Eidgenössische Finanzmarktaufsicht FINMA
Autorité fédérale de surveillance des marchés financiers FINMA
Autorità federale di vigilanza sui mercati finanziari FINMA
Swiss Financial Market Supervisory Authority FINMA

Technical description of the SST standard model reinsurance captive

Standard model insurance

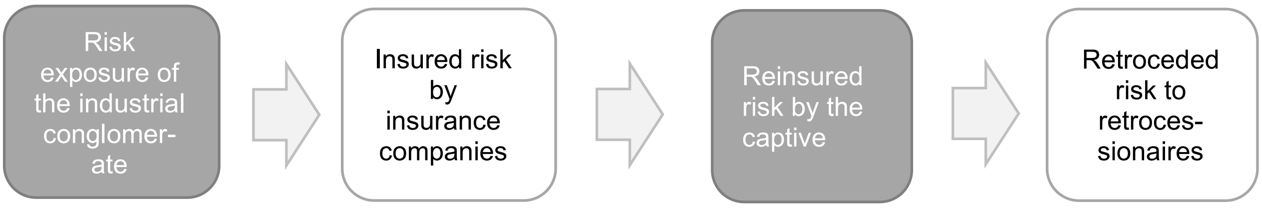
31 October 2025

Contents

1 Aim

This technical description defines the standard model for reinsurance captive (in the sequel: *captive model*) according to Art. 45 para. 1 ISO (*AVO/OS, SR/RS* 961.011) and is intended for **reinsurance captives** (in the sequel: *captives*) subject to the Swiss solvency test (SST). For the record of changes relative to the previous year, see Section 13.

A captive normally reinsures only the risks of its parent company, which is often part of a larger industrial conglomerate. There is usually a close relationship between the captive and the parent, allowing for access to detailed ground loss data and shared financial arrangements, such as participation in a cash pooling system. The following figure illustrates the insurance scheme, with dark grey coloured boxes being in the industrial conglomerate.



2 Scope

The captive model covers the non-life insurance risk of captives, which corresponds to the dark gray box in the figure below. For the modules market risk, credit risk as well as aggregation and market value margin, please refer to the dedicated technical documentations on the SST page of the FINMA website[1].

Target capital (TC)						
Market risk	Credit risk		Insurance risk			Additional scenarios
	of other assets	of ceded retro	Life risk	Health risk	Non-life insurance risk	

This technical description provides

- the description of the captive model;
- guidance on how to reflect the assumed reinsurance and ceded retrocession business of the captive on the SST balance sheet;

[1] www.finma.ch > Supervision > Insurers > Cross-sectoral tools > Swiss Solvency Test (SST)

- formulas for calculating the market value margin to the extend as being specific to captives;
- instructions on how to prepare input from the captive model for other modules, e.g. interest rate risk on the insurance cash flows and spread risks due to reinsurance and retrocession agreements within the market risk model.

Company-specific adjustments must be adequately documented, especially adjustments that are not subject to prior approval according to Art. 9 para. 3 let. a ISO-FINMA (*AVO-FINMA/OS-FINMA*; *SR/RS* 961.011.1), see Section 11.1.4. The sections below provide more specific guidance where company-specific adjustments can be made.

3 Captives insurance business

3.1 Introduction

Insurance business (equivalently named **insurance contracts**) means here the **assumed (i.e. active) reinsurance** and the **ceded (i.e. passive) retrocession** of a captive. This section explains in which positions this is reflected in the SST balance sheet. Moreover, a reporting requirement of the portfolio into a standardised segmentation is defined that is independent of the risk model.

3.2 SST balance sheet

The following specifies the positions in which the insurance business of a captive has to be reported on the SST balance sheet. See Art. 3 ISO-FINMA and Section 4.6.1 for the scope of the SST balance sheet.

