Enterprise risk management at Munich re

Tony Green FSA, CERA, MAAA, MS, MPhil
Vice President ERM (North America Life)

May 17, 2012 ACHS Annual Meeting
Agenda

- Enterprise risk management
  - Risk strategy
  - Risk modeling
    - Credit risk
    - Insurance (aka biometric) risk
    - Pandemic risk
    - Market risk
    - Operational risk
  - 2011 ERC results
Risk strategy
## Munich Re's risk strategy

<table>
<thead>
<tr>
<th>Category</th>
<th>Risk criteria</th>
<th>Measure</th>
<th>Criteria's objective</th>
<th>ERM objective addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole portfolio criteria</td>
<td>Financial strength</td>
<td>· ERC · Rating · Solvency</td>
<td>Safeguarding sufficient excess capital and limiting frequency of negative economic results of Munich Re's entire risk portfolio</td>
<td>Maintaining Munich Re's financial strength, thereby ensuring that all liabilities to our clients can be met</td>
</tr>
<tr>
<td></td>
<td>Avoiding financial distress</td>
<td>Negative economic earnings tolerated every 10 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplementary criteria</td>
<td>· Peak risk management</td>
<td>VaR limits as % of AFR or limit for maximum exposure</td>
<td>Limiting losses from individual risks or accumulation exposure and liquidity risks that could endanger Munich Re's survival capability</td>
<td>Protecting and increasing the value of our shareholders' investment</td>
</tr>
<tr>
<td></td>
<td>· ALM limits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Liquidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other criteria</td>
<td>E.g.,</td>
<td>Individual risk limits in absolute value</td>
<td>Limiting risks that could sustainably damage the trust of stakeholders in Munich Re</td>
<td>Safeguarding Munich Re's reputation, thus perpetuating future business potential</td>
</tr>
<tr>
<td></td>
<td>· Counterparty-credit risk</td>
<td></td>
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<tr>
<td></td>
<td>· Single risks</td>
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<td></td>
<td>· Alternative investments</td>
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<td></td>
<td>· Non-investment-grade investments</td>
<td></td>
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</tbody>
</table>
Risk modeling
Quantitative risk modeling: Core element of ERM at Munich Re

Risk modeling
Central, competitive advantage balancing flexibility and stability

Risk steering
Risk triggers, limits and measures facilitate accountable management action

Risk management culture as a solid foundation

Risk identification and early warnings
Necessity of a panoramic vision with focus on core areas

ERM-cycle

Risk strategy
Set explicit limits
Clear internal and external signaling effect
Define framework for operative activities

Risk adequate" incentives and sustainable responsibility

Set explicit limits
Clear internal and external signaling effect
Define framework for operative activities

Comprehensive risk governance and effective risk management functions

"Risk adequate" incentives and sustainable responsibility
Quantitative risk modeling: Based on economic balance sheet concept

From an economic view, the following valuation principles prevail:

- Assets are valued at their observable market values.
- Liabilities are valued with techniques that are consistent with financial valuation principles, e.g., options and guarantees in primary life business are valued with risk-neutral valuation techniques.

The choice of the valuation principle is crucial for the risk measure.
Economic risk capital (ERC) = 175% VaR (99.5%)

Events that lead to a deviation of MCEV

- From the expected value
- Over a one year horizon
- 99.5th percentile = Solvency II standard
- Munich Re targets 175% of VaR(99.5%)
- Sufficient to maintain AA rating or VaR(99.97%)
All risks are separately analyzed and aggregated using the underlying risk drivers.

- **Credit**: Corporate bonds, Retro receivables, Deposit receivables
- **P&C Basic Risk**: Premium risk, Reserve risk
- **P&C Large Losses**: Nat Cat, Terror, Further large losses
- **Life & Health**: Mortality, Lapse, Incidence, Recovery, Dis. mortality, Calamity
- **Market**: Equities, Real estate, Interest rates, Exchange rates, Implied volatilities
- **Operational**: Fraud, Business interruption, Reporting, IT risks, Legal risks

Individual modeling of all risk drivers
Credit risk models quantify credit risks under consideration of portfolio effects:

- Default models: losses due to defaults are analysed.
- Mark-to-market models: in addition losses due to changes in market values of instruments are taken into account.

