accounts. The prime brokerage business is currently small relative to other securities firms, but this is an area Lehman plans to grow. As of May 2005, the aggregate gross market value of counterparties' positions was approximately \$83 billion (\$48 million long and \$35 million short), the total loan amount was \$24 billion, and the Net Potential Exposure (defined as VaR minus equity) was \$30 million.

b. Tools

i. Potential Exposure Modeling

As a result of its OTC derivatives trading, financing transactions (e.g., repos) and prime brokerage activity, Lehman bears credit risk arising from the possibility that a counterparty will default at a time when the termination value of outstanding trades is in Lehman's favor, or when the collateral held by Lehman is worth less than the amount lent against that collateral. CE is used to represent Lehman's loss were such a counterparty to default today, assuming zero recovery of unsecured exposure. CEs may change substantially over time, not only from new transactions, but purely as a function of movements in markets. For instance, two parties may enter into an interest rate swap today, at the market (expected present discounted value of the floating leg and fixed leg payments are equal), so that the CE to both is zero. However, depending on how rates evolve over time, the contract's value could change substantially so that one party is bearing substantial credit risk with respect to the other. Thus in risk managing derivatives and financing activities, securities firms must concern themselves not only with CE, but with future PE as well. PE models provide probabilistic estimates of how CE may evolve over time as a function of market movements. At Lehman, PE is the primary tool by which counterparty trading risk is managed and also serves as a critical input into the RA usage calculation.

The CE with respect to a particular counterparty is simply the MTM value of the portfolio, or portfolio replacement cost, taking into account netting and collateral. If netting is allowed, positive and negative transaction level MTM values can be added to calculate counterparty level CE. In the absence of netting, the current exposure comprises the sum of only positive marks. Thus without netting the fear is that, in the event of default, Lehman might have to make the defaulting counterparty whole for its

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<sup>42</sup> This includes Bonds Borrow/Lending vs Cash, Dollar Rolls, Bonds Borrow/Lending; Repurchase/Reverse Repurchase Agreements; and Gentan Repo trades.

<sup>43</sup> In addition, deposits to banks or investments in Global Money Market funds generate a CE of \$5.6 billion.

(the counterparty's) positively valued trades while separately seeking compensation for the trades that have positive value from Lehman's perspective.<sup>44</sup>

To model PE is essentially to model the forecast distribution of the value of a counterparty's portfolio, taking into account the applicable collateral terms. A single PE metric serves as an estimate or forecast of what the CE for a portfolio will be in the future. However, for each point in time - e.g., three months or six months from today, there is an entire forecast distribution of possible CE outcomes. For instance, there is a three month expected/mean outcome, a 5<sup>th</sup> percentile outcome, a 95<sup>th</sup> percentile outcome, and so on. The primary PE metrics used at Lehman are (in Lehman parlance):

- *Potential Exposure (PE)* – Refers generically to a CE forecast, or to an entire CE forecast distribution, but not to any particular point on the distribution. PE is always modeled to take into account netting terms but not upfront collateral and/or variation margining. Variation margining refers to additional collateral (beyond the upfront collateral) posted in response to decreases in the value of the portfolio, and is discussed further below.
- *Effective Potential Exposure (EPE)* – The PE after accounting for margining.
- *Maximum Potential Exposure (MPE)* – The 95<sup>th</sup> percentile PE. MPE is a curve over time - i.e., there is three month MPE, six month MPE, and so on.
- *Expected Exposure (EE)* – The mean PE. EE is also a curve over time.
- *Peak Potential Exposure (PPE)* – The peak point on the MPE curve. For instance, the two-year MPE might be the greatest MPE, making it the PPE.
- *Effective Peak Potential Exposure (EPPE)* – The PPE after accounting for margining terms.

A robust PE framework should somehow capture the mitigating impacts of margin agreements. With a margin agreement in place, counterparties are required to post additional collateral if, following market movements, the portfolio replacement cost exceeds a specified unsecured threshold.<sup>45</sup> Thus variation margining requires the modeler to consider the fact that the forecasted CEs will be continually pulled back towards this unsecured threshold amount.<sup>46</sup> In other words, if a CE exceeds the unsecured threshold, the risk horizon for which the CE could continue to grow past that excession is limited, since the portfolio would eventually either be re-collateralized or closed-out.<sup>47</sup> For the vast majority of Lehman counterparties, margin calls can occur daily and delivery is the next business day. However, a cure period of two weeks is allowed to reflect a dispute resolution time. Thus the total risk horizon modeled for counterparties with margin agreements is typically two weeks.

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<sup>44</sup> With netting:  $CE = \max(V_1 + V_2 + \dots + V_n, 0)$   
Without netting:  $CE = \max(V_1, 0) + \max(V_2, 0) + \dots + \max(V_n, 0)$

<sup>45</sup> For example, if Lehman has an in-the-money swap position with counterparty xyz with a value of \$1 million (meaning xyz would have to pay Lehman \$1 million to walk away from the trade), and xyz has posted \$800,000 in cash collateral to Lehman, the unsecured amount is \$200,000.

<sup>46</sup> Typically with variation margining a minimum transfer amount is specified, which requires some minimum change in value for collateral to be called (which avoids "nuisance" calls).

<sup>47</sup> In order to take variation margin into account, collateral flows must be modeled as the CE drifts across these unsecured threshold (plus minimum transfer amount) boundaries. This causes EPE to become path dependent - i.e., simply knowing the forecasted CE is not sufficient for modeling collateral flows, but also the path by which CE arrived at its forecasted value.

In order to estimate PE distributions, future values for the risk factors that determine the values of the portfolio's instruments must be modeled. This can be accomplished using various broad statistical approaches, and at large banks and securities firms is often achieved through Monte Carlo simulation. This type of framework involves the modeler using market price and/or historical risk factor data, along with certain statistical assumptions, to specify the joint stochastic process that describes the evolution of risk factor movements over time and then using random number generation technology to generate hypothetical future states of the world. Other statistical approaches to modeling risk factor distributions include HistSim and VCV. HistSim involves using actual historical movements in risk factors and applying those movements to the current risk factor values to generate the forecast risk factor and PE distributions. A VCV approach allows the modeler to identify specific points on the PE distributions (e.g., the 95<sup>th</sup> percentiles) without estimating the entire distributions. Such a computationally convenient approach involves reliance on a statistical assumption of the joint normality of the risk factor distributions and thus normality of the PE distribution being modeled. Under such a normality assumption, only estimates for the risk factor volatilities and correlations are required to obtain these PE distribution point estimates. Lehman actually utilizes all of the above statistical approaches, with the approach varying by product type. In addition, for credit derivatives Lehman uses a stress testing approach. Below we briefly describe and assess the PE approach taken by product type.

#### *Fixed Income and Foreign Exchange Derivatives*

For over 99% of FX and approximately 90% of fixed income products a Monte Carlo simulation is used for modeling PE. QRM uses 1,000 simulation paths in estimating the PE distributions. While this tends towards the lower range of the typical number of paths used for PE purposes, QRM asserts this specification is appropriate given the additional computational costs that would be incurred versus the amount of benefit (in terms of decreased simulation error) that would be reaped by increasing the number of paths.<sup>48</sup> The PE term structures are modeled out to a 30 year horizon, with all exposures discounted back to current dollars. While not all firms express PEs in terms of current dollars, QRM argues this is desirable from the credit analysts' perspective since they think in terms of current dollars for permissioning trading levels across the exposure maturity term structure. Another advantage in expressing PE in current dollars is that within the context of RA, PE is aggregated with VaR and Event Risk, which are both denominated in current dollars. There are over 100 maturity points modeled with much of the granularity in the first year. Variation margin is dynamically modeled within the simulation to produce EPE. Further, the model captures the aging of portfolio - collateral roll-off, trade expirations, option exercises, etc.

Fixed income and FX risk factors/products are modeled within a single simulation. In doing so, interest and exchange rates are modeled as uncorrelated, where FX rates are assumed to follow a multivariate lognormal distribution (correlated with one another) that is independent from the interest rate generating processes.<sup>49</sup> For interest rates, an arbitrage-free two factor model calibrated to yield-curve, swaption, and cap volatilities is used.

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<sup>48</sup> OPSRA staff will further investigate this issue in the future as progress is made towards developing and implementing PE validation techniques, as discussed below.

<sup>49</sup> With the caveat that the drifts applied to the FX distributions are calibrated to the differential of the interest rates (short rates) of the currencies in question, based on a model of uncovered interest rate parity.

QRM takes a “risk neutral” approach to the parameterization of the risk factor distributions used in the simulation model. In short, this involves applying risk free rates of drifts (or expected values) to the risk factor distributions, rather than calibrating distributions to historical drifts. Such an approach can result in substantially lower exposure estimates, especially for longer maturity transactions in non-margined portfolios, as compared to alternative “econometric” or “real world” modeling approaches. Often risk neutral risk model frameworks involve calibrating additional distributional parameters (namely volatilities) to price curves, such as forward curves and implied volatilities, rather than from historical risk factor data.<sup>50</sup> However, where price data are lacking, historical volatilities, etc. may be used. Furthermore, correlations are typically measured empirically as market implied correlation parameters are not available for most factors.

As there is clearly no consensus amongst practitioners and academics alike as to what the best approach is, OPSRA staff are somewhat agnostic regarding this real world versus risk neutral PE debate. Each approach has its advantages as well as disadvantages. For instance, an argument in favor for the risk neutral approach is that it is more of a forward looking calibration, using the market’s view on distributional parameters rather than simply assuming history will repeat itself. In addition, QRM asserts that using risk neutral scenarios is computationally efficient since the re-pricing of instruments in the face of risk factor movements is performed using risk-neutral distributions. Alternatively, empirical evidence suggests certain risk factors, such as equity returns, exhibit expected values above that of the risk free rate of return, particularly over longer horizons. Going forward, we intend to examine the techniques/processes QRM develops internally, discussed further below, to validate empirically with these PE model outputs.

For the 10% of fixed income and 1% of FX transactions not modeled in the simulation, which are the more exotic/complex transactions, proxy instrument PEs are used or conservative “risk factor add ons” are applied. The add-ons involve the use of a pre-simulated grid of generic trade PPEs. The non-modeled trade is matched to a generic trade based on notional amount, maturity, currency, etc. The PPE of the non-modeled trade is applied to the portfolio. This is conservative in the sense that the highest peak exposure is used to represent the non-modeled trade’s entire MPE curve and add-ons are simply added to other portfolio exposures regardless of potential diversification benefits or long/short offsets.

### *Equity Derivatives*

For equity derivatives, approximately 80% of trades are modeled using a modified version of the historical simulation VaR model. Approximately 20% of trades, including exotic options and baskets are modeled using a VCV VaR model. For less than 1% of the trades, add-ons are used. For non-margined portfolios (30% of trades), the MPE profile is estimated by scaling up the 1-day VaR by the square root of time to the various PE term maturities and adding the current portfolio MTM value. For margined portfolios, the VaR is scaled up according to the risk horizon (again, usually two weeks) and added to the unsecured threshold and minimum transfer amount.

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<sup>50</sup> For instance, if a modeler requires an estimate of the expected volatility of returns for Lehman Brothers common equity, one approach might be to compute and use the historical volatility of returns. Alternatively, one could observe volatilities implied from Lehman equity option prices and use those as the market’s consensus of the expected volatility.

It is important to note that simply scaling up a 1-day VaR metric ignores the aging of the portfolio examined over time. For instance, as equity levels evolve over time, the portfolio greeks (e.g., the deltas and gammas) will change without adding any new positions (thus changing the relationships between risk factor movements and changes in portfolio value), which impacts any subsequent CE forecasts. Further, certain trades may be scheduled to expire or options will likely be exercised under particular scenarios. This static approach of scaling up the VaR implicitly assumes the risk profile does not change over time and captures none of these effects. Obviously, the aging impacts not captured are larger for non-margined accounts, where VaR metrics are scaled out to considerably longer maturities. Consequently, QRM personnel have conveyed a desire to refine the modeling of margin provisions for equity products and possibly move non-margined equity portfolios to a Monte Carlo framework.

The current historical simulation is adopted from the market risk VaR model, and utilizes the same times series and re-pricing technology. The only notable exception with respect to the market risk specification of the model is that, for PE purposes, equal weighting is applied to all historical risk factor data (versus the exponential weighting used for VaR purposes). The VCV model uses a delta-vega (i.e., linear) re-pricing approximation and one year of historical data. The VCV deltas are mapped to single name equity return data and vegas are mapped to historical implied volatility data on one of eight regional indices. Although less material in the context of PE versus VaR models (given that counterparty level risk profiles tend to be more directional in nature and require aggregation across fewer risk types than desk or business unit level profiles), neither a linear VCV approach nor the use of such a limited number of implied volatility series seems ideal for modeling the non-linear price and volatility risks associated with options. However, pending certain front office system enhancements, QRM intends to extend the historical simulation method to cover key exotic positions.

### *Credit Derivatives*

For the credit derivatives business, QRM is currently using a scenario analysis approach to measuring PE, rather than a typical statistical approach. The scenario analysis involves calculating potential exposures resulting from large, contemporaneous trade-by-trade credit spread shocks. These individual transaction level exposures are eventually aggregated by taking the maximum exposure of either all of the long or all of the short positions in a portfolio. In other words, no credit risk factor correlations are explicitly modeled. This ad-hoc aggregation results in conservative PE estimates in the case of a balanced long and short portfolio.

The magnitudes of the credit spread shocks are intended to be 95<sup>th</sup> percentile movements, stressing each position's underlier in the direction that increases Lehman's exposure. These stresses are calibrated either from 1) internally generated market implied credit transition and default probabilities, and corresponding mark-to-market impact matrices, or 2) from Lehman's historical spread data. For non-margined accounts, underlying implied ratings are stressed at a 95% confidence level using the front office transition matrices and corresponding spread and price changes are obtained from the MTM matrices. These transition matrices are annual in periodicity and extend out to 10 year horizons. Thus a metric is produced for the PE one-year out, two-years out, and so on, through the tenth year. While the transition probabilities are initially based on historical data, they are calibrated to market implied survival curves/default probabilities. For margined accounts, a spread risk factor, reflecting a 95<sup>th</sup> percentile

two-week spread move and estimated from the firm's historical data, is used. These risk factors are estimated by rating<sup>51</sup>.

