The Actuarial Profession
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GIRO Convention

23-26 September 2008
Hilton Sorrento Palace

Risk Aggregation in a Multi-Line, Multi-Entity Group

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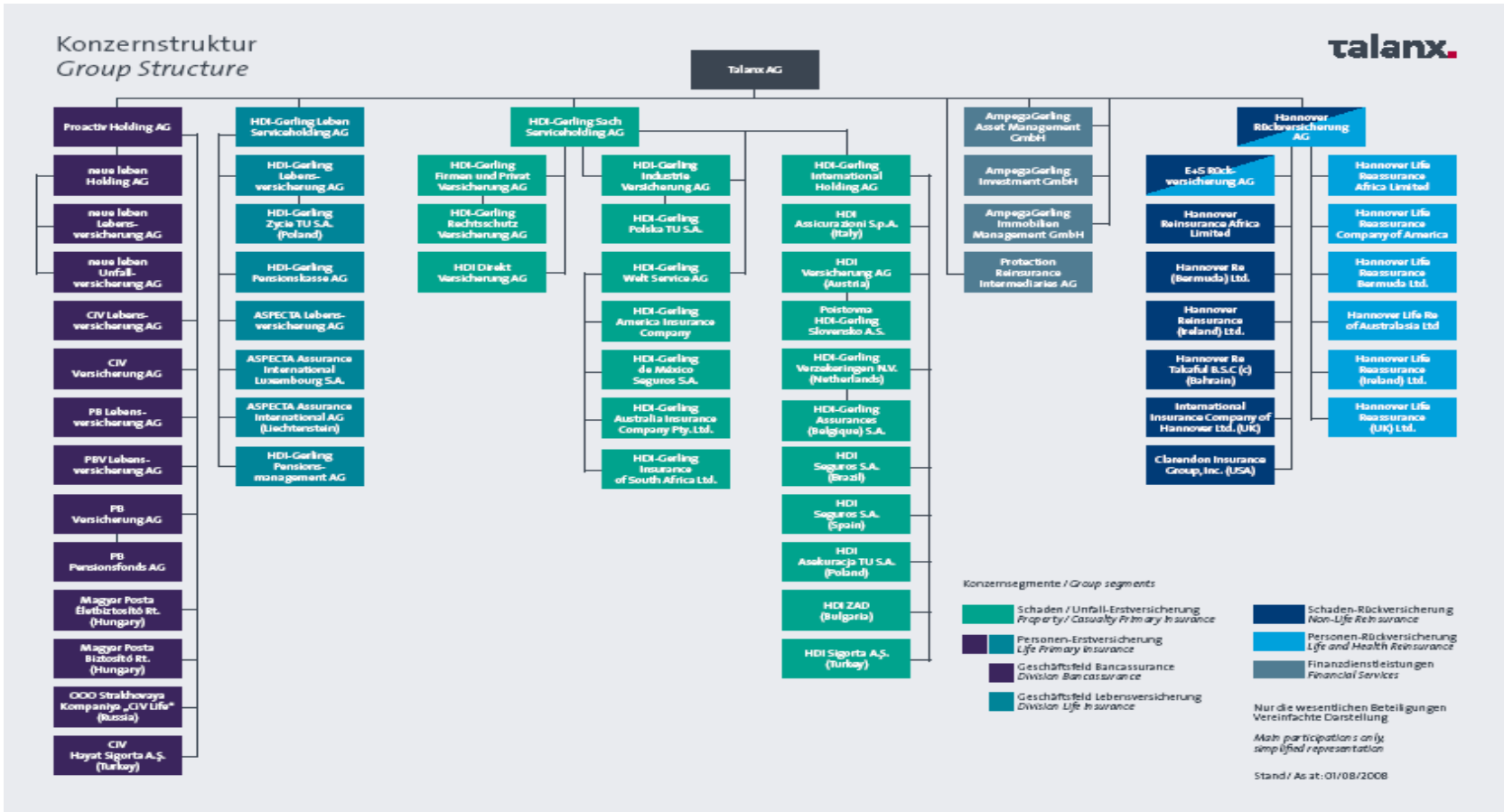
Talanx Group: a Multi-Line, Multi-Entity Group Domiciled in Hanover, Germany



Talanx Group: History and Evolution

- **1903**: founding of *Hafpflichtverband der deutschen Eisen- und Stahlindustrie*
- **1936**: drop "*Eisen- und Stahl*" to become simply *HDI*
- **1953**: offer insurance to non-members
- **1970**: merge with *Feuerschadenverband rheinisch-westfälischer Zechen*, owner of *Hannover Re* (est. 1966)
- **1991**: start to offer life insurance
- **1994**: partial spin-off of *Hannover Re* through IPO
- **1996**: group restructured under *HDI Beteiligung AG*, a non-listed stock company, wholly owned by *HDI V.a.G.*
- **1998**: renaming of holding company as *Talanx AG*
- **2006**: acquired *Gerling* life and property-casualty companies (est. 1904)
- **2007**: €19 billion gross written premiums, number 3 insurance group in Germany

Talanx Group: Risk Modelling Situation

- Talanx Group comprises numerous, diverse companies
  - Bancassurance, Life assurance, primary Property-Casualty insurance (industrial, commercial, private), Life and Health reinsurance, Property-Casualty reinsurance, asset management
- Traditionally these have been operated “federally”
  - Five divisions, several brands in each
- Impact on risk modelling
  - Companies have made different choices for modelling
  - Companies are at different levels of sophistication
  - Recently acquired companies (Gerling) contribute to the complexity