Name	Position number (*EHP-AVO-Kontenplan*)	Description in the SST balance sheet of the corresponding position	Explanation
Assets			
Retro receivables	110'200'100	Receivables from insurance companies: ceded	Receivables from retrocessionaires for ceded retrocession claims payments for already paid assumed reinsurance claims
Retro recoverables	106'203'000	Active reinsurance: non-life insurance business *Active reinsurance (non-life) - earned business* *Active reinsurance (non-life) - unearned business*	Receivables from retrocessionaires for ceded retrocession claims payments for not yet paid assumes reinsurance claims: • *earned* • *unearned*

Reinsurance premium receivables	110'200'200	Receivables from insurance companies: assumed	Receivables from cedants (or intermediaries) for assumed reinsurance premium payments
Reinsurance deposits	104'000'000	1.4 Deposits made under assumed reinsurance contracts	Receivables from cedants (or intermediaries) for assumed reinsurance premium deposits

Liabilities			
Reinsurance provisions (reserves)	201'203'000	Active reinsurance: non-life insurance business Active reinsurance: best estimate of insurance liabilities (non-life) - earned business Active reinsurance: best estimate of insurance liabilities (non-life) - unearned business Active reinsurance: best estimate of other insurance liabilities (non-life)	Obligations towards cedants for assumed reinsurance claims payments (gross): • *earned* • *unearned* • *other*
Retro premium liabilities	207'000'000 excluding 207'300'200	Other liabilities from insurance business	Obligations towards retrocessionaires for ceded retrocession premium payments
Retro deposit liabilities	206'000'000	2.6 Deposits retained on ceded reinsurance	Obligations towards retrocessionaires for ceded retrocession premium deposits

3.3 Reserves and premiums reporting requirement

Net reserves (reinsurance reserves minus retro recoverables) at the SST reference date and net expected premiums must be reported in the prescribed reporting segmentation, possibly through appropriate proxies, as published in the SST-Captive-Template[2]. Note that here the reporting of undiscounted values is requested.

[2] This corresponds exacly to the "RE_reserves_and_premiums" sheet in the SST-StandRe-Template, see the technical description for the SST standard model reinsurance (StandRe), Section 3. The prescribed reporting segmentation defines LoBs, geographical regions and types of contracts.

4 The one-year change for insurance risk

4.1 Introduction

For the purpose of defining the standard model for non-life insurance risk of the captive, we use the definitions of best estimate and one-year change introduced in Sections 4.2 and 4.3, with further simplifying assumptions applicable to the captive model given in Section 4.6. For the link between these definitions and more general definitions, in particular the one-year change in risk-bearing capital underlying the target capital, as well as the market risk and the credit risk of underlying insurance contracts, see Section 12.5 in the Appendix.

The insurance risk defined in Section 4.3 is further decomposed into reserve risk and premium risk, as outlined in Sections 4.4 and 4.5, reflecting the distinct nature of the underlying risk factors. The captive model provides distributions for both reserve risk and premium risk, and explains their aggregation into overall insurance risk in Sections 5 trough 8, based on the simplifying assumptions set out in Section 4.6.

4.2 Cash flows and best estimates

A cash flow outstanding at time $u \geq 0$ is denoted by

$$CF_{(>u)} \coloneqq \{CF_s\}_{s>u} = \{CF_{u+1}, CF_{u+2}, \ldots\}.$$

Given a set of segments SEG, which shall be defined later according to the situation, where each segment is associated with exactly one currency, the cashflow CF_s for each time $s > u$ is defined as a vector of components:

$CF_s \equiv \{CF_s^{seg}\}_{seg \in \mathrm{SEG}}$, with each component CF_s^{seg} expressed in the currency assigned to the segment seg.

The **best estimate** at time $t \geq 0$ of the underlying cash flow $CF_{(>u)}$ outstanding at time $u \geq \max(0, t-1)$, is defined as

$$BE_{t,(>u)} \equiv BE_t\big(CF_{(>u)}\big) \coloneqq \big(1 + r_{0,t}\big)^t \cdot \sum_{seg} \sum_{s>u} FX_0^{CUR} \cdot \big(1 + r_{0,s}^{CUR}\big)^{-s} \cdot E\big(CF_s^{seg} \big| \mathcal{F}_t\big),$$

where

- CUR is the currency associated with the segment seg ; by omitting the subscript CUR, one refers to the SST currency;
- CF_s^{seg} is the cash flow at time s in currency CUR, and $FX_0^{CUR} \cdot CF_s^{seg}$ converts it into the SST currency using the exchange rate at time $t = 0$, where FX_0^{CUR} denotes the value in SST currency of one unit of CUR;