Munich Re uses economic CreditMetrics approach (mark-to-market model) implemented in the CreditManager software. Three main components:

- Change of credit quality of a counterparty over the horizon of the analysis (MRCM: 1 year) ➔ **Ratings** with respective transition probabilities
- Change of market value of an instrument taking into account possible changes in the credit quality of the issuer ➔ **Credit spreads, recovery rates**
- Dependency of changes in credit quality of several issuers ➔ **Correlations**
Credit risk modeling: Exposures from investments and other receivables considered

Market value and rating at the beginning of the one-year simulation horizon

Simulated credit quality in one year calibrated using transition probabilities

Revaluation using respective credit spread curves

Market value at the end of the simulation horizon

- Aggregated value distribution in one year
- Typically skewed distribution for credit risk
- Multitude of standard analysis available within the CreditManager
Life insurance risk

One-year horizon: goal is to capture the full distribution of “change in value” over one-year

Change in value can be broken down into two parts:

1. **Experience variance** = deviation in year 1 results

2. **Change in expectation of future** = change in expectation of cash flows in \( t > 1 \) after observing one year of experience

Change in embedded value = \( \Delta PVNCF_1 + E\{\Delta PVNCF_2^+ \mid \text{Experience Year 1}\} \)
Change in embedded value = $\Delta PVNCF_1 + E\{\Delta PVNCF_{2+} \mid \text{Experience Year 1}\}$

Experience variance: $\Delta PVNCF_1$ easy to simulate:
- Generate one-year incidence, termination, and lapse shocks
- Then recalculate net cash flows

Change in expectation: $E\{\Delta PVNCF_{2+} \mid \text{Experience Year 1}\}$
- Difficult to estimate: we are essentially trying to model the valuation actuary.
- Valuation function needs to be simple enough for reasonable run time.
The mortality risk driver is built up from four components:

- **Process risk:** Random fluctuation
- **Trend risk:** Long-term trends
- **Basis risk:** Future vs. experience used to develop assumptions
- **Calamity risk:** (Additive Model) Infrequent, catastrophic loss events

**Aggregation:** Assumed independence of risk components
Morbidity & Other risk drivers follow similar approach:
Built from a basket of up to four risk components
Example: Mortality risk driver is built up from four components

\[
\text{Simulated\_Mortality} = P \times B \times T \times \text{Best\_Estimate\_Mortality} + C
\]

The process, basis, trend random variables have mean = 100\%. The calamity random variable has a mean of 0.

So that \( E[\text{Simulated Mortality}] = \text{Best Estimate Mortality} \)

Simulate incidence, active life mortality, disabled life mortality, recovery, and lapse using Monte Carlo simulation (100,000+ iterations)
Example: Mortality risk driver is built up from four components

**Process Risk:** Random Fluctuation

- Does not depend on results in previous time steps
- Calibrated to our current portfolio characteristics. (e.g. larger portfolio $\Rightarrow$ smaller process risk; broader NAAR distribution $\Rightarrow$ higher process risk)

**Calamity:** influenza pandemic, other infectious diseases, terrorism

- Event frequency is drawn from a discrete random variable
- Severities, given that an event has occurred, are drawn from parametric distributions.
- The parametric models are calibrated to our simulation-based pandemic and terrorism models
Example: Mortality risk driver is built up from four components

**Basis Risk** \((B_t)\): Misestimation of the base assumption.

- Simulated values of \(B_t\) is dependent on the previous time step \((B_{t-1})\).
- Calibrated to MARC’s and Munich Re’s historical experience.
- Some expert judgment required as past experience is not always indicative of the future.
Example: Mortality risk driver is built up from four components

**Trend Risk:** Misestimation of the trend (e.g. mortality improvement) assumption.

- Based on the **Lee-Carter model**. $T_t$ has a mean of 100% and depends on results from the previous time step ($T_{t-1}$).