Talanx Group: Risk Modelling Challenge

- Develop a risk aggregation process meeting the Group's need for
  - economically sound financial and risk management
  - an internal model for Solvency II, certifiable by the regulators
  - cost effectiveness
- …and that
  - Preserves the federal culture of the group
  - Achieves maximum buy-in from local management
  - Leverages the value of the modelling work already carried out
  - Maintains strong connection between modelling and managing
  - Provides a step by step progression route for smaller companies with more limited resources

How to Handle Risk Aggregation?
Different Ways to Solve the Problem

- 1. Single risk modelling system
  - One big model for the whole group
  - Links together sub-models for each operating company using the same modelling system
- 2. Aggregate risk bottom-up using correlation matrix
  - Each operating company's model feeds into correlation matrix
- 3. Simulation-based bottom-up aggregation
  - Companies' existing models feed scenario results
  - Aggregates scenario-by-scenario

How to Handle Risk Aggregation?
1. Single Risk Modelling System

- How it works
  - Companies convert existing models to the selected system
  - Companies' sub-models use consistent assumptions
  - Companies provide their sub-models to the centre
  - Sub-models linked together in large Group model run centrally
- Features and requirements
  - Potentially costly and time consuming
  - Training effort and learning curve for everyone
  - Possible disconnection from existing models and applications
  - Possible duplication of effort (if continue existing models in parallel)
  - Confusion and ambiguity about which one is the real model
- Conclusions
  - Highly complex solution but highly consistent for detailed Group management information

How to Handle Risk Aggregation?
2. Bottom-up Correlation Matrix Approach

- How it works
  - Model sources of risk separately
  - Superimpose correlation / dependence structure using correlation assumptions
  - Calibrate to individual companies' own models where possible
- Features and requirements
  - Large disconnect from existing models and applications (connection not transparent enough)
  - Significant calibration issues (correlations pulled out of thin air)
  - Suspect quality of information for group management (inadequate information, single number, lack of intermediate results, lack of explanation of what is driving the results)
- Conclusions
  - Simple and quick but provides only limited (and sometimes wrong) management information

How to Handle Risk Aggregation?
Correlation Matrix Approach: S.II QIS4*

QIS4 builds SCR bottom-up

$$SCR = BSCR - Adj + SCR_{Op}$$

QIS4 formula for BSCR

$$BSCR = \sqrt{\sum_{rxc} CorrSCR_{r,c} \cdot SCR_r \cdot SCR_c}\ ,$$

where

$CorrSCR_{r,c}$	=	the cells of the correlation matrix CorrSCR
SCR_r, SCR_c	=	Capital charges for the individual SCR risks according to the rows and columns of the correlation matrix CorrSCR
Adj_{FDB}	=	Adjustment for the risk absorbing effect of future profit sharing
Adj_{DT}	=	Adjustment for the risk absorbing effect of deferred taxes

and CorrSCR is defined as follows:

$CorrSCR=$	SCR_{mkt}	SCR_{def}	SCR_{life}	SCR_{health}	SCR_{nl}
SCR_{mkt}	1				
SCR_{def}	0.25	1			
SCR_{life}	0.25	0.25	1		
SCR_{health}	0.25	0.25	0.25	1	
SCR_{nl}	0.25	0.5	0	0.25[30]	1

QIS4 formula for Market Risk SCR

$$SCR_{mkt} = \sqrt{\sum_{rxc} CorrMkt_{r,c} \bullet Mkt_r \bullet Mkt_c}$$

where

$CorrMkt_{r,c}$	=	the cells of the correlation matrix CorrMkt
Mkt_r, Mkt_c	=	Capital charges for the individual market risks according to the rows and columns of the correlation matrix CorrMkt

and the correlation matrix CorrMkt is defined as:

$CorrMkt$	Mkt_{int}	1. Mkt_{eq}	2. Mkt_{prop}	3. Mkt_{sp}	4. Mkt_{conc}	5. Mkt_{fx}
Mkt_{int}	1					
Mkt_{eq}	0	1				
Mkt_{prop}	0.5	0.75	1			
Mkt_{sp}	0.25	0.25	0.25	1		
Mkt_{conc}	0	0	0	0	1	
Mkt_{fx}	0.25	0.25	0.25	0.25	0	1

...and so on through a cascade process

*Source: http://ec.europa.eu/internal_market/insurance/docs/solvency/qis4/technical_specifications_2008_en.pdf

How to Handle Risk Aggregation?
3. Simulation-based Bottom-up Approach

- How it works
  - Companies continue with existing solutions (based on stochastic simulations)
  - Standardize the theoretical risk measure (definition of economic capital)
  - Apply consistent risk parameters
  - Aggregation tool combines individual model results
- Features and requirements
  - Analyze dependencies into environmental, causal (functional) and statistical
  - Standardize the environmental (economic and nat cat) scenarios used
  - Require minimum degree of granularity of individual models
  - Needs new aggregation tool to be built
  - Provide simple (balance sheet based) tool for less sophisticated companies
- Conclusions
  - Leverages existing models
  - Enhances group management information (more granular information)
  - Captures the key dependencies applying the 80/20 rule
  - Continues the existing federal approach

How to Handle Risk Aggregation?
Summary: Talanx Solution

Solution	Advantage	Disadvantage
Single Consistent Model for all Lines and Entities	High Consistency for maximal Management Information	High Complexity, may demand one Software Solution for everyone
Factor Model with Aggregation by a Correlation Matrix	Quick and simple Solution	Limited (possibly even wrong) Management Information
Federal Approach with consistent Risk Collector Aggregation	Feasible Solution with sufficient consistency for Management Information	Compromise - does not achieve maximal Management Information

Talanx Solution.