- cash flows are assumed to occur at the end of the corresponding one-year period, i.e. $CF_\tau^{seg} = CF_s^{seg}$ for $s-1 < \tau \leq s$ and $s = 1,2, \dots$;
- the sign convention (i.e. whether a positive value represents an inflow or outflow) is defined according to the specific context, see Sections 4.3 and 5;
- $r_{0,s}^{CUR}$ denotes the risk-free interest rate at time $t = 0$ for a nominal amount of one unit of CUR at time $s \geq 0$ (maturity $k = s - 0 = s$ years);
- $\mathcal{F}_t$ denotes the information available at time t (filtration), with $t = 0$ corresponding to the SST reference date; only $E(CF_s^{seg}|\mathcal{F}_t)$ for $t \neq 0$ is stochastic in the formula above.

Special cases used later include:

- $E(\cdot)$ shall denote $E(\cdot\,|\mathcal{F}_0)$;
- BE_t shall denote $BE_{t,(>t)}$;
- the **undiscounted** best estimate, denoted by $BE_{t,(>u)}^{(N)}$, is defined by setting $r_{0,s}^{CUR} = 0$ and $r_{0,t} = 0$ in the formula above.

4.3 One-year change in scope

$t = 0$ denotes the **SST reference date** and $t = 1$ twelve months later.

The change in risk bearing capital over one year, denoted by ΔRBC_1, from which the target capital is derived, can be decomposed as $\Delta RBC_1 = \Delta RBC_1^{ins} + \mathrm{rest}$, where ΔRBC_1^{ins} is the change related to insurance contracts of the captive (assumed reinsurance and ceded retrocession).

ΔRBC_1^{ins} can be further decomposed as:

$$\Delta RBC_1^{ins} = \overline{\Delta RBC}_1^{ins,IR} + \overline{\Delta RBC}_1^{ins,MR} + \overline{\Delta RBC}_1^{ins,CR} + REM_1^{ins} + \mathrm{ExpInsRes},$$

where

- $\overline{\Delta RBC}_1^{ins,IR}$ depends on stochastic insurance risk factors and deterministic other risk factors, and analogously for market risk with $\overline{\Delta RBC}_1^{ins,MR}$ and credit risk with $\overline{\Delta RBC}_1^{ins,CR}$;
- REM_1^{ins} capture terms with several stochastic risk categories;
- The macron[3] indicates centered random variables (i.e. expected value zero), providing in this representation the expected insurance result $\mathrm{ExpInsRes}$ as a separate deterministic term.

Here the focus is on the insurance risk component $\overline{\Delta RBC}_1^{ins,IR}$ and the expected insurance result $\mathrm{ExpInsRes}$. For the derivation of the above decomposition including the expressions defined below, see further explanation in Section 12.5 in the Appendix.

The **one-year change related to insurance risk** is defined as

[3] A macron is a straight bar placed above a letter

$$\overline{\Delta RBC}_1^{ins,IR} = \sum_{seg}\sum_{s>0} FX_0^{CUR} \cdot \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot \left[E\left(CF_s^{ex+new,seg} \middle| \mathcal{F}_1\right) - E\left(CF_s^{ex+new,seg}\right)\right]$$
$$= \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{ex+new} - BE_0^{ex+new}$$
$$= \sum_{seg} FX_0^{CUR} \cdot \left(1 + r_{0,1}^{CUR}\right)^{-1} \cdot CF_1^{ex+new,seg} + \left(1 + r_{0,1}\right)^{-1} \cdot BE_1^{ex+new} - BE_0^{ex+new},$$

and the **expected insurance result** as

$$\text{ExpInsRes} = \sum_{seg}\sum_{s>0} FX_0^{CUR} \cdot \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot E\left(CF_s^{new,seg}\right) = BE_0^{new},$$

where

- ex is the **existing business**, i.e. the portfolio included in the SST balance sheet at time $t = 0$ according to Art. 3 ISO-FINMA;
- new is the **new business,** i.e. expected to be included in the SST balance sheet between $t = 0$ (exclusive) and $t = 1$ (inclusive), but not included at $t = 0$;
- $ex + new$ is the combined portfolio of existing and new business;
- cash flows CF_s include premiums, claims payments and costs, net of retrocession and gross of expected credit risk[4]. Positive values represent inflows, negative values outflows.