- Calibrated to observed long-term population mortality trends + some expert judgment required as past experience is not always indicative of the future.
Munich Re produces an event set of about 4,000 pandemic scenarios representing both influenza (flu) and emerging infectious diseases (EIDs).

Unique events are further defined by other important factors such as demographic impacts, national countermeasures and underwriting quality.

Likelihoods are assigned to each event through a commonly used approach called a susceptible, infected, and recovered (S-I-R) model which calibrates the event set against historical data.

The flexible model structure allows for sensitivity analysis across the event set.
Lethality and infectiousness: the defining characteristics of a pandemic outbreak

The **lethality** of a pandemic is measured by the deaths per case (DpC) the number of deaths given infection. DpC is typically calibrated to a Weibull distribution.

**Infectiousness** (R0) is the average number of people who are infected by an infected individual and are best fit with a lognormal distribution.

Combining the DpC and R0 reproduces historic pandemic events, i.e. the 1918 Spanish Influenza had (DpC, R0) of (2.5%, 2.25).
Results of pandemic model are incorporated into the current economic risk capital (ERC) framework. The models derive a total excess mortality - exceedence probability curve for each major business unit.

In order to compute required capital, the tail of the exceedence probability curve is fit to a Pareto distribution.

The nature of the Munich Re ERC model incorporates the pandemic model directly for each business unit and product line.

This flexibility allows detailed analysis of total pandemic risk at the group level, and for each new deal.
Market risks: Analyzed in Algorithmics based on replicating portfolios

Group-wide consistent measurement of all capital market risks (assets and liabilities) in one system:
- Consistent modelling of all capital market risks
- “Use Test“ by applying identical methods and portfolios in risk modelling and steering by MEAG during the period guaranteed
- Implementation in the software “Algorithmics“, which is available on the market and which is about to become a standard product (used by Allianz, AXA, ING, Zürich et al.)
- Group-wide access to the system for asset manager (MEAG), risk manager (IRM), and CIO functions (ALM)
- Transparency with respect to portfolios and methods used
- Numerous evaluations for different purposes available
- Partly based on proprietary data and methods (e.g. modeling of risk drivers, valuation functions)
Market risk modeling: Stochastic risk drivers and valuation function in Algorithmics

**Risk drivers**

- Determination of type and number of risk drivers over all portfolios
- Stochastic modeling of risk drivers over a time horizon of one year considering the correlation structure

**Valuation function**

- Previously first and second order approximation used
- Step-wise migration to “full valuation” mode from Q2-2010 onwards (especially important for with-profits business in life and all derivative positions)

Value of Put-Equity option

---

Profit/Loss

---

Frequency

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Profit/Loss

---

Equity value

---

Profit/Loss

---

Equity value

---

VaR

---

Profit/Loss

---

Frequency

---
Operational risk: Representation within the MRCM

<table>
<thead>
<tr>
<th>Process to determine ERC for operational risks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk categorization</strong></td>
</tr>
<tr>
<td>• Separation in primary and reinsurance segment due to the different business models</td>
</tr>
<tr>
<td>• Categorization based on business processes</td>
</tr>
<tr>
<td>• Based on ORIC1-categories</td>
</tr>
<tr>
<td><strong>Scenario development and evaluation</strong></td>
</tr>
<tr>
<td>• Development of representative scenarios based on the chosen categorisation (materiality)</td>
</tr>
<tr>
<td>• Setting probabilities and severities for the scenarios (expert estimates)</td>
</tr>
<tr>
<td>• In the future: Link to ICS</td>
</tr>
<tr>
<td><strong>Stochastic modelling</strong></td>
</tr>
<tr>
<td>• Refinement of critical scenarios (M&amp;A, antitrust, business interruption ERGO) through techniques from property / casualty modelling</td>
</tr>
<tr>
<td>• Use of Bernoulli-models2 for the other scenarios</td>
</tr>
<tr>
<td><strong>ERC-determination and allocation</strong></td>
</tr>
<tr>
<td>• Scenarios within RI and PI deemed uncorrelated</td>
</tr>
<tr>
<td>• Assumption of a 50% correlation between RI and PI</td>
</tr>
<tr>
<td>• Tail-dependency between technical and operational risks</td>
</tr>
</tbody>
</table>