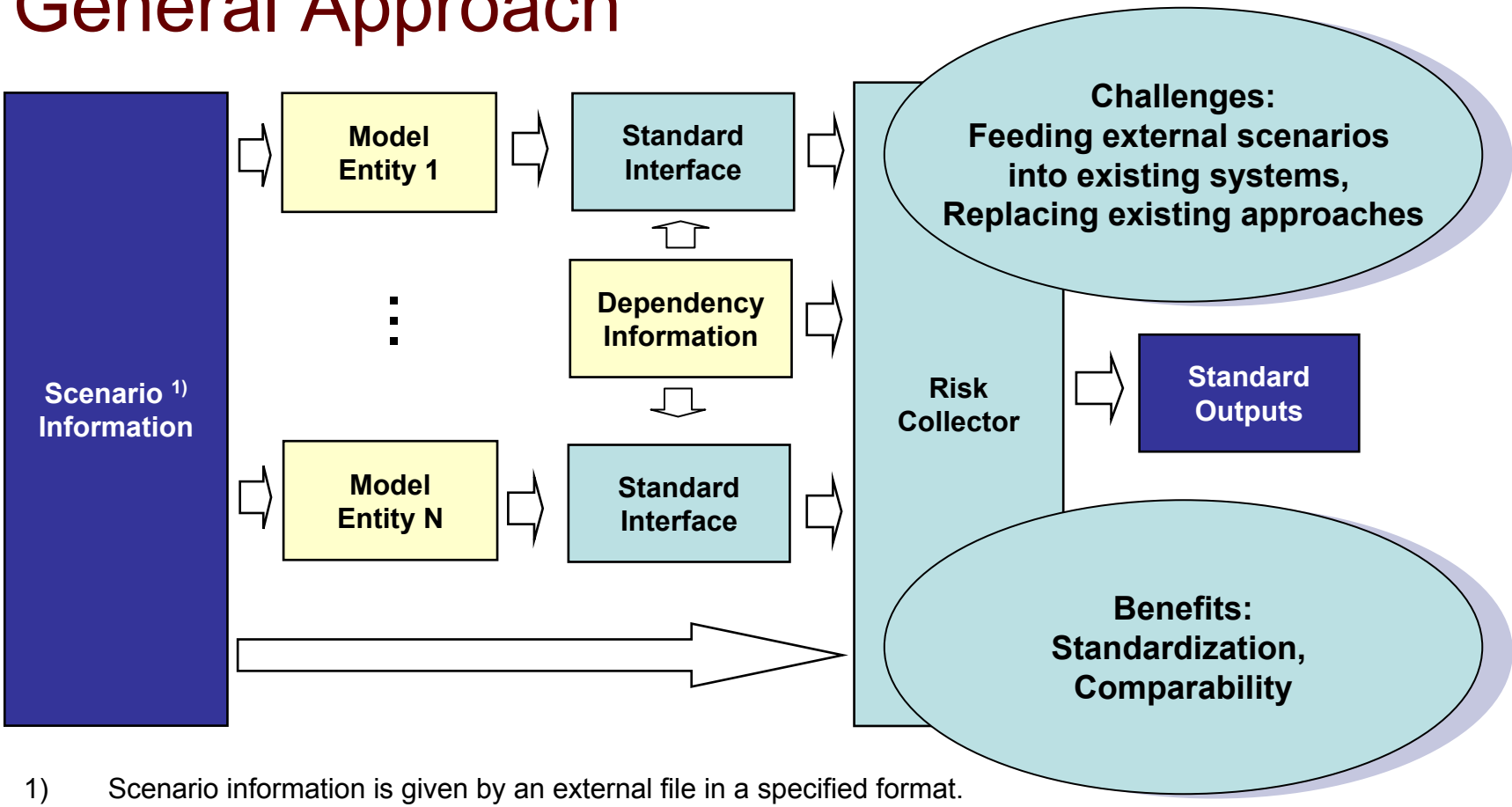
Talanx Group: Risk Aggregation
Key Components of Chosen Solution

- Consistent management metric – net worth to shareholders
  - Economic Capital (P&C)
  - Embedded Value (Life)
- Standardized environmental scenarios
  - Economic scenarios
  - Catastrophe scenarios
- Aggregation tool – “Risk Collector”
  - Stochastic
  - Modular
  - Standard data interface
- Base model + standard parametrization
  - For operating companies lacking (as yet) a full internal model

Risk Collector Concept: Architecture
General Approach

- Tool that establishes a stochastic economic group balance sheet
  - Flexible definition of **balance sheet entries**
  - Consistent treatment of **capital market and nat cat scenario** information
- The properties of a balance sheet entry are defined by
  - Information in a given interface not by special formulas in the program
  - The program simply has to resample individual entities' results based on the input distributions defined from the individual systems
  - Balance sheet entries may be original or "linked" stochastic variables
  - The stochastic distribution and / or the linkage are defined in the interface
- This enables the aggregation of the balance sheets of individual entities to a group balance sheet in a consistent way
- The interface supports a "RC base model"
  - Entities without an individual model can also be included in the risk aggregation

Risk Collector Concept: Architecture
General Approach



1) Scenario information is given by an external file in a specified format.

Risk Collector Concept: Architecture
Stochastic Dependencies

Path identity

The implementation of capital market and Nat Cat scenarios enables a consistent treatment of stochastic dependency through the external environment.