The aim of the captive model is to define the distribution of $\overline{\Delta RBC}_1^{ins,IR}$, based on the assumed reinsurance and the ceded retrocession contracts, and to compute the (stand-alone) insurance risk as $-ES_\alpha(\overline{\Delta RBC}_1^{ins,IR})$ with $\alpha = 1\%$ (see Annex 3 ISO for the definition of the expected shortfall ES_α).

In the following, the expression **insurance risk** may refer, depending on the context, to the one-year change related to insurance risk, its probability distribution, or the negative of the expected shortfall.

Additionally, the captive model defines the computation of the expected insurance result, which is deducted in the computation of the target capital.

4.4 Partition of the business

The business in scope of the SST when assessing the one-year change in RBC is $new + ex = new_1 + ex_0 = new_1 + new_0 + ex_{-1} = new_1 + new_0 + new_{-1} + \cdots$. This represents a partition based on the **underwriting year**, i.e., the year in which the business is new. By convention, new_{t+1} refers to business that is included in the SST balance sheet the year from t (exclusive) to $t + 1$ (inclusive) according to Art. 3 para. 4 ISO-FINMA.

At the SST reference date $t = 0$, and from the perspective of the run-off view starting at $t = 1$, any new business after $t = 1$ is *out of scope*, i.e. $new_2 = \emptyset$, $new_3 = \emptyset, \ldots$.

[4] An extended formula with the expected credit risk can be found in the *technical documentation for the SST standard model aggregation and market value margin*.

The term new_1 refers to the new business as forecasted at $t = 0$. As part of ex_0, only the past business $new_0, \ new_{-1}, ...$ that is not yet settled at time $t = 0$ is considered. A business is considered **settled** at time t if the best estimate of its outstanding cash flows at time t, conditional on the information available at time t, is zero, hence it no longer appears on the SST balance sheet at that time.

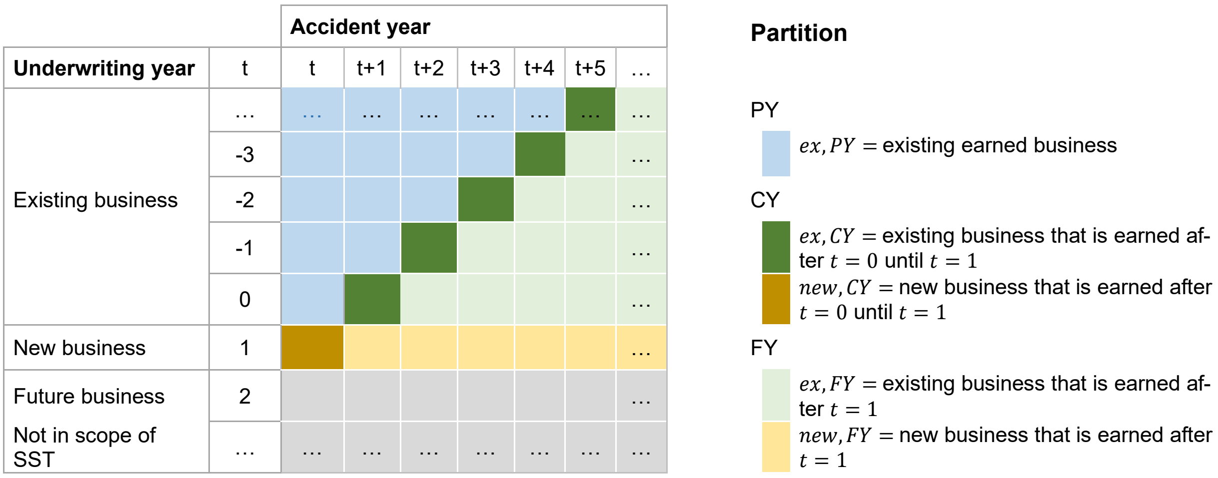
Thus, new_1 contains the part of the new business which is in the SST balance sheet at time $t = 1$ and the claims from the new business settled until $t = 1$. The latter is *not* in ex_1, the business in the SST balance sheet at time $t = 1$.