The PE results produced from this scenario analyses are completely insensitive to the existence of legal netting, and the aging of portfolios over time is not captured. Furthermore, this ad-hoc process of adding up the risk from all the longs versus all the shorts and taking the greater of the two resonates as a fair approximation to actual exposure. In other words, using this approach, PEs will not necessarily increase or decrease with increases and decreases in actual risk. Consequently, QRM is planning to implement a Monte Carlo simulation model for credit products in the near future. In the meantime, QRM asserts some comfort with the fact that the current aggregation bears on the side of caution in ignoring diversification effects<sup>52</sup>.

#### *Fixed Income and Equity Financing*

For securities financing transactions, a spreadsheet implemented Monte Carlo simulation model based on a VCV matrix is used for measuring PE. For these businesses, all securities are mapped to one of 52 indices/benchmarks. This includes, for example, ten US equity indices by sector. The use of a VCV based simulation and associated normality assumptions does not seem particularly worrisome given the relatively linear nature of the instruments covered by these businesses. However, OPSRA staff note the relatively non-granular benchmark mapping scheme used. While QRM does attempt to compensate for potential concentrated and basis risks not captured by increasing volatilities for concentrated positions, the concern remains that such mappings could result in the inaccurate offset of exposures. However, QRM again notes the relatively directional nature of most counterparty portfolios. Furthermore, QRM plans on transitioning the financing businesses to the historical simulation VaR based methodology by the end of this year.

#### *Prime Brokerage*

For prime brokerage clients Net Potential Exposure (NPE), defined as the VaR minus the equity in the account, is the PE metric used. The VaR statistic, like with much of the equities derivatives business, is estimated from the market risk group's historical simulation VaR model. Again, the PE version of the VaR model uses the same specification as used for computing the firm's VaR except for the equal weighting of historical risk factor data. All prime broker accounts are fully collateralized and subject to daily margining.

#### *Revaluation Techniques*

As discussed in the VaR section of this report, there are three central steps to constructing a probabilistic risk aggregation model. The above discussion focuses much

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<sup>51</sup> One of these two approaches is taken for the vast majority of Lehman credit derivative transactions, which are mostly single name CDS and CDOs. Some of the more exotic trades, such as credit default swaptions, are not captured since QRM has not developed the re-pricing calculators to quantify the MPEs resulting from the stress shocks. QRM is currently in the process of developing notional based add-ons to capture risk for such transactions.

<sup>52</sup> While one could imagine hypothetical portfolios, such as a concentrated portfolio consisting of several longs and shorts, for which this approach might underestimate risk, OPSRA staff are told that when QRM moves the credit business to a simulation model PEs are expected to fall for essentially all counterparties.

on the modeling of risk factor movements for PE purposes. In terms quantifying the P&L impacts of those movements, QRM uses a combination of front office pricing models, including risk sensitivities and stress matrices, and its own models and calculators which may utilize full revaluation or various re-pricing approximations. While industry standard seems to be to use front office re-pricing technology for VaR models, firms often build their own calculators for PE purposes due to the higher computational demands of these methods, especially when using Monte Carlo techniques. Furthermore, PE models require additional counterparty level information to that stored in front office systems (and more than is needed for VaR), such as collateral terms. However, while OPSRA is open to the use of QRM developed re-pricing calculators (versus front office models), we intend to examine in the future QRM's validation efforts with respect to such models, as discussed below.

### *PE Validation*

Due to the relatively longer time horizon across which PE models are used to project potential risks, as compared to VaR models, empirically validating PE calculations poses additional challenges. Consequently, techniques in addition to pure statistical comparisons of model predictions against actual CE realizations should be considered. Some institutions appear to be moving in the direction of developing techniques that emphasize intuition and risk management practices in assessing model adequacy, as opposed to focusing on a particular statistical test. Further, in addition to empirically validating model outputs, some firms gain comfort in assessing the various components of the overall PE methodology from a sort of bottom-up approach. For instance, separate processes can be established for evaluating the formulas used for repricing instruments (as with front office pricing models) versus the stochastic models used for describing risk factor evolutions over time.

QRM intends to implement a two-stage PE model validation process. The first stage is to validate the re-pricing techniques and calculators one-by-one. OPSRA staff are told this process will be much akin to the model review process for vetting front office pricing models, and will also be carried out by the model validation group in QRM. In addition, various ad-hoc analyses will be performed to evaluate the risk factor forecasts produced by the models. These sorts of processes entail reconciling the risk factor movements leading to large exposures (i.e., drilling down into the MPE simulation path) with intuition as well as with directly observable historical movements in factors. The second stage of the validation effort involves performing a form of backtesting of hypothetical portfolios. The idea is to walk back through time and calculate what the CE history looks for a hypothetical portfolio, were it to have been created at various historical dates, and compare that distribution of CEs to the actual (current) estimated MPE. In other words, suppose one has estimated a two-week MPE of \$1 million for some hypothetical transaction today. The modeler calculates what the realized CE would have been, two weeks after initiation, had that transaction been put on various days in the past. The QRM plan is to implement such tests, starting with more simple portfolios, and to expand it to portfolios with perhaps more complex correlation structures and instruments. The proposed PE validation plan appears reasonable and is consistent with approaches used elsewhere in the industry.

## ii. Internal Credit Ratings

A major component of CRM's function is the analysis of counterparties leading to the assignment of ICRs.<sup>53</sup> Credit analysis begins with a comprehensive review of counterparty information. Included in the review is an analysis of counterparty-specific information such as audited financial statements, prospectuses, external credit rating agency reports, external news reports and company press releases. Credit also relies on due diligence including on-site client visits, particularly for hedge funds. Industry analysis is also performed, including peer analysis and benchmarking particularly for banks and hedge funds. Finally, market data, including credit spreads associated with the counterparty's debt or credit default spreads, are utilized.

ICRs are assigned to all counterparties, except for short dated cash trading and counterparties with an MPE less than \$1 million, by credit analysts within CRM. Lehman uses a scale of eight bands ranging from iAAA to iD. Bands from iA to iB are further defined by the addition of a plus or minus to show relative standing within each rating band.

Lehman has developed a series of industry-based scorecards that are used by analysts to assign ICRs.<sup>54</sup> Each scorecard contains a number of quantitative and qualitative factors germane to the particular industry. Analysts input each quantitative factor and score each qualitative factor from 0 (weak) to 5 (excellent). Each factor is given a predetermined risk weight that cannot be modified by the analyst. Each factor's score and risk weight is combined ( $\sum \text{value} \times \text{weights}$ ), leading to a final score which is compared to a pre-calibrated industry specific scale to get the final ICR. Analysts may override the scorecard produced ICR, but must provide a justification for doing so. Ratings are subject to a sovereign cap, and hedge funds are capped at BBB+.

Analysts are required to refresh counterparty ratings at least annually. When new information about a counterparty becomes available, analysts may refresh the ICR more frequently. Analysts are encouraged to downgrade counterparties as soon as negative information is received, whereas they are encouraged only to upgrade counterparties when positive information is backed by evidence of actual improvement.

A comparison of Lehman's ICR with external ratings reflects a conservative bias in Lehman's ICR approach. Approximately 700 counterparties, representing fewer than 20% of the counterparty population, have Moody's and S&P ratings. With Moody's, the ICR matches 45% of the ratings and the ICR is lower in 46%, including 8% where they are more than two notches lower. With S&P, the ICR matches 54% of the ratings and the ICR is lower in 32%, including 4% where they are more than two notches lower. Sovereign ICRs are broadly consistent with rating agency ratings.

Lehman's method of assigning ICRs through the use of scorecards provides consistency and transparency. The same scorecards are used globally, increasing consistency. The scorecards were developed internally by Lehman, not by a third party consultant, and thus there is a sense of "buy-in" among analysts worldwide. Currently only analysts can access the scorecards on Lehman's internal website, but there are

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<sup>53</sup> ICRs directly inform a counterparty's maximum available credit limit, as well as documentation and margin terms.

<sup>54</sup> The major industry classes that are covered by the scorecards include: insurance, banks, hedge funds, sovereigns, corporates, municipals, special purpose vehicles, investment advisors, and broker dealers. In addition, a scorecard may be treated as "miscellaneous" for counterparties outside of the pre-defined industries. OPSRA examined the scorecards for insurance companies, banks, sovereigns, and hedge funds in detail.

plans to allow the businesses to view them once security concerns have been addressed.

c. Limits and Permissioning

There are multiple layers of credit risk limits at Lehman. The most comprehensive limit is RA, which has a market, credit, and event risk component. The credit component of RA is a statistical measure of potential credit losses over a one year time horizon. Lehman also imposes firmwide country risk estimated loss potential (ELP) limits. The ELP measure is a conservative estimate of the loss Lehman might experience in the event of an instantaneous crisis in a country. It estimates market risk and counterparty credit risk losses across all products at the country level. The CRO sets country limits. In addition to these limits, there are several counterparty credit limits in place at Lehman governing the tenor of exposures in a particular country.

Credit limits are further delimited by family (i.e., all entities within a related group of counterparties) and by counterparty. These limits are set by Credit Analysts in CRM within their delegated authority.<sup>55</sup> There are three applicable classes of limits that are monitored by CRM. First, pre-settlement limits cover pre-settlement credit risk arising from the possibility that Lehman may incur a credit loss if a counterparty defaults at a time when the termination value of outstanding trades is in Lehman's favor and exceeds the proceeds from liquidating any collateral. These limits apply primarily to the OTC derivatives business. Second, settlement limits cover the open delivery risk associated with trades in which Lehman, due to market convention, has free delivery and could be at risk for the full value of the trade being delivered due to non-simultaneous settlement. This is mainly an issue in the FX business. Third, treasury limits cover the credit risk associated with deposits made for liquidity management purposes.

Family and counterparty limit authorities are set by ICR. For pre-settlement risk, limits are further defined by trade tenor, are measured in MPE and take into account enforceable netting agreements and collateral.<sup>56</sup> The family-level authorities for the Global Head of CRM are set forth below, in USD millions.

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<sup>55</sup> There are five levels of authority (in descending order): the Global Head of Credit Risk Management (Jeffrey Glibert), Level 0 Approvers (Steve Simonte in New York and David Oman in London), Level 1 Approvers (6 worldwide), Level 2 Approvers (15 worldwide), Level 3 Approvers (10 worldwide), and Level 4 Approvers (19 worldwide).

<sup>56</sup> The PE metric utilized for hedge fund exposures, both OTC and within prime brokerage, is measured as the Net Potential Exposure (NPE), defined as the VaR minus the equity (surplus collateral or initial margin) in the account. This number is a better metric for dynamic hedge fund portfolios that are subject to daily margining. See the prime brokerage section of the report below.

ICR	Pre-Settlement Risk MPE Limits by Tenor				Settlement Limits	Treasury Limits
	<=1 yr.	<= 5 yrs.	<= 10 yrs.	>10 yrs.		
iAAA	675	375	275	200	1000	925
iAA	675	375	275	200	1000	925
iA+	525	375	275	200	425	925
iA	525	375	275	200	425	925
iA-	525	375	275	200	425	925
iBBB+	275	200	175	150	250	425
iBBB	275	200	175	150	250	425
iBBB-	175	100	100	100	0	225
iBB+	125	75	75	75	0	125
iBB	125	75	75	75	0	125
iBB-	100	75	55	50	0	100
iB+	60	60	50	45	0	75
iB	60	60	50	45	0	75
iB-	50	50	40	35	0	55
iCCC	50	50	40	35	0	55
iD	35	25	25	25	0	35

Limits for lower levels of credit authority are correspondingly more restrictive. For example, the pre-settlement risk MPE limit for a iAAA rated counterparty for exposure with less than one year tenor is \$600 million for Level 0 approvers, \$500 million for Level 1 approvers, \$300 million for Level 2 approvers, \$150 million for Level 3 approvers, and \$15 million for Level 4 approvers.

Limits are further delimited into product limits by Lehman legal entity. These cover specific product areas and are denominated in notional amounts. Limits for repos, FX, and securities lending will be recast product level PE limits in the near future.

Although the credit limit guidelines provide analysts with clear mandates on maximum limits, analysts are still expected to exercise judgment in two ways. First, actual limit recommendations are often less than guidelines. This is primarily due to a lack of business requirements warranting the full amount, and a desire by Lehman not to have "excess credit" to counterparties. Second, the guidelines do not prescribe rules for sub-allocating product-specific limits within a family.

Transactions that are not covered by a credit limit require trade specific review and approval by a credit analyst. Active financial institutions operate under pre-approved limits for all products. Select corporate and insurance clients trade under pre-approved limits for fixed income products, and require trade-by-trade approval for CDS and equity derivatives. All other counterparties, including hedge funds, must have all trades approved individually by credit analysts. Lehman is moving towards having all active counterparties, including hedge funds, operate under pre-approved limits and having infrequent users operate under trade-by-trade approval. From an operational standpoint, this change will alleviate some of workload for the credit analyst.

In addition, the private client business (Private Investment Management) counterparties are provided with pre-approved product lists including notional limits, margin, and haircut requirements and tenors for various client types. This business operates under Reg T and the accounts are all highly margined well in excess of VaR.

#### d. Technology Systems

At Lehman, credit risk staff from all geographic regions use the same global technology platforms containing the same information. The various credit risk reports and applications are accessed from the LehmanRisk CRM Webpage. The primary Credit Risk applications/systems include Credit Work Station (CWS), the MPE System, the Credit Approval System (CAS), Credit Risk Reporting applications, and the Internal Risk Rating Scorecard Application.