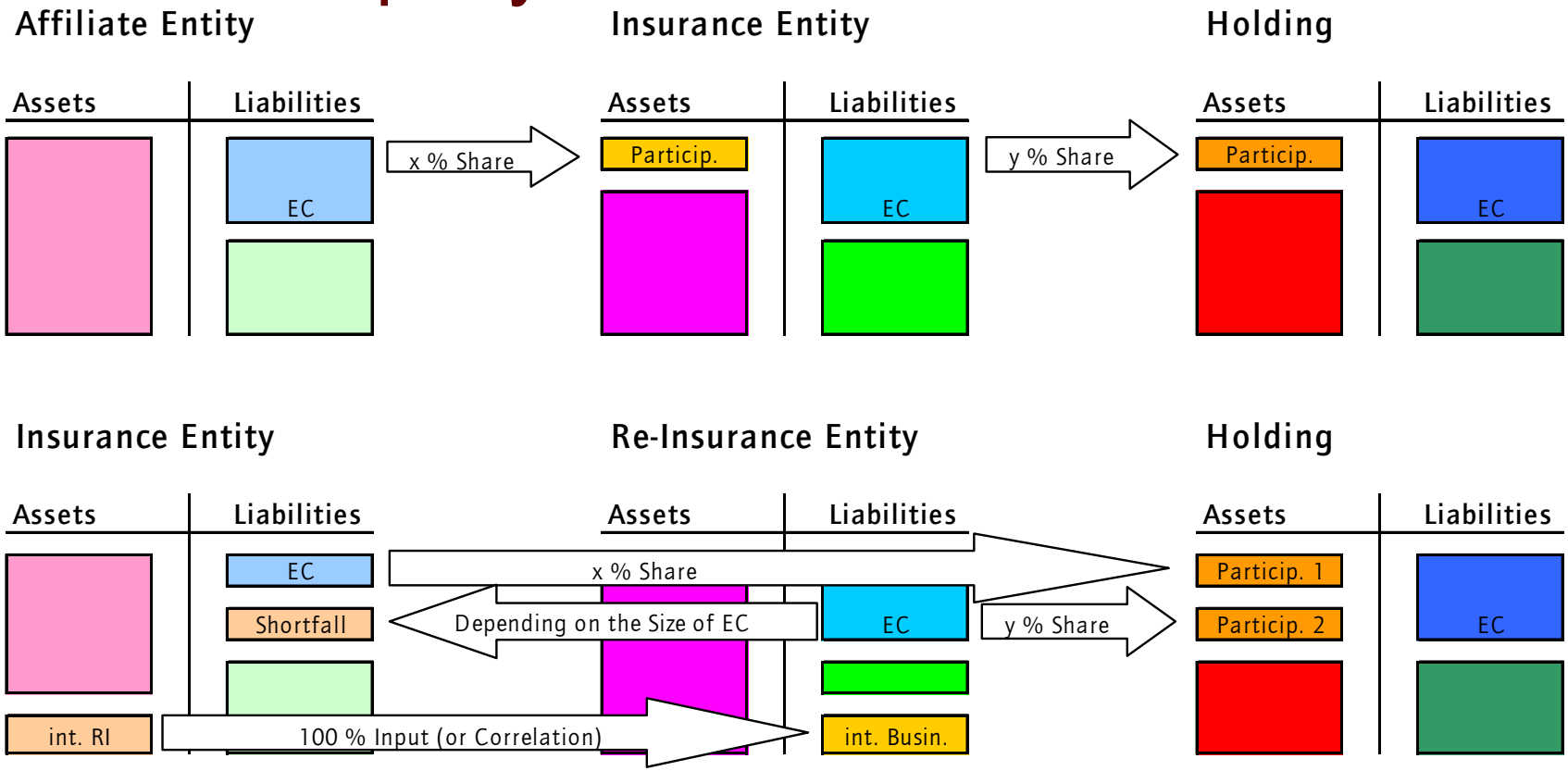
Linkage

A stochastic variable can be defined as a function of other stochastic variables. Pre-defined (system) and user-defined functions and transformations (e.g. linear splines) are permitted.

Correlation

Two original stochastic variables can be linked by (rank) correlation with copulas in the usual way.

Risk Collector Concept: Architecture
Intercompany Transactions



Risk Collector Concept: Data Interface General Structure

Identification of a Balance Sheet Entry	Identification of linked Balance Sheet Entries	Run Indices	Data Group	Description	Linked Entries	Distribution	Tax	Capital Costs	Cash Flow
				Description of the Balance Sheet Entry	Information needed to steer Linkage	Information needed to define original stochastic Variables	Information needed to steer Tax Treatment	Information needed to steer Capital Cost Treatment	Information needed to steer Market Scenario Treamtment

The complexity of the data interface is determined by the Risk Collector base model, where the RC can treat original as well as derived stochastic variables.

Risk Collector Concept: Data Interface
Calculation Scheme for the RC Base Model

Entity	Business	Business Period [1]	Evaluation Period	Balance Sheet Category [2]	Balance Sheet Line [2]	Data Item	Link Value	Stochastic Multiplier	Base Value	Market Factor	Market Adjusted Value	Capital Costs	Fair Value	Latent Tax	Fair Value inklusive Latent Tax
1	Old		2007	Asset	1		1,0	1.000,0	1.000,0	0,987	987,0	-87,0	900,0	35,0	935,0
1	Old		2007	Liability	2		1.000,0	0,1	100,0	1,000	100,0	0,0	100,0	-35,0	65,0

The calculation scheme covers original as well as derived stochastic variables. It is trivial for internal models.