Another way to partition the business is by **accident year (**also named **occurrence year**), which refers to the calendar year in which a claim occurs. This may include contracts on risk attaching basis and on loss-occurring basis. At time $t \geq 0$, the business can be split into:

- **Earned business**: existing business ex_t (i.e. in the SST balance sheet at time t) with claims that occurred in the **previous accident years** PY_t (i.e. up to time t) ;
- **Unearned business:** the remainder of the portfolio, which can be further split into
  - **Current accident year** CY_t (from t [exclusive] to $t + 1$ [inclusive]);
  - **Future accident years** FY_t after $t + 1$.

When t is omitted in the notation (i.e. PY, CY, FY), it assumed to be $t = 0$. Definitions for $t > 0$ are used in the context of the market value margin.

Combining both partitions (underwriting year and accident year) at $t = 0$, the business $ex + new$ is devided into five categories: (ex, PY) existing and earned, (ex, CY) existing and unearned but earned at time $t = 1$, (ex, FY) existing and unearned at time $t = 1$, (new, CY) new and earned at time $t = 1$ and (new, FY) new and unearned at time $t = 1$. This partition is illustrated in the following representation:



A third dimension is given by the calendar year in which a cash flow occurs (**payment year**), see the definition of best estimate introduced in Section 4.2 used below.

4.5 Definition of reserve risk and premium risk

From the partition above, by linearity of expectations and assuming implicitly linear and unbiased estimators, the insurance risk can be decomposed as

$$Z^{\text{NL-insurance-risk}} := \overline{\Delta RBC}_1^{ins,IR} = \nu_{0,1} \cdot BE_{1,(>0)}^{ex+new} - BE_0^{ex+new} = \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,PY} - BE_0^{ex,PY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,CY} - BE_0^{ex,CY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{new,CY} - BE_0^{new,CY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,FY} - BE_0^{ex,FY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{new,FY} - BE_0^{new,FY}\right),$$

with $\nu_{0,1} := \left(1 + r_{0,1}\right)^{-1}$. From this, we define

- $Z^{\text{reserve-risk}} := \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,PY} - BE_0^{ex,PY}\right)$, the **reserve risk** (also named **PY risk**); and
- $Z^{\text{premium-risk}} := Z^{\text{CY-risk}} + Z^{\text{URR-risk}}$, the **premium risk**, where
  - $Z^{\text{CY-risk}} := \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,CY} - BE_0^{ex,CY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{new,CY} - BE_0^{new,CY}\right)$ defines the **CY risk**, and
  - $Z^{\text{URR-risk}} := \left(\nu_{0,1} \cdot BE_{1,(>0)}^{ex,FY} - BE_0^{ex,FY}\right) + \left(\nu_{0,1} \cdot BE_{1,(>0)}^{new,FY} - BE_0^{new,FY}\right)$ defines the **URR risk**.

The URR risk corresponds to change of valuation between $t = 0$ and $t = 1$ of the *unexpired risk reserve* (*URR*) in the SST balance sheet at $t = 1$.

Note that all the differences Z^* defined above are centred (i.e. expected value zero). Distributions for these risk components are provided in Sections 5 to 8.

4.6 Simplifications for the insurance risk in the captive model

4.6.1 Underwriting year

The underwriting year is determined by the incepting date, i.e. the date of the beginning of the coverage (see art. 3 para. 5 ISO-FINMA).

4.6.2 Nature of the cash flows

At time $t = 0$, only claims payments (possibly including allocated costs) are considered stochastic. Premiums and (unallocated) costs are assumed to be deterministic. Thus, the insurance risk depends only on claims payment cash flows, often referred to as **losses**. The terminology used includes:

- **Gross loss**: losses ceded to captive gross of ceded retrocession;
- **Net loss:** losses ceded to captive net of ceded retrocession;
- **Outstanding losses:** includes all outstanding loss payments, regardless of whether they are reported or not ("ultimate view"). Includes in particular case reserves, ACR (additional case reserves), IBNyR (incurred but not yet reported), IBNER (incurred but not enough reported) and the corresponding claims adjustment expenses (ULAE and ALAE);
- **Ultimate losses (at time t)** : sum of cumulated paid at time t and outstanding losses;

- **Best estimate of ultimate losses (at time t)** : sum of cumulated paid at time t and best estimate of outstanding losses, conditional on the available information at time t;
- **Final ultimate losses (at time t)** : cumulated paid losses at time t when the best estimate of outstanding losses conditional on the available information at time t equals 0, i.e. settled losses.