##### i. Credit Work Station

CWS is the “downstream” credit system. All important information and tools, from a credit risk management perspective, are brought into CWS. It serves as a repository for counterparty, family hierarchy, credit ratings and trade information, and is used for exposure aggregation and report generation. Within CWS one may view all credit analyst reviews, external credit ratings and various client as well as industry and country data. In addition, all credit lines/limits as well as the current usage of those lines are viewable in CWS. In order to be able to cut data/reports different ways and view exposure at various levels of aggregation, CSW can perform simple MTM (re)calculations. CWS is also used by the analysts to create new credit lines.

##### ii. MPE System

The MPE system calculates counterparty credit exposure for four major purposes: 1) pre-trading analysis and trade approval, 2) reporting of counterparty exposures, 3) calculation of the counterparty risk components of Risk Appetite, and 4) the credit valuation adjustment (CVA). As discussed in the MPE section above, various types of modeling techniques are employed for MPE calculations, varying by product type. However, the same techniques are applied consistently globally within product type. The MPE system produces a standardized set of outputs and reports. For instance, weekly CE and MPE reports showing aggregated exposures to the counterparty level are produced.

In terms of pre-trade analysis, credit analysts and sales personnel can currently estimate the likely portfolio MPE impact of relatively vanilla trades. MPE “risk factor tables” are used to provide conservative estimates of the MPE effects of other new trades on an existing portfolio. The MPE system calculates these impacts for approximately 100 generic proxy trades. However, often, especially for more “sensitive accounts” and more exotic trades, the Credit Risk Analytics team (within QRM) will need to model the impact of a proposed transaction. This may involve either modeling the trade directly, in proxy form, or using an “add-on” (as discussed in the MPE section). In doing so, Credit Risk Analytics has a “generic desktop utility” at its disposal that calculates the effects of adding one or more predefined (generic) trades to portfolios. This calculator offers additional functionality to the risk factor tables – e.g., it allows for variation in margin terms for the marginal simulation. However, QRM is currently developing a “true” MPE calculator that will be available to analyst and business personnel for calculating MPE impacts of actual proposed transactions “on the fly”. This tool should enhance the permissioning processes and reduce the number of transactions that require explicit QRM attention for approval purposes.

### iii. Credit Approval System

The CAS stores pre-approved counterparty credit limits and credit analyst trade approvals. For non-pre-approved counterparts, credit analysts record credit terms for proposed transactions and obtain and assign credit approval numbers for each trade proposal. Transaction management then validates the credit terms in the trade confirmations (front office) with the credit terms in CAS, and a "credit handshake" is performed to ensure the trades that are booked are in fact the trades the credit analysts approve. Within CAS one can view a full history of past trade approvals and can pull up the details on any trade.

### iv. Credit Risk Reporting Applications

The credit risk systems are used to generate a variety of standardized reports, and also provide the capability to generate ad-hoc reports. Types of reports generated include portfolio, country risk, exposure, analyst, and control reports. Again, the CRM webpage is the central depository of risk reports. Daily reports focus on exposure (CE, MPE and settlement). In addition to generating daily current and potential exposure reports, line (limit) utilization and excess reports are created that facilitate limit monitoring. Credit risk managers have the ability to view client activity across all product areas/business lines (e.g., derivatives trading, repos, loans) for a particular counterparty, with the exception of prime brokerage activity. While prime brokerage activity is not currently consolidated with LehmanRisk in an automated matter, OPSRA staff are told this is a project for 2005. In terms of information reviewed by senior management reviews, we are told that every week the Executive Committee receives a package similar to what OPSRA staff review monthly, with an additional cover page highlighting top changes, etc. Furthermore, CRM conveyed an intention to enhance its risk reporting to senior management to provide high level exposure reports with drill down capability and more historical trend analysis.

### v. Risk Rating Scorecard Application

Standardized and automated scorecard applications are used at Lehman to ensure quality control around ICRs. ICRs can only be updated using a scorecard, and when there is an update the changes are stored (each scorecard is date and time stamped). Each counterparty is assigned to an industry and each CWS industry is mapped to a particular Industry Class scorecard (discussed in ICR section). Examples of score card application functionality include automatically applied sovereign ICR caps, mandatory comments in the event of application overrides, definition pop-ups, etc. In the future, Lehman intends to expand the scorecard application to cover internal facility ratings.

### vi. Future Enhancements

Risk management is currently investing resources to enhance credit risk technology in various ways. CRM is continually working to automate processes and integrate systems. For instance, it intends to develop an automated reconciliation between the MPE system and the General Ledger. Furthermore, CRM intends to make improvements to the credit analyst interface, such as by developing a "workflow management tool which will manage the credit review and limit recommendation process, trade approval and reconciliation, and 'push' exception reporting to analyst".

Furthermore, various reporting enhancements, such as improving country risk reporting, are on the CRM agenda.

e. Specific Business Areas

i. Lending Activities

*Leveraged Finance*

The high yield business at Lehman includes a leveraged finance group. This business provides event-driven financing for acquisitions, leveraged buy-outs and refinancings such as dividend recapitalizations. The financing packages typically include multiple instruments. There are often longer term financings such as term loans and revolvers, as well as shorter term bridge loans, which are generally taken out by longer term capital sources such as high yield bond offerings. These pieces can vary in terms of seniority in the capital structure as well as in the probability of being funded.

The approval process for a leveraged loan begins with the deal team conducting due diligence and preparing a detailed transaction memorandum. The deal team is composed of investment bankers, ratings advisory analysts<sup>57</sup>, and credit research analysts. The transaction memo summarizes the transaction, the competitive dynamics and Lehman's role. Also included is a summary of the diligence conducted, historical financials and projections, business and industry overview, an assessment of management and any significant pending litigation or other issues. The credit analysis performed by the deal team places a heavy focus on the prospective cash flows. They consider the robustness of the primary source of repayment, such as cash flows from operations, as well as any secondary sources such as liquidation proceeds. A final recommendation is made by the deal team.

After the deal team has completed its memo, the findings are presented to the divisional commitment committee, the High Yield Commitment Committee (HYCC). The analysts present their opinions, and there is a discussion of the proposed commitment terms, pricing, and syndication. Approval of the proposed terms by the HYCC requires satisfactory diligence, research and ratings opinions, and syndication strategies. Occasionally, the deal team will perform an informal "fly-by." That is, one month before presenting the formal memo to the HYCC, the deal team will discuss the transaction with the HYCC to figure out what the major issues will be and to get a feel for whether the transaction is potentially viable. This is more likely to happen for industries with which the HYCC is not familiar and for large sponsor deals.

Deals approved by the HYCC are then elevated to one or more of the firmwide commitment committees. The two committees relevant to this business are the Investment Banking Commitment Committee and the Bridge Loan Committee.<sup>58</sup> The former has broader representation across risk management and senior management of the firm. These firmwide committees ensure that the transaction fits within Lehman's funding and risk frameworks, and ensures that there is proper coordination across the firm. In addition, they ensure that even in downside scenarios, the transaction will meet minimum return hurdles. They also make sure that the due diligence has been

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<sup>57</sup> The rating advisory analysts are former employees of the rating agencies who advise on the projected ratings that transactions will receive from the rating agencies.

<sup>58</sup> The other two firmwide committees are the Fairness Opinion Committee and the Investment Committee, which approves principal transactions such as private equity, real estate and venture capital.

thorough, that the firm is comfortable doing business with the client, and that the firm is protected from a legal perspective. Transactions above specified thresholds or those with significant reputational or client risk are elevated to the Executive Committee for final approval.

Lehman engages in a number of measures to mitigate risk post-commitment. The primary mechanism by which they mitigate risk is by syndicating the commitment to third parties. They will seek to sell a portion of the loan and bridge commitment through wholesale commitment syndication and general primary syndication. Factors considered in deciding how much to syndicate include agreements with issuer on hold size and syndication timing, length of commitment, overall risk level, and market conditions. Syndication is completed prior to closing of the deal except in Europe where syndication must take place post-closing. Commitment syndications are legally binding and thus constitute risk transference from Lehman to the buyers of syndication pieces. Post-closing of the transaction, the loan trading desk will generally make markets in the loan and will opportunistically seek to reduce Lehman's remaining exposure in accordance with issuer agreements and market conditions.

Post-syndication of deals, the business is often left with exposure to certain pieces of the capital structure, either client-mandated minimum hold levels or allocation that was not sold. The goal of the business is to hedge the entire position. For unfunded positions, they seek to hedge the entire commitment size, recognizing that a counterparty is likely to borrow under the entire revolver prior to default. They hedge by making two sided markets in loan only deliverable CDS (88%), a product Lehman has engineered that eliminates basis risk by requiring the delivery of loans and not bonds in the event of default, and with unsecured bond referenced CDS (12%). Customer demand for hedging products is generally present only when it is newly issued or when there is an event surrounding the name. The business will engage in opportunistic hedging depending on market liquidity to increase the amount of protection. Also, on occasions when the counterparty pays back their commitment and Lehman ends up net short credit, they will look to unwind their existing hedges.

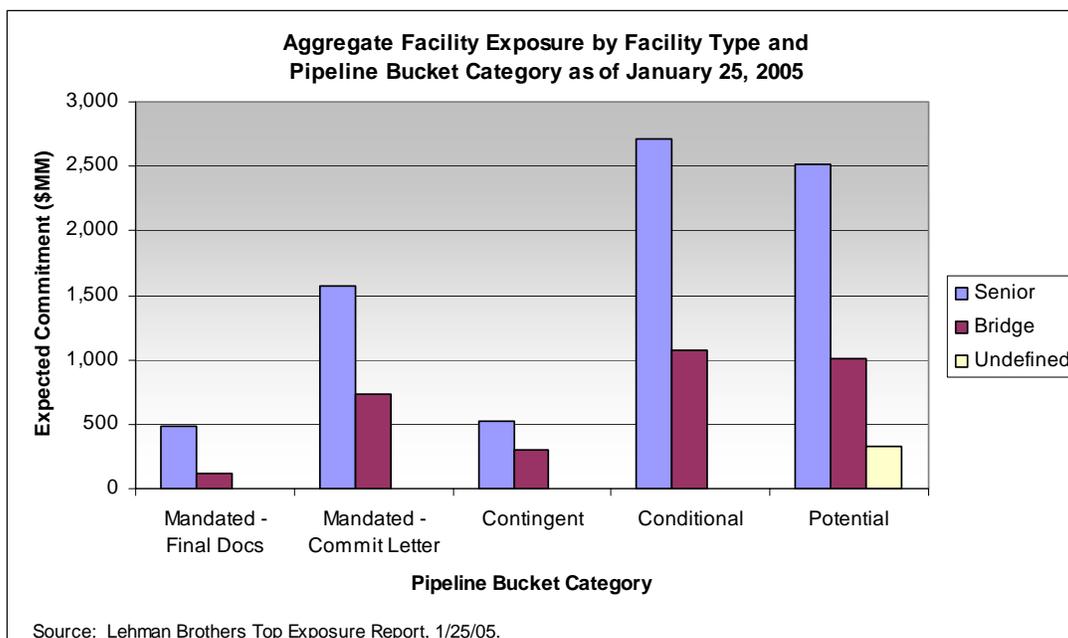
The business is often not able to hedge the entire hold position due to a lack of demand by third party investors. There are currently 29 borrowers with exposures greater than \$10 million after hedges. The largest current position is a \$45 million revolver, none of which was hedged due to a lack of investor demand. Ongoing monitoring of these positions is performed by the Loan Portfolio Management Group, a group within the business.

CRM works actively with the business units to keep informed of developments in the pipeline. For risk analysis purposes, pending transactions are categorized and tracked in five buckets, based on two factors. First, what is the probability of the deal actually happening? Second, when does Lehman legally take on exposure? The five buckets include:

- Syndication Risk Final Documents – Executed final documents. The transaction may have closed but not finalized the syndication process. The deal could be either funded or unfunded.
- Syndication Risk Commitment Letter – Issued a Commitment letter which has been accepted by the client.
- Contingent Transaction – Signed letters with limited outs – Issued a commitment letter with conditions. The letter has not yet been accepted by the client.

- Conditional – Unsigned letters or signed with material outs – Issued an unsigned letter or a letter with significant conditions such as completion of due diligence and committee approvals.
- Potential Transaction – In the process of analysis and prior to presentation to the Committees.

The following chart represents Lehman's aggregate facility exposure by facility type and by bucket as of 1/25/05.



CRM ensures that transactions can be accommodated within all applicable limits, including RA and Single Transaction Limits.<sup>59</sup> The Marginal Risk Appetite (MRA) is reported on all high yield commitments. MRA represents the incremental contribution of a deal to the high yield business' total RA usage. The calculation is done broadly in two parts. First, the exposure size over the course of a year needs to be determined. This is complicated by the fact there is uncertainty about whether or not deals in the pipeline actually come to fruition, and by the assumptions necessary to determine what the market conditions will look like in an adverse environment. Second, the standard RA methodology, with two exceptions noted below, is applied to the predicted exposures calculated in the first step.

In the first step, MRA is calculated for deals that have firm, conditional or potential commitments. One hundred percent of the calculated MRA is added in the case of firm commitments, while the conditional or potential commitments are weighted by a deal-specific probability of deal completion assigned by the deal team. The deal size is calculated as Lehman's share of the total facility. As RA measures potential annualized losses in extreme market conditions, MRA seeks to measure the potential losses from deals in which the syndication process is disrupted due to adverse market conditions. Adverse market conditions, such as high default rates, dramatic spread

<sup>59</sup> See the discussion of Single Transaction Limits in Section I.c.

widenings, demand/supply imbalance, and significant fund outflow, could result in Lehman's holding bridge and loan commitments longer than anticipated. Lehman calculates exposures for three different market scenarios and averages the resulting losses to come up with the final exposure. The three scenarios include a closed market (no syndication, hold 100% of the position for the year), a difficult market (bridge taken out with a high yield issuance in six months and loans close in three months at 25% hold level with further syndication to 10% within a year), and a friendly market (bridge taken out in three months and loans syndicated to 5% final hold level at closing). The average of the three scenarios generally approximates the difficult scenario.