Risk Collector Concept: Data Interface Layout of the Output

Business	Balance Sheet Category	
Old	**Asset** Analogous to asset positions, usually with positive sign.	**Liability** Analogous to Liability positions, usually with positive sign.
	Netted Analogous to P/L positions, with positive as well as negative sign.	**Surplus** = ∑ Assets + ∑ Netted - ∑ Liabilities. Internal Variable calculated by the RC.
New	**Asset** Analogous to asset positions, usually with positive sign.	**Liability** Analogous to Liability positions, usually with positive sign.
	Netted Analogous to P/L positions, with positive as well as negative sign.	**Surplus** = ∑ Assets + ∑ Netted - ∑ Liabilities. Internal Variable calculated by the RC.
Not Assigned	**Asset** Analogous to asset positions, usually with positive sign.	**Liability** Analogous to Liability positions, usually with positive sign.
	Netted Analogous to P/L positions, with positive as well as negative sign.	**Surplus** = ∑ Assets + ∑ Netted - ∑ Liabilities. Internal Variable calculated by the RC.
Total		**Surplus** Sum of all Surplus.

Risk Collector Concept: Group Issues Necessary Supplements

- Severe losses in a subsidiary requires a capital transfer
- Operational losses (modelled at group level) affect several companies simultaneously
- Life company's operational losses may be partially absorbed by policyholders

Risk Collector architecture
allows Management Rules like these to be included
Work in progress: multi-period functionality

Risk Collector Implementation
Standard Outputs – 1

Economic Balance Sheet in Mio. €

Entity: SV2_AG, evaluation period: 2007, paths selected (125): All

				Balance Column / Values							
				Asset / Netted			Liability / Surplus				
Business	Business Period	Balance Sheet Category	Balance Sheet Line	Fair Value	Latent Tax	Fair Value After Tax	Fair Value	Latent Tax	Fair Value After Tax	Non Linear Tax Effect	Economic Capital
Old		Asset	231 Fixed Income	629.126,0	1.772,8	630.898,7					
			239 Other Income	0,5	270.325,1	270.325,6					
			4011 Internal Reinsurance SRV1	605.524,1	-204.189,0	401.335,1					
			402 External reinsurance	153.427,0	15.999,5	169.426,6					
			9 Other Assets	65.681,6	22.965,0	88.646,7					
		Netted	2214 Participation SRV1	87.582,0	889,0	88.471,0					
		Liability	33 Reserves				895.955,6	19.363,9	915.319,5		
			3411 Default Internal Reinsurance SRV1				43.686,6	-15.360,3	28.526,3		
			342 Default External Reinsurance				2.444,9	-855,7	1.589,2		
			4311 Default Fixed Income				3.263,1	-1.142,1	2.121,0		
			4319 Default Other Income				0,0	-0,0	0,0		
			432 Cash Flow Mismatch				15.984,9	-5.594,7	10.390,2		
			9 Other Liabilities				255.575,4	2.924,5	258.499,8		
	Total Old	Surplus	Total Surplus				324.230,8	108.426,9	432.657,7		
New	2007	Asset	313 Assets Generated by Net Premiums	487.359,2	1.931,6	489.290,8					
			40201 External Reinsurance Except Nat Cat	61.597,4	6.825,9	68.423,3					
			40202 External Reinsurance Nat Cat	-28.241,0	19.999,3	-8.241,6					
		Netted	2214 Participation SRV1	17.044,2	-5.965,5	11.078,7					
		Liability	330201 Claims Except Nat Cat				491.221,2	8.657,9	499.879,1		
			330202 Claims Nat Cat				95.354,2	-21.509,0	73.845,2		
			34201 Default External Reinsurance Except Nat Cat				146,6	-51,3	95,3		
			34202 Default External Reinsurance				-59,4	20,8	-38,6		
			431 Default Assets				4.250,3	-1.487,6	2.762,7		
	Total New	Surplus	Total Surplus				-53.153,0	37.160,6	-15.992,5		
N/A		Liability	431 Operational Risk				2.181,2	-763,4	1.417,8		
	2007	Netted	2214 Participation SRV1	-2.935,0	1.027,2	-1.907,7					
	Total N/A	Surplus	Total Surplus				-5.116,2	1.790,7	-3.325,5		
Total	Total	Surplus	Total Surplus				265.961,6	147.376,1	413.339,7	-54.514,2	358.825,6

Risk Collector Implementation
Standard Outputs – 2

Crucial Paths - Economic Capital in Mio. €

Entity: SV2_AG, evaluation period: 2007, quantile: 0, selected paths: 21, total paths: 125

		Entity	
Number	Path	SV2 AG	SRV1 AG (linked)
1	9	-622.124	-1.254.722
2	12	-146.031	-3.694.483
3	19	-310.012	-1.874.379
4	28	-88.427	-2.966.275
5	29	-645.196	-1.560.323
6	40	-39.858	-1.989.472
7	49	-409.734	-399.512
8	58	-55.772	-3.287.315
9	59	-545.465	-906.614
10	61	-17.600	1.537.478
11	65	-100.067	-812.752
12	69	-468.022	-3.628.769
13	70	-96.239	-2.444.511
14	74	-15.205	-1.672.304
15	75	-28.851	-2.516.214
16	79	-294.593	-93.830
17	86	-124.341	-1.395.632
18	89	-481.376	-508.878
19	99	-4.107	577.721
20	118	-65.362	-2.214.048
21	119	-483.087	-1.139.155