4.6.3 Currencies

The standard currencies of the captive model are CHF, EUR, USD, GBP and JPY. Exchange rates and risk-free interest rates at $t = 0$ are prescribed by FINMA for these currencies.

For other currencies, the mapping to the standard currencies has to be consistent with the mapping used in the SST standard model for market risk.

If the captive needs to use its own currency, it has to apply for an adjustment, subject to approval according to Art. 9 para. 3 let. a ISO-FINMA.

The **SST currency** is defined in Art. 4 ISO-FINMA.

4.6.4 Materiality

The concept of **materiality** is used as defined in Art. 42 al. 2 ISO (*Wesentlichkeit / Caractère significatif*).

5 Reserve risk model

The captive model assumes that the reserve risk component as introduced in Section 4.5 can be further decomposed into a sum of random variables:

$$Z^{\text{reserve-risk}} = -X^{PY} - \epsilon^{PY}$$

This section works with loss variables, where a loss is represented by a positive value, meaning that X^{PY} is positive whereas $Z^{\text{reserve-risk}}$ is negative as in Section 4.3. X^{PY} represents a loss resulting from the lognormal distribution of the reserve risk model below and ϵ^{PY} represents the part of the reserve risk that is not or not sufficiently modelled by the reserve risk model. ϵ^{PY} can be partially modelled by individual events, see Section 7. X^{PY} results from net cash flows after retrocession recoverables, if applicable.

The aggregation of the reserve risk into non-life insurance risk, including the dependency assumptions and the non-modelled remaining part, is explained in Section 8.

Writing $X^{PY} = v_{0,1} \cdot BE_1(Y^{PY}) - BE_0(Y^{PY})$ with $Y^{PY} \equiv Y^{PY}_{(>0)}$ denoting outstanding losses at time $t = 0$ for the business incepted in previous years and earned until $t = 0$, and the discount factor $v_{0,1} = \left(1 + r_{0,1}\right)^{-1}$, the captive model assumes that $v_{0,1} \cdot BE_1(Y^{PY})$ follows a log-normal distribution (see Section 12.2 in Appendix for properties of the log-normal distribution).

With the simplifying assumption $\nu_{0,1} \cdot BE_1(Y^{PY}) = d^{PY} \cdot BE_1^{(N)}(Y^{PY})$, where d^{PY} is a deterministic discount factor, it follows that the distribution of $\nu_{0,1} \cdot BE_1(Y^{PY})$ is specified by d^{PY}, the mean μ and the coefficient of variation CV of the undiscounted best estimate $BE_1^{(N)}(Y^{PY})$.

The captive defines an appropriate set of segments regarding its earned business, the previous years' parameter segments PY-SEG, providing the decomposition $Y^{PY} = \sum_{m \in \text{PY-SEG}} Y_m^{PY}$. Here the Y_m^{PY} are expressed in SST currency using the exchange rates at time $t = 0$. We denote the mean and the coefficient of variation of $BE_1^{(N)}(Y_m^{PY})$ by μ_m and CV_m, respectively, and the components of the related correlation matrix by Γ_{ij}. It suffices to provide estimates to μ_m, CV_m and Γ_{ij} to obtain μ and CV by moment aggregation, see Section 12.1 in Appendix.

μ_m is equal to $BE_0^{(N)}(Y_m^{PY})$, i.e. the net reserves for earned business at $t = 0$ related to parameter segment m. However, no reserve risk needs to be allocated for claims that are fully reserved in the SST balance sheet up to the full contract limits with no further deterioration possible; these reserves can be excluded from $BE_0^{(N)}(Y_m^{PY})$ for the reserve risk.

The correlation between parameter segments is set to 0.5, i.e. $\Gamma_{ij} = 0.5$ for $i \neq j$ and $\Gamma_{ij} = 1$ else.