In the second step, MRA incorporates both the market risk and the event risk component of RA. The standard methodology applies with two exceptions. The first exception is that pricing flex mitigates market risk on a one-for-one basis, and full flex completely mitigates market risk, leaving only event risk.<sup>60</sup> Event risk captures the possibility of downgrades or defaults of the bridge and loan positions that Lehman is forced to hold in the adverse market conditions. The second exception to the standard methodology is that Lehman assumes defaults are correlated within sectors and independent across sectors.<sup>61</sup> The loss given default is derived from recovery rates published by Moody and S&P, with a downward adjustment for the first year LBO default rate.<sup>62</sup>

To illustrate how MRA captures risk, consider the Intelsat deal. Lehman was the lead bookrunner in this large acquisition financing deal during the fall of 2004. On 8/16/04, the acquisition agreement was signed and announced. Lehman agreed to provide \$1.107 billion in financing, made up of an \$800 million bridge loan, a \$67 million senior revolver, and a \$150 million term loan. The resulting MRA number was \$106 million. From mid-September through October, the bridge loan was syndicated. Lehman's position was reduced from \$850 to \$314 million, and MRA went from \$46 to \$20 million. Lehman expressed comfort that these numbers reasonably reflected the risk of a loss in a stressed environment on these positions. However, CRM focuses on the total size of the deal, which is the maximum loss Lehman would encounter in the event of default, when approving a deal. From CRM's perspective, RA is a good metric to use to aggregate risk across the portfolio, but their focus is on the total size of the transaction.

CRM plays a number of other roles in the leveraged finance business.<sup>63</sup> They analyze key transaction risks, including key business risk, projected financial plans, proposed capital structure and market views on syndication, and reputation risk. They participate in the Investment Banking Commitment Committee and sign off on all

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<sup>60</sup> "Pricing flex" refers to Lehman's ability to adjust pricing in response to market conditions. For example, 100 bp of flex indicates that Lehman can increase or decrease the spread by up to 100 bps. Full flex allows unmitigated pricing changes.

<sup>61</sup> In other areas of RA where defaults are modeled, Lehman assumes that defaults are uncorrelated. They feed probabilities of default and risk exposures for each counterparty into a "binomial distribution calculator" to obtain the full distribution of credit loss estimates. In the case of correlated defaults within an industry, they utilize the same binomial calculator but treat all counterparties within an industry as one counterparty. This effectively gives the result with perfect correlation. Lehman then interpolates between the uncorrelated and the perfectly correlated results.

<sup>62</sup> The CRO related that the adjustment to the first year LBO default rate was due to conversations between RMD and personnel in the high yield business, illustrating how RA evolved from collaboration between the two groups and thus "buy-in" by the business unit.

<sup>63</sup> Currently, one person responsible for Commitments, Patrick McGarry, reports to Jeff Glibert. Lehman is in the process of hiring one additional person to work in this area.

transactions approved by the committee. They engage in ongoing follow up with the respective deal teams as transactions move from approval to closing, final syndication and target hold level.

Senior management is kept well informed of developments in the pipeline through a series of reports. The Firmwide Risk Snapshot is presented to senior management weekly and, among other items, reports on commitments in each bucket besides Potential Transaction. The report lists the counterparty, the deal probability, the expected amount of the exposure, and the weekly change in exposure. The Top Exposure Report contains information on the full pipeline (i.e., all five buckets) and contains detail on the commitment by facility type. More detail about the deals can be found in the Lehman Expected Commitments reports. This report contains a series of bullet points about each deal, such as the purpose of the financing, acquisition price, total financing package, any MACs and pricing flex, and the current state of the deal.

### *Relationship Lending*

Relationship loans, made to investment grade counterparties, are generally unprofitable on a standalone basis but are made in order to perpetuate an existing relationship or to strengthen a growing relationship. Investment Banking (IB), the business unit responsible for structuring the transactions, performs the risk-reward analysis of the loans. On an ongoing basis, they perform periodic reviews to determine the profitability of the whole relationship. The Credit Facilitation Group, a public side group outside of IB within the fixed income franchise, is responsible for determining the mark-to-market cost of the loans and the cost of the hedges.<sup>64</sup> These costs are then reported to finance, which splits the costs evenly among IB, fixed income, and equities.

Similar to other corporate loan exposures, Lehman seeks to mitigate as much of the committed exposure as possible. They primarily utilize traditional CDS products to hedge, but also use some loan-only CDS and some equity options. They also seek to sell off part of the loan facilities. Hedging is particularly challenging for these investment grade facilities, given that they are generally unfunded.

Before a relationship loan is made, it must first be approved by the Loan Participation Committee. This committee is composed of IB personnel and considers the revenue versus risk tradeoff of the loan over time in making its decision. After approval by this committee, the loan must be approved by the High Grade Credit Committee. This committee is staffed more broadly and considers the credit fundamentals of the counterparty as well as the risk in granting its approval.

Ongoing monitoring of the loans is performed by the High Grade Loan Portfolio Group. The Credit Facilitation Group is responsible for the ongoing hedging decisions, as well as monitoring the exposures on a portfolio, sector, and single name basis.

The current RA limit for this business is \$75 million, broken down geographically in the U.S. and Europe. The business is also subject to a \$4 million VaR limit which is also broken down between the U.S. and Europe. RMD is responsible for monitoring the utilization of RA and VaR by the business.

### *Warehouse Lending*

Warehouse lending facilities are generally 364 day facilities and the majority of the collateral is either alt-A or subprime loans. The warehouse lending business, unlike

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<sup>64</sup> Since financing is provided at rates that are uneconomical from Lehman's perspective, a day one initial markdown/loss is taken on these positions.

relationship lending, is profitable on a stand-alone basis. However, the primary goal of this business is to generate ancillary business, such as a pipeline for the purchase of whole loans for a Lehman securitization or for the agency securitization business. Lehman has either purchased from or securitized loans for 13 of its 14 warehouse lending counterparties over the past year.

The evaluation and management of the risk associated with these secured lines of credit is primarily done within the business area, in that the business area will determine the advance rates, or haircuts<sup>65</sup> and will conduct the ongoing marking and monitoring of the underlying collateral. However, both the Residential Mortgage Risk Department<sup>66</sup> and RMD<sup>67</sup> will be involved in the upfront due diligence and approval process.

The risk management process around this business starts with the due diligence focused on both the counterparty and the underlying collateral. A Deal Manager within Warehouse Lending is charged with the responsibility of coordinating and running both the upfront due diligence process and the post-close monitoring of the counterparty and collateral. In addition to business personnel within Warehouse Lending, CRM, Residential Mortgage Risk, in-house counsel and a mortgage loan underwriting and compliance specialist third party firm are involved in the upfront due diligence process. The due diligence activities include: (1) Corporate review, (2) Business operations review, (3) Financial review, (4) Litigation/regulatory review, (5) Loan-level due diligence review<sup>68</sup>, and (6) Discussion with external auditor of the counterparty. The corporate and business operations reviews are done on-site. CRM<sup>69</sup> is involved in the corporate review, financial review, and auditor discussion.

Once the due diligence has been successfully completed, Warehouse Lending will start the facility structuring process. As with any asset-based lending business, the facilities will be structured to provide protection to the lender on two fronts: (1) covenants<sup>70</sup> with respect to the counterparty and (2) credit terms with respect to advance rates and additional collateral provisions. The facilities are structured so that Lehman has the right to determine the market value of the mortgage loans serving as collateral for the facility at any time and the counterparty is required to cure any deficit in margin

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<sup>65</sup> Typically, the haircuts range from 2 to 3% and generally the value of the securities upon which the haircuts are based is capped at "par".

<sup>66</sup> This department is headed up by Eric Hibbert and creates the credit policies with respect to the mortgage business. Eric's group does not report into Warehouse Lending, however, it is part of the overall Securitized Products business area.

<sup>67</sup> Jeff Goodman, SVP in MRM reporting to Paul Shotton, sits on the Investment Banking Commitment Committee which approves the warehouse lending facilities as well as debt and equity offering transactions.

<sup>68</sup> Loan level due diligence includes running a sample of mortgage loans through a re-underwriting and compliance analysis to evaluate underwriting guidelines and regulatory compliance. This is done by a third party specialist initially when a counterparty is establishing a facility with Lehman. Typically, additional loan level diligence can be conducted by Lehman if the client either sells loans to Lehman or uses Lehman to securitize loans. If neither of these situations occurs, Lehman will again use the third party specialist to conduct additional periodic loan-level diligence reviews.

<sup>69</sup> Currently, Jeff Goodman is performing the due diligence responsibilities that CRM participates in. Historically, these duties have been performed by a credit analyst reporting to Jeff Glibert, Global Head of CRM. However, this position has been vacant and Jeff Goodman has been performing these duties. CRM is currently interviewing for this opening.

<sup>70</sup> Warehouse Lending focuses on having financial covenants concerning the counterparties' cash position, liquidity in general, and leverage. Each facility arrangement requires the counterparty to report monthly, regarding their compliance with the financial covenants.

that may occur based on a market value determination or any other collateral margin call within 24 hours of notice. In addition, the advance rates defined in the facility documents are based upon percentages of the lesser of unpaid principal balance or market value as determined by Lehman in its sole discretion. Finally, there are additional restrictions on the collateral, such as aging/time-on-line, concentration limits, collateral eligibility criteria, etc.

Once the facility structure is completed, then the proposal will go to the Investment Banking Commitment Committee for approval. The committee includes representation from the business area, Residential Mortgage Risk, and the independent RMD. Specifically, Steve Valentino, Eric Hibbert, and Jeff Goodman among others sit on the Committee.

Once a facility commitment has been extended, Warehouse Lending will perform the daily administration and risk management of the warehouse lending facilities. There will be periodic monitoring of the counterparty and more importantly the daily marking and monitoring of collateral. As discussed previously, the Deal Manager is responsible for the ongoing monitoring of the facility. The administration is conducted by the Mortgage Middle Office on a daily basis and includes all fundings, payoffs and interest coming through Lehman's proprietary Whole Loan Tracking System (WLT). They will get a tape of the collateral positions from the third party custodian and match up the collateral with the warehouse line to the client and then calculate the margin requirements. On a daily basis, Warehouse Lending and the Mortgage Middle Office will utilize WLT to monitor the collateral based on the collateral restrictions (e.g., aging, eligibility, concentration limits, etc). If any collateral deficiencies occur, Warehouse Lending will issue a margin call.

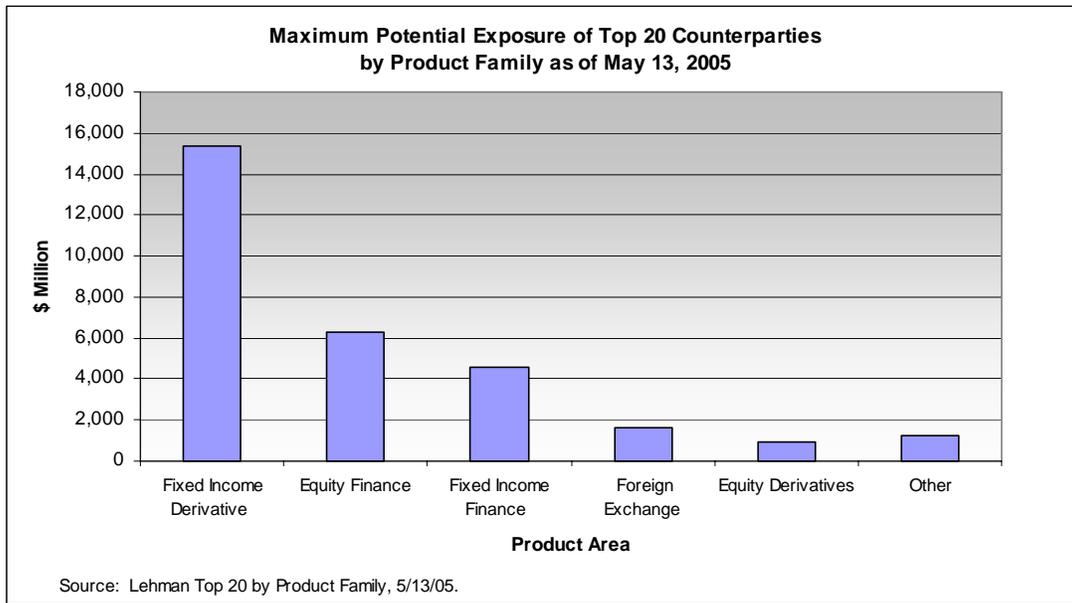
Warehouse lending will calculate the collateral market value for each facility on a weekly basis or more frequently if necessary. Warehouse lending uses the same model used by the whole loan desk to price the whole loan collateral. Each loan is valued on a discounted cash flow basis, with the cash flows generated based on projections of prepayments, defaults, and losses. The projections are a function of loan characteristics, forward rates and projected home price appreciation. In addition, as a reality check, Warehouse Lending will have conversations with the MBS/ABS trading desks as well as with Lehman's own residential home loan origination businesses concerning the portfolio collateral values<sup>71</sup>. Finally, Warehouse Lending will perform ongoing monitoring of financial covenants, loan level due diligence, and an annual on-site corporate due diligence review.