The evaluation of operational risk within the MRCM proceeds along the corresponding business processes.

1 ORIC = Operational Risk Insurance Consortium
2 Bernoulli-model: Model with a deterministic loss, which can occur with a specific probability exactly once (0-1-situation)
Munich Re uses a collection of profit metrics and other analyses to measure the inherent profitability of new business, including:

1. IRR Spread
2. Return on Risk Adjusted Capital
3. Profit Margin
4. Pandemic Exposure & Impact
5. Both 1 & 2 using Rating Agency Capital
6. Credit Risk analysis
Risk results & Opportunities
Munich Re: A leading global (re)insurer

Key business segments

Reinsurance

- Leading expertise worldwide for 130 years
- Full range of products: From traditional reinsurance to alternative risk financing
- Diversification – A key success factor

Primary Insurance

- Germany-based with presence in attractive growth markets in Eastern Europe and Asia
- Offers P-C, life and German health insurance
- Multi-channel sales strategy and a powerful new brand

Munich Health

- A leading specialised risk carrier in selected international health markets
- Unique selling proposition: Flexible combination of business models and products across healthcare sector value chain

Premium breakdown by segment 2011

<table>
<thead>
<tr>
<th>Segment</th>
<th>Premium 2011 Q1–4 (€bn)</th>
<th>2011 vs 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinsurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property-casualty</td>
<td>€16.9bn (33%)</td>
<td>▲ 7.7%</td>
</tr>
<tr>
<td>Life</td>
<td>€9.6bn (19%)</td>
<td>▲ 21.5%</td>
</tr>
<tr>
<td>Munich Health</td>
<td>€6.1bn (12%)</td>
<td>▲ 19.3%</td>
</tr>
<tr>
<td>Total</td>
<td>€49.6bn</td>
<td></td>
</tr>
</tbody>
</table>

Premium breakdown by geography 2011

<table>
<thead>
<tr>
<th>Region</th>
<th>Premium 2011 Q1–4 (€bn)</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>€27.2bn (55%)</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>€14.9bn (30%)</td>
<td></td>
</tr>
<tr>
<td>Asia and Australasia</td>
<td>€5.0bn (10%)</td>
<td></td>
</tr>
<tr>
<td>Africa, Near and Middle East</td>
<td>€1.0bn (2%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>€49.6bn</td>
<td></td>
</tr>
</tbody>
</table>