Risk Collector Implementation
Standard Outputs – 3

Economic Capital Distribution in Mio. €

Entity: SV2_AG, evaluation period: 2007, discount factor 1.0000

	Values									
Row										
Expected Value	358.826									
Standard Deviation	307.069									
Probability of Ruin	16.80%									
Average Ruin	240.070									
Average Shortfall in %	40.09%									
Selected Discount Factor	100.00%									
Downside Value	0									
Downside Probability	16.80%									
Level	Quantile	Level Achieved?	Value @ Risk	E[X]-V@R	Discounted E[X]-V@R	Tail Value @ Risk	E[X]-TV@R	Discounted E[X]-TV@R	Avg Shortfall in %	
Rating Level	0.10%	no	-642.335	1.001.161	1.001.161	-645.196	1.004.022	1.004.022	0.28%	
	0.20%	no	-639.474	998.300	998.300	-645.196	1.004.022	1.004.022	0.57%	
Solvency Level	0.50%	no	-630.891	989.717	989.717	-645.196	1.004.022	1.004.022	1.42%	
	1.00%	no	-603.726	962.551	962.551	-640.582	999.407	999.407	3.69%	
Minimal Solvency Level	2.00%	no	-515.524	874.349	874.349	-616.021	974.846	974.846	10.31%	
	5.00%	no	-389.789	748.615	748.615	-535.633	894.458	894.458	16.31%	

Risk Collector Implementation
Standard Outputs – 4

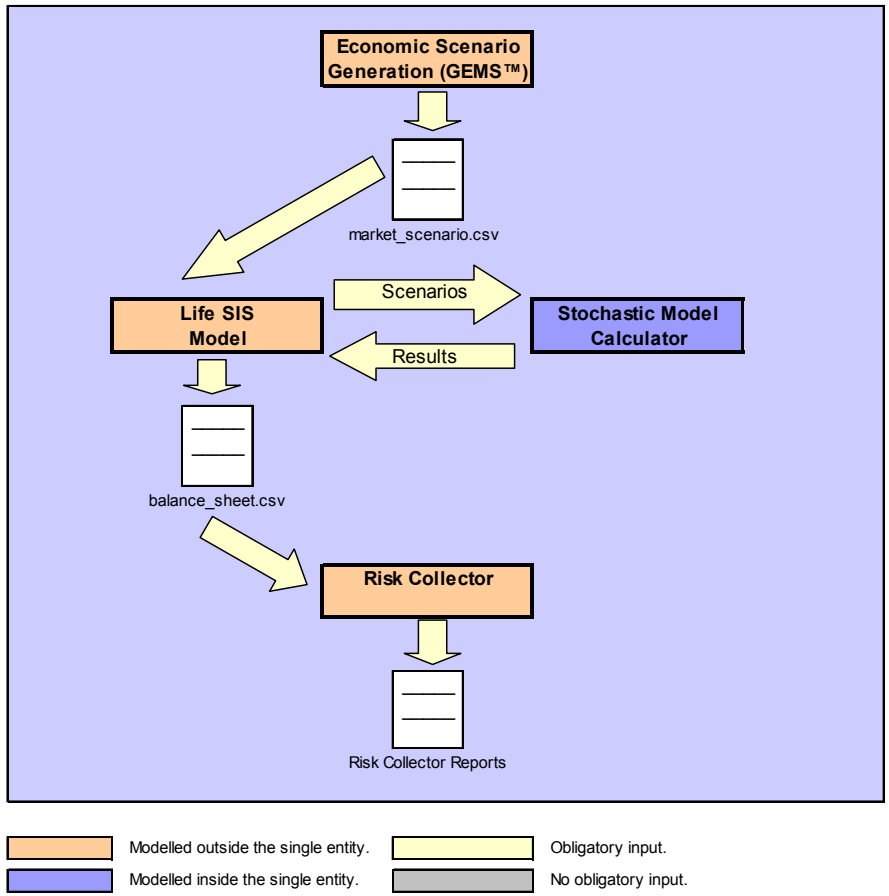
Risk Capital Allocation in Mio. €

Entity: SRV1_AG, evaluation period: 2007, percentile: 1,0%, separate non-linear tax effect: Yes