The default value for the coefficient of variation CV_m is set to 15% for each parameter segment. Alternatively, a company can or might even have to use its own CVs if, when using the standard CVs, the capital requirement is not sufficient in relation to the risk situation. In this case, own CVs have to be derived and applied to each and every parameter segment. The choice of the individual parameters shall be justified. Own CVs may be based on gross rather than net data for simplification.

d_m^{PY}, the discount factor for the parameter segment m, is derived from a payment pattern that needs to be provided by the captive. d^{PY}, the discount factor over all segments, is a weighted mean over all d_m^{PY}, see Section 12.4 in the Appendix for formulas.

The reserve risk module in the captive model uses the value of the net reserves. It does not rely on explicit ground-up simulations and/or the explicit modelling of reinsurance conditions. If the risk situation requires a different modelling approach, the captive must apply for the approval of an adjustment to the standard model according to Art. 9 para. 3 let. a ISO-FINMA.

6 Premium risk model

6.1 Introduction

The premium risk model is a model for the current year risk component of the decomposition introduced in Section 4.5. Analogous to the reserve risk, the captive model assumes a decomposition $Z^{\text{CY-risk}} = -X^{CY} - \epsilon^{CY}$ and $Z^{\text{URR-risk}} = -\epsilon^{URR}$, where X^{CY} represents the modelled loss from the CY risk distribution determined below, ϵ^{CY} represents the part of the current year risk that is not or not sufficiently modelled by X^{CY}, and ϵ^{URR} reflects that no specific model is defined for the URR risk.

The loss in X^{CY} is after retrocession recoverables, if applicable. Alternatively gross instead of net modelling (of ceded retrocession) is permitted if it is conservative. In this case, reinsurance conditions are applied only to assumed reinsurance contracts.

The captive defines an appropriate set of segments regarding its unearned and new business, the current year parameter segments CY-SEG, providing the decomposition $X^{CY} = \sum_{m\in\text{CY-SEG}} X_m^{CY}$. Here the X_m^{CY} are expressed in SST currency using the exchange rates at time $t = 0$. The CY parameter segments may differ from the PY parameter segments if necessary.

The captive model assumes independence between CY parameter segments.

We write $X_m^{CY} = v_{0,1} \cdot BE_1(\tilde{Y}_m^{CY}) - BE_0(\tilde{Y}_m^{CY})$ with $\tilde{Y}_m^{CY} \equiv \tilde{Y}_{(>0),m}^{CY}$ denoting outgoing cash flows (as positive values) outstanding at time $t = 0$ for business earned between $t = 0$ and $t = 1$ (current accident year CY made of unearned existing business and new business), in the parameter segment m.

For the CY risk, the captive model assumes the ultimate loss as proxy for the best estimate at time $t = 1$, that is $X_m^{CY} \approx d_m^{CY} \cdot \left(\tilde{Y}_m^{CY} - BE_0^{(N)}(\tilde{Y}_m^{CY})\right)$, where d_m^{CY} is a deterministic discount factor for the parameter segment m derived from a payment pattern that needs to be provided by the captive, see Section 12.4 in the Appendix for formulas.

Two approaches are available for modelling CY risk:

- Ground-up modelling: the distribution of $\tilde{Y}_m^{CY}$ is derived from ground-up claims data of the parent company (see Section 6.2); or
- Maximal possible loss (MPL) modelling: a simplified conservative alternative (see Section 6.3).

6.2 Ground-up modelling

In this approach, CY claims are modelled from the ground-up claims using a transformation function that maps them to captive claims. This transformation incorporates conditions across multiple parameter segments where necessary. Ground-up claims are modeled using frequency-severity approaches per CY parameter segment m, followed by a transformation that reflects the assumed reinsurance and ceded retrocession structures. The resulting distribution represents captive claims. The following applies per parameter segment, with the index m omitted for clarity.

6.2.1 Ground-up claims model

The ground-up claims consist of attritional claims or large claims, both being modelled by a frequency-severity approach:

- attritional claims are assumed to have a Poisson-distributed frequency N^a and a Gamma-distributed undiscounted severity Y^a;
- large claims are assumed to have a Poisson-distributed frequency N^l and a Pareto-distributed undiscounted severity Y^l;
- all random variables N^a, Y_1^a, Y_2^a, ..., N^l, Y_1^l, Y_2^l, ... are assumed to be independent.