1 Consolidated figures.
2 2011 compared to 2010.
## Breakdown of group required economic risk capital (ERC)

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Year end</th>
<th>Group</th>
<th>RI</th>
<th>PI</th>
<th>MH</th>
<th>Div.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property-casualty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.9</td>
<td>9.5</td>
<td>9.4</td>
<td>0.6</td>
<td>–</td>
<td>–0.5</td>
<td>Slightly higher exposure in natural catastrophes scenarios (partly driven by model enhancements)</td>
</tr>
<tr>
<td>Life and health</td>
<td>5.1</td>
<td>6.6</td>
<td>4.8</td>
<td>2.5</td>
<td>0.6</td>
<td>–1.3</td>
<td>Lower interest rate environment</td>
</tr>
<tr>
<td>Market</td>
<td>9.9</td>
<td>11.4</td>
<td>5.7</td>
<td>8.5</td>
<td>–</td>
<td>–2.8</td>
<td>Increase mainly driven by lower interest rates and higher implied volatility</td>
</tr>
<tr>
<td>Credit</td>
<td>4.5</td>
<td>6.7</td>
<td>4.5</td>
<td>2.2</td>
<td>–</td>
<td>–</td>
<td>Strong increase mainly driven by lower interest rates, downgrades of counterparties</td>
</tr>
<tr>
<td>Operational risk</td>
<td>1.6</td>
<td>1.2</td>
<td>0.9</td>
<td>0.6</td>
<td>0.1</td>
<td>–0.4</td>
<td>Refinement of operational risk scenario set</td>
</tr>
<tr>
<td>Simple sum</td>
<td>30.0</td>
<td>35.4</td>
<td>25.3</td>
<td>14.4</td>
<td>0.7</td>
<td>–5.0</td>
<td></td>
</tr>
<tr>
<td>Diversification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>effect</td>
<td>–9.3</td>
<td>–11.0</td>
<td>–8.8</td>
<td>–3.1</td>
<td>–</td>
<td>–</td>
<td>Slightly higher diversification due to increases in risk exposures</td>
</tr>
<tr>
<td>Total ERC</td>
<td>20.7</td>
<td>24.4</td>
<td>16.5</td>
<td>11.3</td>
<td>0.7</td>
<td>–4.1</td>
<td></td>
</tr>
</tbody>
</table>

1 Risk categories broadly based on refined "Fischer II" risk categories recommended for standardised industry disclosures.  
2 Credit (re)insurance included. 3 Default and migration risk.  
4 The measured diversification effect depends on the risk categories considered and the explicit modelling of fungibility constraints.
# Summary of economic capital disclosure

## Position as at 31 December 2011

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Available financial resources (AFR)</strong></td>
<td>28.3</td>
<td>29.6</td>
</tr>
<tr>
<td><strong>Economic risk capital</strong></td>
<td>24.4</td>
<td>20.7</td>
</tr>
<tr>
<td><strong>Economic capital buffer</strong></td>
<td>3.9</td>
<td>8.9</td>
</tr>
<tr>
<td><strong>Economic capital buffer after share buy-back and dividends</strong></td>
<td>2.8</td>
<td>7.4</td>
</tr>
</tbody>
</table>

- **Solvency II capital**
- **Hybrid capital**

Solid capitalization in challenging times. Economic solvency ratio at 111% according to internal model and 194% at Solvency II calibration.

1. Solvency II capital based on VaR 99.5%, Munich Re internal risk model based on 175% of Solvency II capital.
2. After announced dividend payout of ~€1.1bn for 2011 to be paid in April 2012.
3. Without recognition of the impact of restatement in the AFR at 105%.
Sensitivities of Munich Re Group's economic solvency ratio

### Economic solvency ratio1 – Sensitivity

<table>
<thead>
<tr>
<th>%</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio as at 31.12.11</td>
<td></td>
</tr>
<tr>
<td>Interest-rate +100bps</td>
<td></td>
</tr>
<tr>
<td>Interest-rate −100bps</td>
<td></td>
</tr>
<tr>
<td>Spread +100bps</td>
<td></td>
</tr>
<tr>
<td>Equity markets +30%</td>
<td></td>
</tr>
<tr>
<td>Equity markets −30%</td>
<td></td>
</tr>
</tbody>
</table>

### Key observations

- Opposite interest-rate sensitivities in reinsurance and primary insurance mitigate sensitivity at Group level
- Even further deterioration of the interest rate environment would result in Group Solvency ratio well above the internal limit
- Moderate equity exposure leads to low sensitivity

Limit at 80% according to Munich Re’s risk strategy

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Munich Re able to withstand further stress scenarios

1 Solvency ratio defined as Available Financial Resources (AFR) over capital requirement; AFR after announced dividend for 2011 of ~€1.1bn to be paid in April 2012.
Thank you