## ii. OTC Derivatives/Securities Lending/Repos

The size of Lehman's OTC derivatives trading, financing (repo/reverse repo), and securities lending businesses is noteworthy. With the exception of commodities, Lehman is active in all of the major product areas, including interest rate and FX derivatives, equity derivatives, and credit derivatives, and trade with a variety of counterparty types - e.g., hedge funds, corporates, sovereigns, municipals, financial institutions, etc. These businesses generate current (unsecured) and well as potential exposures and operate within the firm's counterparty limits framework. The following chart reflects Lehman's largest 20 Potential Exposures by product area as of 5/13/2005:

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<sup>71</sup> The business believes that Lehman's vertical integration in the residential mortgage market provides added value in marking the collateral for the warehouse lines since the business has multiple access to trends and data points for valuing collateral.



Credit analysts are responsible for approving and rating new counterparties, setting counterparty as well as product level limits, approving individual transactions as necessary, determining counterparty and transaction level credit and collateral terms, and monitoring counterparty exposure levels as well as counterparty credit quality and market events. In risk managing these activities, CRM relies upon and interacts with several other groups that facilitate the mitigation/management of risks. The Transaction Management Group (TMG) is primarily responsible for drafting and negotiating Lehman's derivatives and funding documentation, and the Global Margin Group (GMG) is responsible for the daily calculation and collection of collateral requirements.

Credit analysts are organized by counterparty industry. There are distinct groups responsible for covering financial institutions, hedge funds, corporates, investment advisers and mutual funds, insurance companies and municipals, and special purpose investment vehicles (e.g., CDOs)<sup>72</sup>. One analyst covers a single name/counterparty, and monitors and manages risk taking across all product types for that name<sup>73</sup>. Further, the analysts who perform the initial and periodic credit assessments/ratings of counterparties are the same individuals responsible for approving transactions and monitoring counterparty exposures post trade execution.

As described in the Limits section above, Lehman currently specifies counterparty level PE limits and product level notional limits with a plan to migrate to product level PE limits for pre-settlement risk, and notional limits for counterparty level settlement risk. Credit analysts establish these limits for new and existing counterparties within their delegated authority and, for many counterparties, approve all trades pre-execution. At both the counterparty and transaction level, analysts are responsible for mitigating risks by ensuring that the appropriate credit and collateral terms are in place (in the ISDA Master Agreements, etc.). This includes determining acceptable collateral

<sup>72</sup> In addition to this industry based organization, groups are further organized by geography. For instance, there is an Americas as well as a European corporates team.

<sup>73</sup> Although within industry and geographic location there are reporting hierarchies (i.e., there are typically several more junior analysts who report to a more senior analyst).

types, applicable haircuts, and unsecured threshold amounts, as well as establishing termination events such as ratings and NAV triggers. Often CRM will seek and obtain collateral to reduce the magnitude of the unsecured exposures, even for individual transactions that fall within the firm's accepted risk tolerance levels. In addition, prior to approving individual transactions, credit analysts sometimes require risk mitigation via the purchase of CDS protection for investment grade corporate counterparties or through the purchase of options on the transaction underliers for other counterparties.<sup>74</sup>

Credit analysts are also responsible for the ongoing monitoring of existing exposures. CE and PE, including limit excessions, are monitored on a daily basis, and material changes are examined to ensure that the drivers are understood (i.e., new activity versus market movements). For actively traded accounts, which are often hedge fund counterparties, trading activity is reviewed daily. CRM also monitors, in conjunction with the GMG (discussed below), the behavior of counterparties in meeting margin calls. In addition to monitoring exposures, counterparty, industry, and country events are monitored. Credit analysts regularly update their credit views of counterparties based on newly released financial data (including NAV data for hedge funds), press releases, information from industry and investor publications, market data (e.g., credit spreads), etc. Analysts produce for their regional supervisors Daily Credit Summary reports, highlighting major news and events. The Credit Committee, headed by Jeff Glibert, has periodic global credit calls/meetings to discuss trends, exposures, and recent credit reviews. These discussions are often very industry focused. For instance, staff may discuss recent and expected events in the targeted industry, current exposures of big counterparties, credit reviews and scorecard results of those specific counterparties and the resulting limit recommendations.<sup>75</sup>

Obviously, the individual business units take an interest in managing their credit risk as well, given that they are owners of the P&L and thus bear the losses in the event of a default or deterioration in counterparty credit quality. Thus business personnel may pursue hedging should they perceive too much concentrated counterparty risk in their trading book(s). Further, within the Fixed Income Division's derivatives business, a group has been established for dynamically hedging spread risk for corporate counterparties with actively traded CDS and with whom Lehman does not have Collateral Support Agreements (CSA). As credit derivative markets further development, the hedging of counterparty spread and default risk is expected to increase.<sup>76</sup>

Limit excessions can occur actively through the addition of a new trade or passively by large market movements affecting exposure from existing trades. The latter cause is difficult to address. Once a trade has been executed, there are a limited number of actions CRM can take to reduce exposure. One available tool is to refrain from executing additional trades. The renegotiation of credits terms (e.g. sign a CSA) ex-post, however, can be difficult.

TMG, a part of the Corporate Advisory Division, is primarily responsible for drafting and negotiating Lehman's derivatives and funding documentation. In doing so, it seeks to mitigate transaction and counterparty-specific legal and "documentation" risk

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<sup>74</sup> Such transactions are designed to move into-the-money from Lehman's perspective as Lehman's credit exposure grows. However, the premiums paid for such hedges often make transactions unprofitable, thus this is not a common practice.

<sup>75</sup> OPSRA staff attended (via conference call) a Credit Committee meeting on July 14, 2005 during which the U.S. Life Insurance Industry sector was reviewed.

<sup>76</sup> And as counterparty risk becomes more actively hedged, CRM and QRM may feel pressed to incorporate the capture of purchased protection into the firm's PE calculations.

through the use of industry-standard master agreements and transaction-level documentation governing OTC transactions. TMG negotiates and drafts master agreements for the firm's fixed income and equity OTC derivatives, repurchase and securities lending businesses. In conjunction with the Legal department, TMG is also responsible for legal due diligence for OTC transactions in new jurisdictions<sup>77</sup>.

Specific relationship level documentation produced by TMG include ISDA master agreements and CSAs, BMA/ISMA master agreements for OTC repo transactions and related triparty custody agreements, BMA/SIA/ISLA master agreements for securities lending transactions, and local market master agreements. Prior to sending a draft Master Agreement to a counterparty, TMG incorporates credit terms that are determined by the appropriate credit analyst. Typical terms that CRM may request include determining events of default (e.g., including cross default terms), adding contract termination events such as downgrade or NAV triggers, and determining collateral terms (e.g., deciding unsecured thresholds, collateral types and haircuts.). All changes to credit terms must be approved by CRM. TMG also ensures that all agreements adhere to the firm's Documentation Policy, and have a formal exceptions process in place for addressing deviations.

TMG uses a web-based tool called "Entity Master" to manage the negotiation and execution of ISDA Master Agreements. Entity Master houses master agreement and credit support level information. Collateral terms in Entity Master, which are needed for computing and monitoring margin requirements, feed the margin system CAMEO (discussed below).

GMG, which is part of Operations, is responsible for calculating margin requirements, monitoring margin levels and calls, and noticing margin calls (and otherwise interacting with clients regarding when calls will be met, etc.). Margin requirements are calculated according to government regulations, exchange regulations, and internal requirements, which are defined in the legal documentation governing the transactions. Transaction and position information is received by Margin from various processing and risk management systems. All of this information (e.g., master-level margin terms, deal specific requirements, outstanding transactions and collateral holdings) is brought together in CAMEO, the firm's proprietary margin system, to calculate potential margin calls.<sup>78</sup> Margin calls are tracked and reported using CAMEO.

For derivative counterparties, ISDA documentation, at the master and trade level, govern margin requirements. Settlement of margin calls can be the same day, next day, or longer depending on the terms negotiated with the counterpart. For fixed income financing trades and Treasury and mortgage options and forwards, margin calls are calculated using the economic exposure on open trades plus any haircuts. Settlement of these calls is generally expected the next day. For secured lending, margin is calculated based on greater of regulatory or house margin requirements. Clients have three days or longer to meet margin calls, but accounts can be liquidated at Lehman's discretion if exposure grows beyond comfort. For futures, exchange and house margin requirements dictate the margin calculation, and settlement of margin deficits is same day. Collateral received by counterparties is booked in CAMEO as well as in one of the firm's books and records systems, which are reconciled with CAMEO daily. Collateral is priced daily. Failed collateral is not included in the margin calculations and for securities lending

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<sup>77</sup> TMG also prepares and executes trade confirmations for certain lower volume businesses (Asia, US Equities) and handles closing for fixed income structured transactions.

<sup>78</sup> For securities lending and futures margin is actually calculated outside of CAMEO (in ADP's Brokerage Processing System and Rolf & Nolan's RISC system respectively), but is viewable in CAMEO.

collateral is only credited once received. Differences in margin call calculations with clients are reviewed with Sales, Trading and the Middle Office. GMG prepares and distributes to Sales, Trading, Credit, and Management a daily exposure report showing outstanding calls by counterparty.

GMG works with CRM in several ways. The two groups work together to address any client disputes of a margin call. In the event that a client disagrees with margin requirements, GMG reviews the applicable margin terms with credit. For new clients and businesses, GMG works with the credit analysts and TMG to put actionable margin terms in place. In order to calculate margin requirements, GMG has connectivity with credit systems to obtain information such as internal ratings. And, as mentioned above, GMG provides credit a report detailing margin exposures.

### iii. Prime Brokerage

Lehman is a relatively new entrant into the equity prime brokerage business, which continues to be dominated by the "Big Three" of Morgan Stanley, Goldman Sachs, and Bear Stearns. While it currently has approximately 250 clients (advisors), Lehman's business goal is to expand its prime brokerage operations across a variety of services, including execution and financing, service and technology, and business solutions. Through the prime brokerage platform, Lehman provides leverage to hedge fund counterparties, allowing them to create market exposure in excess of what could be obtained through cash holdings/assets alone. Leverage is extended through the provision of margin loans and securities lending, which are fully collateralized and margined on a daily basis. Thus financing provided through this business is asset-backed like in nature, where the only credit exposures are potential exposures. Consequently, in risk managing this business, the monitoring and analysis of the collateral - i.e., the positions in the prime brokerage accounts - is equally important as the monitoring and evaluation of the credit quality of the counterparties.

Lehman's approach to prime brokerage risk management distinguishes it from its peers. While at many firms the risk monitoring and management of counterparty portfolios is performed primarily by quasi-independent groups established within the business units, at Lehman this function is performed by RMD. In particular, a prime brokerage risk management group dubbed Global Clearing Services (GCS) Risk was formed as a joint venture between MRM and CRM to handle the daily monitoring of PB accounts and margin determination process. In addition, CRM exercises certain responsibilities with respect to prime brokerage counterparties. The separation of duties between GCS Risk and CRM can broadly be described in that GCS is more focused on the quantitative market risk type analyses of the funds' positions/collateral and in assessing margin, whereas CRM is more focused on evaluating and tracking the funds themselves - e.g., assigning internal credit ratings, tracking headline events, receiving and reviewing performance reports, etc. However, the two groups work together quite closely in carrying out the primary risk management processes of counterparty credit evaluation, margin determination, and risk measurement, monitoring, and reporting.<sup>79</sup>

All new prime brokerage accounts must be approved by the New Account Committee. This committee is composed of GCS senior management, sales, financing and client service, and CRM. As part of this process, the CRM hedge fund team performs a credit evaluation and due diligence of new funds, including background

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<sup>79</sup> Matt Bowen and Nachi Das are co-heads of GCS Risk, and dually report to Jeff Glibert, head of CRM, and Paul Shotten, head of MRM. Steve Simonte, head of Hedge Fund Credit, reports to Jeff Glibert and is responsible for the due diligence, etc. on hedge funds completed by credit analysts.

checks of managers, evaluation of historical performance, strategy review, organizational structure and management experience, financial, operational and risk management controls, and investor base and redemption policy. It also assigns internal credit ratings to new funds using CRM's proprietary hedge fund scorecards. Funds are evaluated based on 14 qualitative and quantitative factors. Fund-specific factors considered include total net asset value, track record (years experience), investment strategy risk profile, etc., and manager related factors include assets under management, track record, quality of risk management framework, etc. Each factor is weighted, with fund-specific factors carrying 40% of overall weightings and manager-related factors carrying 60%. The final weighted score corresponds to an industry-specific rating scale, but credit analysts assign the final rating manually and must rationalize any deviations from the Scorecard output. Ratings are capped at BBB+<sup>80</sup>.

When a new account is created, GCS risk managers must determine the applicable margining rates. Margin is generally set on a rules basis and is applied instrument-by-instrument. GCS Risk determines margin for a new fund by considering factors such as internal credit rating, trading strategy, portfolio diversification, leverage diversification, underlying asset volatility and liquidity, and expected P&L volatility. In some cases, a sample portfolio is analyzed. Hedge funds are tiered according to credit worthiness, and the most conservative margins are applied to less credit worthy hedge funds. Margin is set by strategy, country and product type. The margin "rate" generally refers to the percentage of gross market value that is taken as margin on trade-by-trade basis. For instance, for a long-short equity portfolio with concentrated positions, GCS Risk may determine that 15% collateral is taken on each position in the portfolio, long or short. In certain instances, some offset may be awarded for highly correlated positions. For instance, on a particular risk arbitrage trade risk managers may agree with a client to calculate margin for multiple trade legs collectively. Put differently, a smaller per leg margin percentage will be applied for those trades considered jointly. In general, risk management asserts minimal margin benefit is given for risk-reducing exposures. OPSRA staff are told total margin is "almost always" greater than the VaR of the portfolio.<sup>81</sup>

GCS risk managers describe their margining process as completely dynamic, meaning they are constantly evaluating the counterparty's portfolio and re-assessing the adequacy of the margin approach. Typically, Lehman has the right to change margin terms anytime, a powerful risk management tool for responding to market events. Margin lock-up agreements are in place for some accounts that commit Lehman to particular terms, typically for a 90 day horizon.<sup>82</sup> Such agreements are privately negotiated and include covenants and termination events. Lehman includes credit provisions such as minimum NAV and performance decline tests in each of its margin commitments, which give Lehman the right to terminate the lock-up agreement in the

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<sup>80</sup> As a test of their hedge fund scorecard rating system, CRM investigated how it would have rated Long Term Capital Management in 1997 (prior to its initial distress). The assessment/score card yielded LTCM a BB rating, which CRM feels is appropriate ex post.