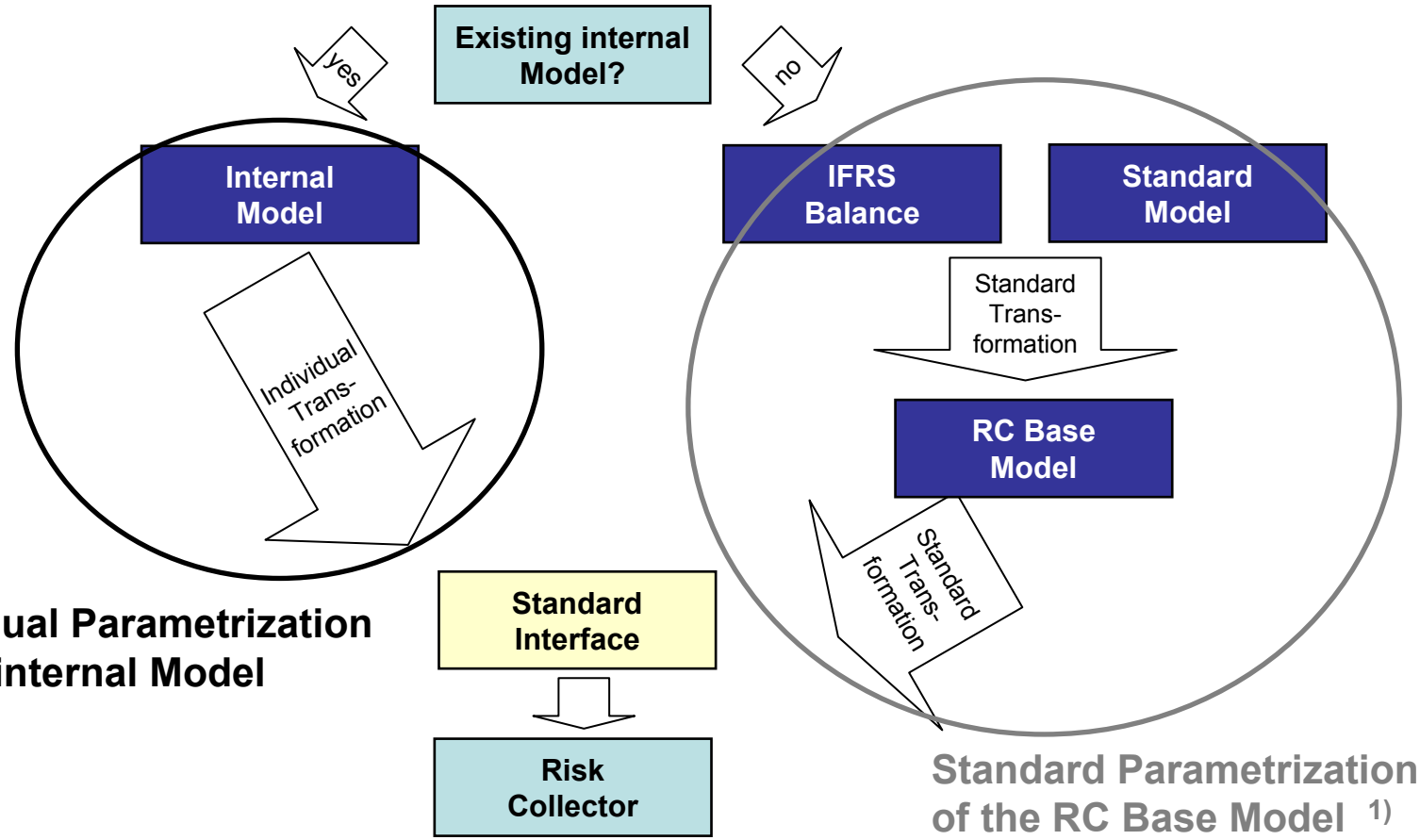
				Balance Column / Values / Type										
				Asset / Netted			Liability / Surplus							
				Fair Value After Tax			Fair Value After Tax			Non Linear Tax Effect			Economic Capital	
Business	Business Period	Balance Sheet Category	Balance Sheet Line	E[X]	Req. Cap.	% Econ. Cap.	E[X]	Req. Cap.	% Econ. Cap.	E[X]	Req. Cap.	% Econ. Cap.	E[X]	Req. Cap.
Old		Asset	231	4.935.602	-122.318	-2,74%								
			239	4.466.760	875.235	19,62%								
			402	1.573.415	-450.749	-10,11%								
			73	43.794	-344.208	-7,72%								
			9	2.645.117	-9.825	-0,22%								
		Liability	1				654.075	25.178	0,56%					
			33011				154.586	13.467	0,30%					
			33012				401.335	55.572	1,25%					
			3302				7.989.982	2.317.887	51,97%					
			342				2.398	3.171	0,07%					
			41				864.918	60.645	1,36%					
			4311				25.697	-12.733	-0,29%					
			4319				6.387	-4.417	-0,10%					
			9				2.689.489	10.155	0,23%					
	Total Old	Surplus	Total Surplus				875.820	2.417.060	54,19%					
New	2007	Asset	40201	192.186	6.853	0,15%								
			40202	-15.797	12.492	0,28%								
		Netted	313	2.982.562	197.882	4,44%								
		Liability	330201				2.767.528	450.034	10,09%					
			330202				214.402	-42.623	-0,96%					
			34201				1.611	-1.256	-0,03%					
			34202				0	0	0,00%					
			431				4.968	-1.507	-0,03%					
	Total New	Surplus	Total Surplus				170.442	621.876	13,94%					
N/A		Liability	431				29.350	-1.907	-0,04%					
	Total N/A	Surplus	Total Surplus				-29.350	-1.907	-0,04%					
Total	Total	Surplus	Total Surplus				1.016.912	3.037.029	68,09%	-322.085	1.422.977	31,91%	694.827	4.460.006