<sup>81</sup> GCS risk managers provided an illustrative margin determination example for a "Tier 1 Fund" following an equity statistical arbitrage strategy. The fund had very little single name or industry concentrations and was largely market neutral investing in liquid equities. The historical daily P&L volatility was approximately 50 basis points. Given the fund's leverage requirements, GCS was willing to charge as low as 5 percent margin per trade side (long and short). However, should the fund's strategy shift towards more concentrated, directional positioning, the margin rate would quickly need to be reassessed.

<sup>82</sup> There are currently 16 funds with margin lock agreements, ranging in duration from 30 to 180 calendar days. These funds have a Long Market Value of \$14,205 and a Short Market Value of \$11,243 million.

event of a breach. While the offset of economic exposure for positions/hedges held away from Lehman is not given, and GCS focuses primarily on the positions held at Lehman in assessing and determining margin rates, the overall fund strategy (and thus positions held away from Lehman) does affect margin decisions. The degree of transparency and level of comfort with the fund relationship affects the extent to which such information is considered.

For certain hedge funds of high credit worthiness and with liquid strategies, Lehman uses portfolio based margining. Its approach to portfolio margining is to compute margin requirements using VaR along with the P&L impacts of various scenario analyses. Currently, risk managers are working on developing a full suite of scenarios to cover the various products/fund strategies. GCS Risk will also consider using portfolio margining for a sub-set of counterparty trades, rather than going to a full blown portfolio approach. While portfolio based margining is currently used on a limited basis, Lehman expects growth in the future consistent with industry trends.<sup>83</sup> Clearly one incentive for prime brokers to move in this direction is to attract additional business. However, there are also credit related arguments in favor of portfolio margining as well, despite the fact that such approaches typically results in margin requirements that are less than requirements yielded by the rules based approaches for a given portfolio. The argument is made that portfolio margin methodologies capture changes in risk more dynamically, resulting in margin requirements that are more correlated with changes in actual risk taking. Further, Lehman argues that portfolio based margining provides clients with powerful incentives to maintain more balanced/diversified portfolios by bringing offsetting positions, currently held away from the prime broker relationship, into the prime brokerage accounts.<sup>84</sup>

GSC Risk and CRM monitor current and potential exposures to hedge funds on a regular basis and report to senior management. For prime brokerage clients NPE, defined as the 95% 1-day VaR minus the equity in the account, is the PE metric used. Given the more complex nature of hedge fund portfolios relative to other counterparties (e.g., many basis risks stemming from relative value strategies), the rapid pace at which risk profiles may change, and the fact that these accounts are all margined on a daily basis, the use of a scaled-up VaR metric as opposed to the product silo-ed MPE metrics is intuitively appealing. On a daily basis, GCS risk management is very focused on examining portfolios with positive or near positive NPEs and engage in discussions with senior prime brokerage management regarding the status of those accounts.<sup>85</sup> If strategy drift has occurred, causing NPE to creep up, margin requirements are re-assessed. Also, GCS personnel may discuss with clients the possibility of adding hedges to the portfolio to reduce NPE to more comfortable levels.

In addition to NPE, GSC Risk monitors a variety of measures on a daily basis, including gross and net market values, greeks/risk sensitivities (e.g., deltas and credit spread sensitivities), event risk measures, concentration/liquidity measures, and stress

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<sup>83</sup> The GCS risk managers do not feel portfolio margining is appropriate for all strategies, such as credit strategies that involve significant issuer-specific risk.

<sup>84</sup> The risk managers also note one drawback of portfolio margining: it is less transparent to clients. In other words, as opposed to a simple percentage based rule, VaR/scenario margin calculations are rather black-box. Although, counterparties are often willing to forgo such transparency in order to receive the additional diversification benefit provided.

<sup>85</sup> The Equity Risk Management Daily Risk Report lists the top five counterparties sorted by NPE. As of May 30, 2005, the NPEs for these top counterparties ranged from \$21.8 million to \$354,000. The outsized \$21.8 million NPE exposure was to fund with short index trades with whom Lehman did not take any initial margin due to a financial guarantee from the fund's Japanese parent.

and scenario analyses. It also monitors market events, evaluates new positions as they are put on, and reviews outstanding margin calls<sup>86</sup>. As mentioned above, risk managers are currently expanding the host of scenarios used to risk manage this business. OPSRA staff will follow up with GSC Risk as these risk measures are further developed as such techniques are important for assessing collateral adequacy. While the VaR-based NPE metric is certainly useful from a risk monitoring and management perspective, accounts collateralized roughly to one-day VaR levels should be expected to exhibit current (unsecured) exposure resulting from market movements somewhat frequently. Thus understanding risks further out into the tails of the counterparties P&L distributions is important.

Hedge funds seeking leverage can obtain financing at securities firms outside of the prime brokerage relationship. OTC derivatives, such as total return swaps and synthetic CDOs, as well as repurchase agreements, embed financing. For obvious reasons, securities firms wish to ensure that economically equivalent risks receive equal treatment throughout the firm's various business units. Lehman risk managers note steps have been and are being taken to ensure that clients can not arbitrage between different Lehman desks/businesses, and that all risks with respect to fund counterparties are transparent and understood by risk management. As mentioned previously, while prime brokerage activity is not currently consolidated with LehmanRisk in an automated matter, this is a project for 2005. Further, risk is viewed on a consolidated basis for certain counterparties on a periodic basis.

## IV. Risk Appetite

### a. Risk Appetite Components

The event risk component of RA simply reflects the event risk calculations discussed above in the business unit descriptions, e.g., for high yield defaults or equity dividend risk. By design, these event risk parameters are set under a one year, 95<sup>th</sup> percentile loss assumption. For example, the -25% shock applied to principal investments in commercial real estate represents the one year loss likely to occur with a one in twenty probability.<sup>87</sup> Given the one year time horizon and 95<sup>th</sup> percentile loss assumption, no transformations are required to find the point of interest in the distribution.

By contrast, Lehman's VaR must be transformed in order to put it on a comparable basis to event risk and the RA limits. Recall, the firm uses VaR as a risk measure reflecting the 95<sup>th</sup> percentile *daily* loss. To transform this metric into the market risk component in RA, it is simply annualized by using a square root of time scaling adjustment.<sup>88</sup> This puts market risk on equal footing with event risk and the RA limits.

The credit risk component of RA requires a more involved transformation. The counterparty component of risk appetite usage provides an estimate of the potential

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<sup>86</sup> The group directly responsible for monitoring margin calls, distributing call notices and monitoring significant changes in client account balances and cash movements reports into the Operations group. As suggested above, GCS Risk and CRM interact with the Margin group regularly as part of their daily monitoring processes.

<sup>87</sup> Note, for some businesses the specification of event risk parameters appears to be based more on intuition than empirical evidence. For instance, in the example above, whether the -25% shock truly represents a 95<sup>th</sup> percentile event is debatable.

<sup>88</sup> In short, market risk equals VaR x sqrt(252), assuming 252 trading days per year.

losses stemming from defaults of counterparties engaging in derivatives trading as well as financing transactions and prime brokerage activity. As with the rest of the risk appetite components, counterparty risk is a one year statistical measure - i.e., it is a 95<sup>th</sup> percentile statistic measuring potential credit losses over a one year horizon. Further, it is intended to capture the potential credit losses across all of the firm's counterparties. To truly estimate such a "joint loss distribution" requires much data collection and the capture of the correlation structures between many factors. PE, PD, and recovery rate estimates for each counterparty are required. In addition, in order to properly aggregate risk across counterparties, the correlation structures between counterparty defaults as well as between the risk factors driving PEs must be modeled.<sup>89</sup> Obtaining robust results for and/or effectively modeling all of these parameters is an extremely challenging task due to data availability and computational costs. In estimating this ambitious aggregate metric, Lehman relies upon several simplifying assumptions and uses various proxy techniques, as discussed below.

In order to estimate the potential credit losses associated with a particular counterparty, an exposure at default (EAD) is required. To estimate EAD, the EE and MPE curves discussed in the potential credit exposure section above are used. For emerging market and hedge fund counterparties one-year MPEs are used. For all other counterparties the average of the one year MPEs and EEs are used. However, Lehman does not simply use the MPE and EE from the first one year horizon modeled. Rather, a fairly intricate process is used for identifying the maximum one year exposures considering thirty one year intervals across the PE Curve. In other words, the "peak exposure year" for a counterparty is identified by evaluating the curve evolutions from year 0 to 1, year 1 to 2, .....year 29 to 30 as separate one year intervals.

"Risk exposure" is then calculated by multiplying EAD by loss given default (LGD), which is simply 1- the recovery rate. For a single counterparty, the 95<sup>th</sup> percentile loss number could next be estimated simply by multiplying risk exposure by the appropriate PD. However, Risk Appetite requires a joint (across all counterparties) loss estimate. Lehman accomplishes this by modeling each counterparty's default as an independent Bernoulli process. That is, each potential default is treated as completely uncorrelated with each of the other potential defaults. Then, the PDs and risk exposures for each counterparty are fed into a "binomial distribution calculator" to obtain the full distribution of credit loss estimates<sup>90</sup>. The procedure involves calculating the probability of each and every possible combination of counterparty defaults, using several numerical approximations to reduce computational cost<sup>91</sup>.

Lehman computes these counterparty risk results at various levels of aggregation. Ultimately, results are provided at four different business unit levels: the

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<sup>89</sup> Further, it can be argued that the correlation between PE and PD should also be somehow modeled to capture the "right way" versus "wrong way" nature of exposures. For instance, a counterparty that has sold put options on its own stock is more likely to default should those options come into-the-money from the option purchaser's perspective.

<sup>90</sup> A binomial distribution results from repeated trials from a Bernoulli distribution. A random variable that follows a Bernoulli distribution may take on two possible outcomes with some probability of success  $p$ . For instance, the flip of a coin is said to follow a Bernoulli distribution with  $p = 0.50$ . The binomial distribution provides the probability of obtaining some number of successes ( $S$ ) resulting from  $n$  Bernoulli trials. For instance, using the Bernoulli distribution, one could compute the probability of realizing exactly 5 heads outcomes resulting from 5 independent coin flips. Thus, under the Lehman framework, the default of any particular counterparty over a one year horizon is said to follow a Bernoulli distribution. Repeating this experiment for each counterparty yields a binomial distribution.

<sup>91</sup> In short, a full enumeration is performed on the first 13 counterparties. As additional counterparties are added, mass is added to the tail of the distribution through a type of marginal analysis.

firm level, division level, global business level, and regional business level. However, exposures must first be computed for the appropriate counterparty, legal agreement, and legal entity combinations and aggregated up. In doing so, Lehman categorizes counterparties into emerging markets and hedge fund versus all other counterparty types. This binary categorization becomes important for latter aggregation since different assumptions are made regarding the correlation between counterparty and market and event risks for these broad counterparty types. Counterparty risk appetite usage numbers are currently computed monthly. OPSRA staff are told the process is being streamlined to allow for more frequent calculations.

This risk aggregation framework requires PD and recovery rate estimates. Lehman recovery rates are industry based, primarily using Moody's research, and PDs are obtained by mapping ICRs to "modified" historical Moody's PDs. Given the limited number of default data available, obtaining robust results for a large portfolio of counterparties is challenging. OPSRA staff intends to examine closer in the future the internal processes used for determining and validating these RA inputs.<sup>92</sup> In addition, a challenge to aggregating risks across counterparties in this manner lies in capturing all of the appropriate correlations. For instance, three different counterparties trading interest rate, credit, and equity products are unlikely to reach their maximum potential credit exposures simultaneously, due to the imperfect correlation between risk factors. The Lehman potential exposure framework does not model correlations across these product areas, resulting effectively in the addition of inconsistent MPEs (under an assumption of perfect correlation) across product areas for the risk appetite calculation.<sup>93</sup> It could also be argued that the Lehman assumption of treating all defaults as independent events is unrealistic. For instance, one might argue there are common factors affecting the PDs of counterparties in the same industry (e.g., the US auto industry). These assumptions tend to offset one another – the first being conservative and the second aggressive.

#### b. Aggregation Process

After transforming each of the risk components into the same "units", one can aggregate them. To do so requires some specification of the correlation between the component risks: market risk, event risk and credit risk. Simply adding them together would implicitly assume complete correlation between the risk types – i.e., that the realized 95<sup>th</sup> percentile loss due to market factor movements occurs simultaneously with the realized 95<sup>th</sup> percentile loss due to events, as well as with the 95<sup>th</sup> percentile loss due to counterparty defaults. This is unlikely and would overstate the total risk, given that some diversification benefit is achieved across the various businesses. If the diversification benefit is overestimated, however, then the aggregate risk will be understated.

Lehman errs on the side of caution when considering market risk and credit risk exposure to emerging market firms and hedge funds (EMG/HF) by assuming perfect correlation – i.e., for total RA exposure calculation purposes, market risk and credit risk

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<sup>92</sup> Further, an alternative approach to using ratings based PDs is to use the PDs implied from traded credit products, an approach risk management has considered. As Lehman continues to develop and refine its risk aggregation framework, OPSRA staff will of course follow up with regard to any such enhancements.

<sup>93</sup> Although, in addition to performing simple sums across product level exposures, summing such exposures under an assumption of independence or 0 correlation is also feasible. QRM has expressed interest in moving to this approach, asserting this would produce more meaningful aggregate risk metrics and avoid the large investment required to build a full blown PE simulation across all products areas.

to EMG/HFs are simply added together. For the other risk components, however, Lehman assumes “50% correlation”. Technically, QRM takes the average between the RA resulting from a 100% correlation assumption between the remaining components (straight sum) and a 0% correlation assumption (square root of sum of squares). This computationally simple technique yields a result which reflects the intuition behind the diversification benefit. The magnitude of this benefit, however, is not guided by any empirical evidence.

These correlation assumptions explain why the component numbers do not sum “horizontally” to the RA exposure usage for each business unit. Similarly, the component numbers do not sum “vertically” for the market risk and credit risk totals because of the underlying mechanics of VaR and the binomial technique described above. The event risks by business are assumed to occur independent of each other, thus a sum of squares approach is used to arrive at the event risk total.<sup>94</sup>

Risk Appetite is also monitored on a geographic basis between Americas, Europe and Asia. No additional correlation assumptions are implied; rather the data is simply calculated at each regional level and reported accordingly.

### c. Risk Appetite Limitations

The RA framework requires significant amounts of judgment. For instance, In coming up with the firmwide RA limit, subjective determinations must be made regarding revenues in a down year, compensation adequacy, and minimally-acceptable ROTE. Similarly, though historical diversification provides a guide for the allocation of RA sub-limits, the business units essentially negotiate these allocations.

From a practical perspective, the RA exposure metric serves as a useful comprehensive risk tool for senior management. When used in conjunction with the “standard” risk management tools (daily VaR, MPE, etc.), RA may facilitate more active comprehensive risk management than most firms’ tools allow. However, from a statistical and financial theory perspective, the RA metric has some notable limitations. Whether it makes sense to compare one unit of market risk (from an annualized VaR) with one unit of credit risk (from a statistical aggregation technique) with one unit of event risk (from a set of subjectively specified stresses in some instances), is open to debate. Also, the degree of subjective parameterization which is required for the calculation to be made raises some questions. More broadly, while aggregating to a single metric is appealing, the benefits of doing so must be weighed against the risk of having risk measures become less meaningful.

Because of the practical usefulness of RA at the senior decision-making levels, processes and tools to maintain quality control over the metric are important. In this vein, fuller documentation of the assumptions behind the methodologies and theoretical and empirical bases underlying the specifications in the RA framework could help, particularly with regards to event risk. In addition, because RA exposures cannot be statistically backtested, a set of meaningful validation techniques may be warranted to alert RA users of potential weaknesses and/or distortions in the measurement.

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<sup>94</sup> Within each business, e.g., leveraged lending, certain correlation assumptions may be made, as described in the business unit discussions above.

## V. Areas of Focus

During the CSE review process at Lehman, OPSRA did not find any areas of immediate concern. Though our review uncovered no material deficiencies, we note below several areas deserving of ongoing monitoring by senior management and OPSRA. RMD recognizes the importance of these issues and has plans in place to address these concerns.

### a. Energy Trading

Lehman has recently stated, both publicly and in conversations with OPSRA, its intent to begin trading energy. As explained to OPSRA, this decision was not motivated by a desire to take advantage of the strong energy market and place proprietary positions. Rather, Lehman has a strong energy banking group. Many of their energy and gas clients have sought to hedge their exposure with Lehman, exposure that Lehman tends to consider right way.<sup>95</sup> Lehman has done a number of leveraged finance deals in this space, and determined that they would like to offer energy hedging capabilities to their clients. They have already entered into one relatively small position which was immediately back-to-backed with a larger bank, leaving Lehman exposed only to counterparty credit risk. They intend to build a team that could hedge this type of position directly in the energy markets.

At a logistical level, the traders will report to the head of Interest Rate trading. Lehman is in the process of building this group. The CRO indicated that Lehman is looking to hire two market risk managers, and two credit risk managers (possibly more in this area). They are looking to hire managers with a good deal of expertise, as this is not an area where Lehman has any recent experience. In addition, the other control functions, such as legal, TMG, and GMG, are looking to hire employees with industry expertise.

OPSRA spoke with members of the NPC about this business, and they explained that they will be reviewing the energy trading infrastructure prior to going live with the business. Their role will not be to evaluate this from a business perspective, as that decision was made by the Executive Committee when it decided to enter this business. Rather, they have the ability to evaluate the implementation, and slow down the process if necessary (e.g., if a control function is not yet comfortable with actual implementation).

OPSRA will be discussing this new line of business with Lehman in the months going forward, both to understand how the business is developing in terms of its scope and mandate, and to understand how MRM and CRM are getting comfortable with the risks present in the energy business.

### b. Risk Appetite

Lehman has an integrated approach to risk management that is distinctive among its peer firms. By closely aligning the market and credit risk functions, the firm is able to leverage personnel, analytics, systems, and information flows. Reporting to senior management reflects the integrated nature of risk management. Event risk, market risk, and counterparty credit risks are all presented individually to senior

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<sup>95</sup> The CRO described positions where the oil companies looked to hedge their production, and would owe Lehman money when oil prices were rising, a situation that represents right way exposure from a credit perspective.

management, as well as the aggregated RA number. The CRO stressed the importance of RA, in that it provides a number for senior management that exists within the context of the firm's budget, since the RA limit is derived from the overall firm fiscal year budget. In addition, while the absolute RA numbers may only be estimates, senior management can focus on the relative changes in RA usage, which provides a sense of the firm's current risk-taking activities. As for event risk, the CRO stated that without including the metric in some form of limit, it is difficult to get true buy-in across the firm. Capturing event risk in the RA calculation circumvents this potential problem.

RA has existed at the firm level for over five years, but was just rolled down to the business level in the current fiscal year. As Lehman continues to examine and refine the assumptions behind RA, and in particular the calculation of event risk, OPSRA will continue discussions about the both the qualitative and quantitative philosophies underlying this unique approach. The prior discussion on RA mentioned some of its limitations, and those will be addressed in subsequent meetings with RMD. In addition, RA is designed for Lehman's current business model: a firm with an overwhelmingly customer-driven business. At the point in time, Lehman does not have a large proprietary franchise. That said, at least two business heads (high grade credit and equity volatility) indicated their intention to grow the proprietary group within their jurisdiction. If Lehman's proprietary positions begin to grow accordingly, it would be prudent to revisit RA and the assumptions underlying the framework.

### c. Scenario Analysis

Stress testing, including historical or hypothetical scenario analysis, is required by Commission rules as well as Basel II. In the past, RMD has occasionally conducted ad-hoc scenario analysis calculations based on historical events and shared these results with senior management, including the Board of Directors. However, RMD has not previously conducted (or had the ability to conduct) scenario analysis on a periodic or automated basis.

QRM is currently developing the capability to perform automated scenario analysis. The plan is to run a fully-automated weekly calculation of various scenarios. Although the firm has not currently "locked down" the complete list of scenarios they plan to run, the eventual list will most likely include both historical market events of significance as well as hypothetical scenarios. The group expects to have this process completed by the end of the current year.

Once operational, RMD intends to use the automated scenario analysis as another monitoring tool that may help alert the Firm to particular concentrations in risk factors that have proved harmful in the past (i.e., historical scenarios) or alternatively for future concerns (i.e., hypothetical scenarios). However, unlike other aggregated risk factors, such as VaR, which have a statistical probability associated with them, the specifications of the various scenario analyses are so extreme that RMD does not believe there is a meaningful or credible way to assign probabilities to these events occurring. As such, they do not plan on using the automated scenarios for either limit-setting or internal capital allocating purposes.<sup>96</sup> Rather, RMD plans to disclose scenario results to senior management, among others, with the expectation that this will help focus senior management on risk positions, even though no limits are attached to these numbers.<sup>97</sup>

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<sup>96</sup> Some of LB's peer firms do have limits based on scenarios in addition to limits based on VaR and other measures as a way to manage the Firm's exposure to extreme events and to capture "fat tail" risk.

<sup>97</sup> In fact, it is anticipated that any outsized scenario results would result in conversations with senior

OPSRA will continue to monitor the developments in this area and expects to have further discussions with RMD personnel as the automated scenario analyses become operational.

#### d. PE Modeling Changes

QRM is investing in and planning to implement various enhancements to its PE framework. A top priority is to increase the coverage of transactions modeled in the fixed income Monte Carlo simulation model to include more exotic products (e.g., Bermudan swaptions). While QRM feels it will always need to use add-ons for certain trades, the goal is to increase the fixed income coverage to approximately 95% of transactions. Another top enhancement priority is to build a Monte Carlo simulation for credit derivatives. The plan is for the simulation to capture rating transitions and defaults as well as portfolio effects and netting and margining agreements, and will be parameterized from transition and default probability data similar to that discussed above. QRM has expressed that it hopes to have completed both of these projects by the end of 2005.

In addition, QRM is in the process of transitioning its financing simulation and equity derivatives VCV VaR covered products to the historical simulation based VaR approach. Thus, the long-run goal is to use some combination of Monte Carlo simulation and HistSim with limited add-ons to cover the full product spectrum. QRM personnel have also conveyed an interest in refining the modeling of margin provisions for equity derivative products and possibly moving non-margined equity portfolios to a Monte Carlo framework. The projects may be undertaken in 2006. OPSRA staff will continue to follow-up with regard to progress made towards all of these various planned enhancements, and will examine in some detail new methodologies after these are implemented.

#### e. VaR Backtesting and PE Validation

Currently, Lehman does monthly VaR backtesting on actual P&L provided by the controllers, and they have customized backtesting reports at both a divisional and business unit level. They are in the process of implementing automated daily backtesting at the firmwide and divisional levels, with this process going live in fall 2005. This formal backtesting will be done against "clean" P&L (i.e., P&L that has the fees and commissions removed). OPSRA will continue to monitor the backtesting initiatives, and ensure that backtesting approaches are within the guidelines specified by CSE.

CSE guidelines specify that PE models must be validated. OPSRA will continue to work with Lehman and the other CSE firms to develop empirical validation processes for the models. Lehman currently has plans in place to validate their PE model in two parts.<sup>98</sup> OPSRA will discuss with QRM on an ongoing basis validation efforts as they continue to develop and refine its approach to establishing comfort with model results in the context of the risk management uses for these metrics. Further, we intend to examine validation efforts and results on a more granular, product-by-product basis as progress is made.

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management similar to the discussions RMD has with senior management today concerning the top exposures reported.

<sup>98</sup> See Section III.b.i for a complete description of the validation plans.

#### f. Changes to Credit Limit Structure

Several changes are planned in the counterparty credit limit structure. First, Lehman is moving towards having all active counterparties, including hedge funds, operate under pre-approved limits and having infrequent users operate under trade-by-trade approval. In conjunction with this change, an MPE "What-If" analytics tool is being developed for traders and sales personnel. This tool will allow traders, from their desktops, to analyze the impact on MPE of proposed trades. Traders will then be able to determine if a trade will fit under the counterparty's pre-approved limit. Second, counterparty credit limits are delimited into product limits by Lehman legal entity. These cover specific product areas and are denominated in notional amounts. Currently, limits for repos, FX, and securities lending are expressed in notional amounts, but they are moving towards an MPE-based structure. Third, Lehman's firmwide country risk ELP limits are being revised. The ELP measure is a conservative estimation of the loss the Firm might experience in the event of an instantaneous crisis in a country. It estimates market risk and counterparty credit risk losses aggregated across all products at the country level. OPSRA staff will follow up with the changes in limits as they are implemented, and will monitor the impact of limit changes on risk-taking throughout the various businesses in the firm.

#### g. Internal Facility Ratings

Lehman currently assigns ICRs on a counterparty basis using the Scorecard application described in Section III.b.ii. CRM is expanding the scorecard application to assign Internal Facility Ratings. OPSRA will follow developments in this area, and will monitor how these facility ratings are used by CRM in risk governance.

#### h. Prime Brokerage

Given the growing importance of hedge funds as clients to securities firms and large banks, competition in this space is fierce. Commercial banks are attempting to break into the prime brokerage market by offering aggressive credit terms. In order for Lehman to grow its market share, it will be competing with these banks as well as Bear Stearns, Morgan Stanley, and Goldman Sachs, experienced players with larger market shares and longer histories in this space. This raises credit related concerns, given that, in order to expand its market share, Lehman could feel pressure to compete on credit terms. Thus, while the risk management of prime brokerage counterparties and hedge funds appears sufficient at this time, this is an area that warrants special attention going forward.

#### i. Model Control

As mentioned in the discussion on the model control function owned by QRM, it is OPSRA's opinion that Lehman has created a risk-based approach to model validation, implying that QRM spends the majority of their time on the models generating the greatest amount of risk. However, OPSRA has not heard this approach articulated as such by QRM, and the limited documentation does not clarify the philosophy underlying the newly implemented model control framework. We view the process as largely reflecting aspirations at this point in time, not surprisingly given that the policy is new. OPSRA will continue its discussions with QRM to ensure that the firm's models are being validated in a reasonable and timely manner.

## **VI. Conclusion**

Overall, OPSRA finds that the market and credit risk management function at Lehman is robust given their current risk profile. Taking into account planned enhancements such as VaR backtesting and PE validation, Lehman will meet or exceed the minimum CSE standards.