Risk Collector: Processing
General Process for Internal Models

Risk Collector: Processing
Special Process for Life Models



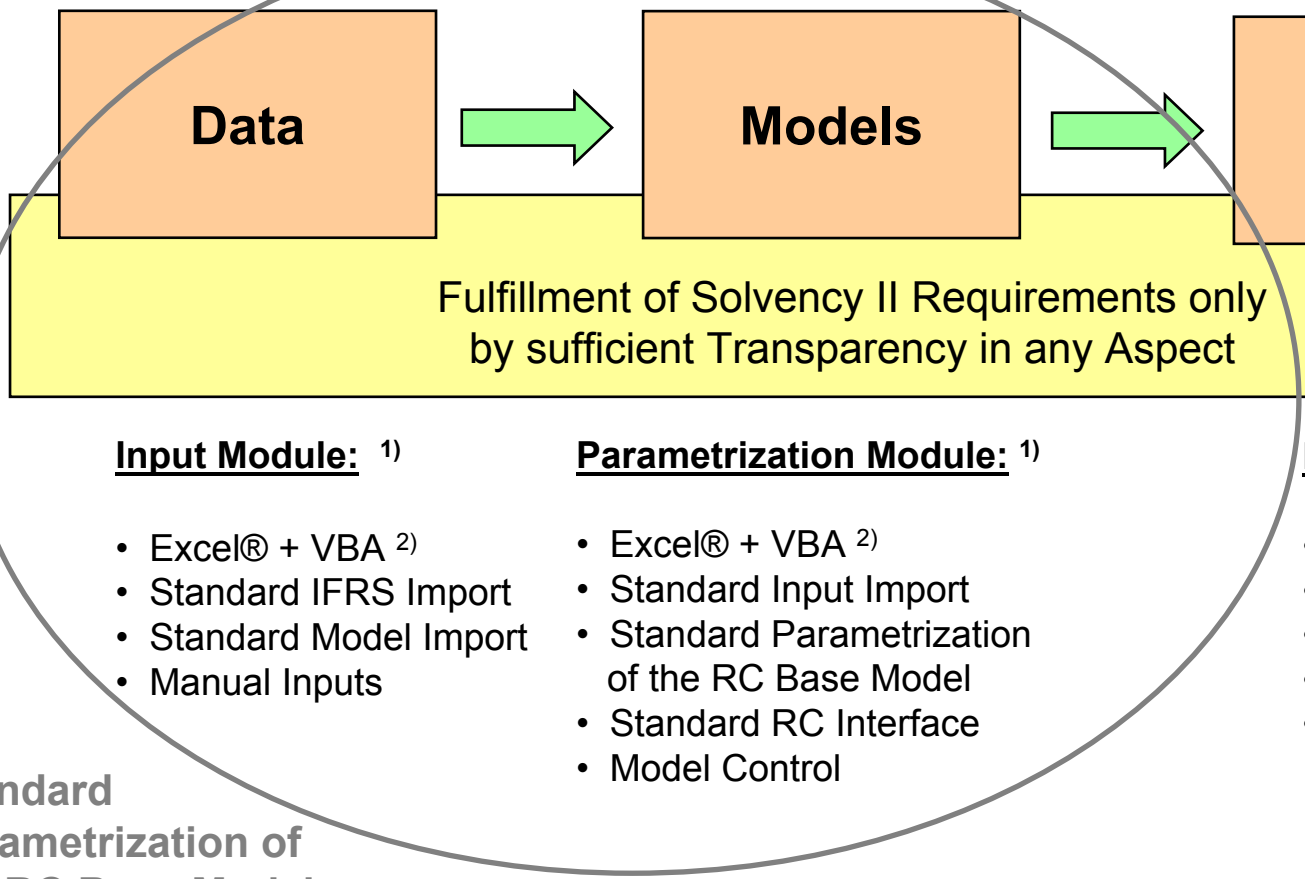
Risk Collector: Processing
Individual vs. Standard Solution (Non-Life)



Individual Parametrization of the internal Model

Standard Parametrization of the RC Base Model [1)]

Risk Collector: Processing
DMT Principle for the Standard Solution



Input Module: [1)]

- Excel® + VBA [2)]
- Standard IFRS Import
- Standard Model Import
- Manual Inputs

Parametrization Module: [1)]

- Excel® + VBA [2)]
- Standard Input Import
- Standard Parametrization of the RC Base Model
- Standard RC Interface
- Model Control

Risk Collector:

- ADVISE™ and GEMS™ [2)]
- Path Identity
- RC Base Model
- Query Functionalities
- Standard Output

Standard Parametrization of the RC Base Model

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1) Excel® + VBA (Visual Basic® for Applications) modules in a printable format for documentation needs

2) Excel® and Visual Basic® are registered trade marks of Microsoft Corporation
ADVISE™ and GEMS™ are trade marks of DFA Capital Management Inc.

Risk Collector: Processing
Output of the Standard Solution

Business	Balance Sheet Category	
Old	Re-Evaluation of IFRS Assets (BY) inclusive Latent Tax Effects	Re-Evaluation of IFRS Liabilities (BY) inclusive Latent Tax Effect
		Surplus = ∑ Assets - ∑ Liabilities. Inclusive Latent Tax Effects
New	Net Premiums (BY + 1) inclusive Latent Tax Effects	Net Base / Major / Nat Cat Losses (BY + 1) inclusive Latent Tax Effect
	Changes in Value (BY + 1) inclusive Latent Tax Effects	Surplus = ∑ Assets - ∑ Liabilities. Inclusive Latent Tax Effects
Not Assigned	Default on Hybrid Capital inclusive Latent Tax Effects	Default Risks, Operational Risks, Liquidity Risk inclusive Latent Tax Effects
	Currency Impact on Surplus (BY + 1) inclusive Latent Tax Effects	Surplus = ∑ Assets - ∑ Liabilities. Inclusive Latent Tax Effects
Total		Surplus = Sum of all Surplus inclusive Latent Tax Effects

Economic Capital = Total Surplus + Non Linear Tax Effects [1)]

1) Additional to the Linear Latent Tax Effects.

Risk Collector: Processing Roles and Responsibilities

- **Process is managed by a central quantitative risk management group (KQR) responsible for**
- Setting technical requirements
  - Model assumptions – including approval of economic and nat cat scenarios
  - Risk Collector aggregation tool –ensuring requirements are met
  - RC Base Model –ensuring requirements are met
- Project management
  - Set timetable and develop back up plans
  - Monitor progress and deal with emerging project risks
- Providing results to Group management
  - Quality assurance: review and challenge individual company models and documentation
  - Assemble, test, understand and interpret aggregation output
  - Form and deliver conclusions and recommendations

- **Individual companies' responsibilities**
- Build models complying with Group requirements
  - Document models (including data, models, tools) with justifications
  - Deliver results on time to KQR
- Assist with audit and review process
  - Maintain audit trail, answer questions
  - Demonstrate usage of their models in running the business (use test)
- Feed back experiences to KQR for continual improvement of the process

Question & Answer Session