<b>Date</b>	<b>Title</b>	<b>Format</b>	<b>Team</b>
April 21, 2005	SEC Risk Review for CSE	Presentation	Market
April 28, 2005	SEC Review of Risk Management	Presentation	Market
May 10, 2005	U.S. Leveraged Loans Overview	Presentation	Market
May 10, 2005	Acquisition Finance	Presentation	Market
May 12, 2005	An Overview of the Mortgage Business	Presentation	Market
May 17, 2005	Fixed Income Finance SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Equity Finance SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Investment Management Division SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Securitized Products SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Equities SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Credit and Municipal Business SEC Risk Review for CSE	Presentation	Market
May 17, 2005	Liquid Markets SEC Risk Review for CSE	Presentation	Market
May 19, 2005	Risk Equity and Risk Appetite Models	Document request	Market
May 19, 2005	General Description of VaR Methodology	Document request	Market
May 19, 2005	Prime Brokerage	Presentation	Market
May 20, 2005	An Overview of the Municipal Markets	Presentation	Market
May 20, 2005	Credit Risk Systems	Presentation	Credit
May 20, 2005	Credit Risk Management	Presentation	Credit
May 20, 2005	General ICR Framework Scorecard Document & Appendices	Document request	Credit
May 23, 2005	Credit Risk Measurement	Presentation	Credit
May 25, 2005	An Overview of the High Grade Credit and CDO Businesses	Presentation	Market
May 25, 2005	An Overview of the Interest Rate Products Business and Liquid Markets Proprietary Trading	Presentation	Market
May 25, 2005	SEC Risk Appetite, Risk Equity Review for CSE	Presentation	Market
June 2, 2005	Capital Markets Product Control	Presentation	Market
June 2, 2005	Risk Management - Acquisition Finance	Presentation	Credit
June 2, 2005	Credit Policy Manual	Document request	Credit
June 2, 2005	Credit Risk Management Product Guidelines	Document request	Credit
June 2, 2005	Risk Management - Prime Brokerage	Presentation	Credit
June 2, 2005	Credit Risk Measurement	Document request	Credit
June 6, 2005	Global Volatility CSE Review	Presentation	Market
June 6, 2005	An Overview of the Global Real Estate Business	Presentation	Market
June 6, 2005	Market Risk Management Limit Policy	Document request	Market
June 6, 2005	Market Risk Management Policies & Procedures Manual	Document request	Market
June 6, 2005	Liquid Markets Proprietary: Risk Management Section of Product Binder	Document request	Market
June 6, 2005	Risk Arbitrage: Risk Management Section of Product Binder	Document request	Market
June 6, 2005	Derivatives Volatility: Risk Management Section of Product Binder	Document request	Market
June 6, 2005	Real Estate: Risk Management Section of Product Binder	Document request	Market

Appendix A: CSE review work papers

June 7, 2005	Risk Arbitrage Business Overview	Presentation	Market
June 7, 2005	Credit Risk Management Credit Review Request	Document request	Credit
June 7, 2005	Firmwide Risk Snapshot (2/25/05)	Document request	Credit
June 7, 2005	Daily Risk Appetite Report (2/28/05)	Document request	Credit
June 7, 2005	95% Daily VaR Usage and Limit (2/28/05)	Document request	Credit
June 7, 2005	Global Current Credit Exposure (CCE) Snapshot by ... (2/25/05)	Document request	Credit
June 7, 2005	NY Credit's CCE Snapshot by ... (2/25/05)	Document request	Credit
June 7, 2005	London Credit's CCE Snapshot by ... (2/25/05)	Document request	Credit
June 7, 2005	Asia Credit's CCE Snapshot by ... (2/25/05)	Document request	Credit
June 7, 2005	Country Risk Report (2/25/05)	Document request	Credit
June 10, 2005	Global Margin	Presentation	Credit
June 10, 2005	Transaction Management	Presentation	Credit
June 13, 2005	Real Estate: Business Overview Section of Product Binder	Document request	Market
June 13, 2005	Warehouse Lending Business	Presentation	Credit
June 15, 2005	SEC Risk Appetite Review	Presentation	Market
June 16, 2005	Municipals: Daily and Weekly Reports Used by Business	Document request	Market
June 16, 2005	Municipal Derivative Products: Risk Management Section of Product Binder	Document request	Market
June 20, 2005	New Products Committee Overview	Presentation	Market
June 20, 2005	Global Model Control Process	Presentation	Market
June 20, 2005	Equity Derivatives Model Control list	Document request	Market
June 20, 2005	Fixed Income - Interest Rate and Muni Derivatives Model Control list	Document request	Market
June 20, 2005	Sample E-mails from Large and Unusual Transactions	Document request	Market
June 20, 2005	Sample E-mails from Documenting Limit Monitoring	Document request	Market
July 11, 2005	Market Risk Management: Working List of Stress Scenarios	Document request	Market
July 11, 2005	Summary of Price Testing Results: April 2005	Document request	Market
July 11, 2005	Firmwide Risk Snapshot (6/24/05)	Document request	Market
July 12, 2005	Bond & Loan Commitment Committee/Bridge Loan Committee Memo re: Intelsat (7/7/04)	Document request	Credit
July 12, 2005	Commitments Reports highlighting Intelsat deal (8/03/04, 8/10/04, 8/17/04, 8/31/04, 9/7/04, 9/22/04, 10/12/04, 1/25/05)	Document request	Credit
July 12, 2005	Firmwide Risk Snapshot Report highlighting Intelsat deal (7/30/04, 8/6/04, 8/13/04, 8/27/04, 9/2/04, 9/17/04, 10/8/04)	Document request	Credit
July 12, 2005	Top Exposure Report highlighting Intelsat deal (8/10/04, 8/17/04, 8/31/04, 9/7/04, 9/22/04, 10/12/04, 1/25/05)	Document request	Credit
July 12, 2005	Intelsat Event Timeline with Marginal Risk Appetite Numbers	Document request	Credit
July 12, 2005	Equity Prime Brokerage description	Document request	Credit
July 12, 2005	Equity Finance Risk Management Daily Risk Report (5/30/05)	Document request	Credit
July 12, 2005	Prime Brokerage sample Margin Requirements agreement	Document request	Credit
July 12, 2005	List of prime broker accounts with lock up agreements for margin terms	Document request	Credit

Appendix A: CSE review work papers

July 12, 2005	Description of the stress testing/scenarios used by risk management in prime broker business	Document request	Credit
July 12, 2005	Statement of risk measures monitored by risk management in prime broker business	Document request	Credit
July 12, 2005	Statement of systems monitoring in prime broker business	Document request	Credit
July 14, 2005	Uses of Pre-Approved Limits in Credit Process (Current State)	Document request	Credit
July 14, 2005	U.S. Life Insurance Industry Sector Review (used in Credit Committee meeting)	Presentation	Credit
July 20, 2005	Historical Market Database - Overview	Document request	Market
July 20, 2005	Large Exposures Summary	Document request	Market
July 26, 2005	VaR Technical Specifications by Product	Document request	Market
August 1, 2005	MPEs by Counterparty, Product Group, Credit Rating, Industry	Document request	Credit
August 3, 2005	Credit Derivatives MPE Model	Document request	Credit
August 11, 2005	Estimated Loan Hedging Costs, Credit Facilitation Group	Document request	Credit
August 11, 2005	Building an Energy Trading Business	Document request	Market
August 22, 2005	Loan Participation Committee Memo (8/22/05)	Document request	Credit

**Meeting Attendee List (provided by Lehman)**

Tuesday, May 10<sup>th</sup>, 2005

- Leveraged Lending
  - Alex Kirk
  - Madelyn Antoncic

Thursday, May 12<sup>th</sup>, 2005

- Mortgages
  - Dave Sher
  - Madelyn Antoncic
  - Jeff Goodman
  - Edward Grieb
  - Gerard Reilly
  - Paul Shotton
  - Robyn Grew
  - Danielle McGraw
  - Lisa Rathgeber
  - Laura Vecchio
  - Anthony Stucchio
  - Louise Ratheram-Browne
  - Scott Simon
  - Scott Kimmel
  - Eduardo Canabarro
  - Beth Rudofker

Tuesday, May 17<sup>th</sup>, 2005

- Market Risk
  - Madelyn Antoncic
  - Paul Shotton
  - Anthony Stucchio
  - Laura Vecchio
  - Clelia Stegnjajic
  - Madelyn Antoncic

Thursday, May 19<sup>th</sup>, 2005

- Prime Brokerage Meeting
  - Ed Grieb
  - John Wickham
  - Richard Story
  - John McBryan
  - Marlisa Vinciguerra
  - Gerard Reilly
  - Jeffrey Glibert
  - Matthew Bowen
  - Madelyn Antoncic
  - Anthony Stucchio
  - Paul Shotton
  - Jeff Fernandez
  - Eduardo Canabarro
  - Beth Rudofker

Friday, May 20<sup>th</sup>, 2005

- Credit Analysis Meeting
  - Madelyn Antoncic
  - Jeff Glibert
  - Eduardo Canabarro
  - Steven Domenicucci
  - Steve Simonte
  - Eric Spray
  - Scott Burton
  - Anthony Stucchio
  - Robert Lutey
  - Martin Roberts
  
- Municipals Meeting
  - Paul Shotton
  - Joe Li
  - Madelyn Antoncic
  - Gary Killian
  - James Lister
  - Mike Bade
  - Scott Simon
  - Scott Kimmel
  - Robyn Grew
  - Beth Rudofker
  - Ed Grieb
  - Eduardo Canabarro
  - Anthony Stucchio
  - Gary Rosen
  - Laura Vecchio

Monday, May 23<sup>rd</sup>, 2005

- Credit Analytics Meeting
  - Jeff Glibert
  - Eduardo Canabarro

Tuesday, May 24<sup>th</sup>, 2005

- Quantitative Risk Meeting
  - Madelyn Antoncic
  - Eduardo Canabarro
  - Manhua Leng
  - Laura Vecchio
  - Anthony Stucchio
  - Paul Shotton

Wednesday, May 25<sup>th</sup>, 2005

- Interest Rate Products & Liquid Market Prop Meeting
  - Kaushik Amin
  - Madelyn Antoncic
  - Browning, James;
  - Simon, Scott A;
  - Paul Shotton
  - Melda Elagoz

Appendix B: Lehman staff consulted during CSE review

- Thomas Hawkins
- Gary Rosen
- Edward Grieb
- Beth Rudofker
- Eduardo Canabarro
- Anthony Stucchio
  
- Credit Products Meeting
  - Rick Reider
  - Jim Ballentine
  - Madelyn Antoncic
  - Paul Shotton
  - Joe Li
  - Shane Flatman
  - Gary Rosen
  - Ed Grieb
  - Beth Rudofker
  - Eduardo Canabarro
  - Anthony Stucchio
  - Laura Vecchio

Thursday, June 2<sup>nd</sup>, 2005

- Product Control Meeting
  - Gerard Reilly
  - Ed Grieb
  - Beth Rudofker
  - Scott Simon
  - Neerag Chopra
  - Anthony Stucchio
  - Laura Vecchio

Monday, June 6<sup>th</sup>, 2005

- Real Estate Meeting
  - Madelyn Antoncic
  - Mark Walsh
  - Kenneth Cohen
  - Jeffrey Goodman
  - Jonathan Cohen
  - Zev Klasewitz
  - Paul Shotton
  - Eduardo Canabarro
  - Lynn Gray
  - Paul Puskuldjian
  - Gary Rosen
  - Beth Rudofker
  - Ed Grieb
  - Laura Vecchio
  - Anthony Stucchio
  - Robyn Grew
  
- Volatility Business Meeting
  - Jon Neave

Appendix B: Lehman staff consulted during CSE review

- Jim Throsby
- Amit Airen
- Paul Shotton
- Madelyn Antoncic
- Spyros Papadakis
- Laura Vecchio
- Kenneth MacHarg
- Gerald Donini
- Anthony Stucchio
- Ed Grieb
- Jennifer Connors
- Robyn Grew

Tuesday, June 7<sup>th</sup>, 2005

- Risk Arbitrage Meeting
  - Madelyn Antoncic
  - Paul Shotton
  - Marc Paley
  - Manhua Leng
  - James Emmert
  - Beth Rudofker
  - Anthony Stucchio
  - Laura Vecchio
  - Ed Grieb
  - John Crowe
  - Robyn Grew

Friday, June 10<sup>th</sup>, 2005

- TMG Meeting
  - Scott Willoughby
  - Zdenka Griswold
  - Allyson Carine
  - Robert Guglielmo
  - Anthony Stucchio
  - Laura Vecchio
  - Ed Grieb
  - Beth Rudofker
  - Jeffrey Glibert
  - Stephen Vena
  - Alex Crepeau
  - Stewart Nineham
- Margin Group Meeting
  - Mark Malin
  - Stewart Nineham
  - Stephen Vena
  - Kendall McLaughlin
  - Alex Crepeau
  - Beth Rufoker
  - Ed Grieb
  - Anthony Stucchio

Appendix B: Lehman staff consulted during CSE review

- Laura Vecchio
- Jeffrey Glibert
- Joseph Lodato
- Robyn Grew
- Scott Willoughby

Monday, June 13<sup>th</sup>, 2005

- Warehouse Lending Meeting
  - Jeffrey Goodman
  - Steve Valentino
  - Errington Hibbert
  - Fred Madonna
  - Gordon Sweely
  - David Sherr
  - Paul Shotton
  - Jeffrey Glibert

Monday, June 20<sup>th</sup>, 2005

- Model Validation Meeting
  - Eduardo Canabarro
  - Jerry Rielly
  - Ed Grieb
  - Manhua Leng
  - Neeraj Chopra
  - Anthony Stucchio
  - Madelyn Antoncic
  - Beth Rudofker
  - Laura Vecchio

Thursday, June 23<sup>rd</sup>, 2005

- Hedging Discussion - Conference Call
  - Alex Kirk
  - Ed Grieb
  - Gary Rosen
  - Peter Chase
  - Jeff Glibert
  - Scott Kimmel
  - James Seery
  - Janice Mereglia

Tuesday, July 19<sup>th</sup>, 2005

- FRL's and Hedging Discussion Meeting
  - Rick Rieder
  - Raymond Kahn
  - Ed Grieb
  - Peter Chase
  - Gary Rosen
  - Scott Kimmel Peter Chase
  - Bari Wolfe
  - Jeffrey Glibert
  - Patrick McGarry
  - Joe Li

Appendix B: Lehman staff consulted during CSE review

- Greg Smith
- Laura Vecchio

Wednesday, July 20<sup>th</sup>, 2005

- Commitment Committee
  - Steven Berkenfeld
  - Kevin Genirs
  - Ed Grieb