Thus the corresponding ground-up parameters have to be estimated by the captive:

- the frequency of attritional claims $E(N^a)$ can be estimated by the average number of historical attritional losses. The same approach applies *mutatis mutandis* to the frequency of large claims $E(N^l)$. Any expected changes in the frequency due to expected developments such as exposure changes, legislative changes, or behavioural changes need to be taken into account;
- the expected severity of attritional claims $E(Y_i^a)$ can be estimated from the average amount of historical attritional claims. The corresponding standard deviation $sd(Y_i^a)$ can be obtained in a similar way;
- the large loss threshold x_0 and Pareto shape α can be determined based on available data and using actuarial expert judgement.

It might be the case that historical attritional claims (paid and incurred) and the number of attritional claims are only available on an annual aggregate basis. This means that only the historical realisations of the random variables $Y^a = \sum_{i=1}^{N^a} Y_i^a$ and N^a are available. In that case the following procedure can be applied:

- The expected number of claims $E(N^a)$ together with the mean $E(Y^a)$ and standard deviation $sd(Y^a)$ of the aggregate claim amount can be estimated.
- The mean $E(Y_i^a)$ and the standard deviation $sd(Y_i^a)$ of a single loss are derived by using the following formulas: $E(Y^a) = E(N^a) \cdot E(Y_i^a)$ and $Var(Y^a) = E(N^a) \cdot Var(Y_i^a) + E(Y_i^a)^2 \cdot Var(N^a)$.

Historical data used for the estimation of parameters have to be adjusted to ensure comparability over time. For instance, incurred losses should be adjusted according to the corresponding inflation. When historical data are insufficient to obtain reliable estimates, the captive explains how the estimate was derived and justifies it.

The frequency distribution is assumed to be Poisson for $N = N^a$ or $N = N^l$; in particular $Var(N) = E(N)$. In case of over-dispersion (i.e. $Var(N) > E(N)$, which may occur if the number of losses is large), the frequency can be modelled by a negative binomial distribution instead of a Poisson distribution, or must be if the impact on solvency is material. When applying a negative binomial distribution, the variance $Var(N)$ must also be estimated.

If the expected frequency of attritional claims is high and might lead to a long simulation run-time, the frequency-severity model can be replaced by an aggregated claims distribution using the following property:

- The sum of N independent identically distributed Gamma random variables is Gamma distributed. The mean and the standard deviation of the aggregate claim distribution can be derived from the expected frequency f, the mean m and the standard deviation s of the single claims. They are given by $f \cdot m$ and $\sqrt{f} \cdot s$, respectively.

In the captive model, the frequency-severity model can be replaced by assuming an expected frequency of 1 and using a severity distribution based on the expectation and standard deviation of the aggregate claims, as described above. Note, however, that applying ground-up claim transformations – defined on single claims – to aggregate claims yields incorrect results. This simplification is acceptable only if the impact on solvency is low. By default, this replacement is applied when the estimated expected frequency in the input is greater than 10, see Section 11.1.7. Not replacing values in the frequency-severity model remains a valid alternative within the captive model.

The model above is used with simulations. One simulation year for the underlying parameter segment m and regarding ground-up claims is depicted as follows. Here, $r.Distribution$ denotes a random draw from the underlying $Distribution$. For the parametrisation of the Gamma distribution, see Section 12.3 in Appendix.

Attritional ground-up claims
$E(N^a) \;\rightarrow\; \lambda = E(N^a) \;\rightarrow\; r.Poisson(\lambda) \;\rightarrow\; n^a$
$E(Y^a),\ \sigma(Y^a) \rightarrow k = \frac{[E(Y^a)]^2}{[sd(Y^a)]^2},\ \theta = \frac{[sd(Y^a)]^2}{E(Y^a)} \rightarrow r.Gamma(k,\theta)\ \ [\,n^a \text{ independent draws}] \;\rightarrow\; y_1^a, \dots, y_{n^a}^a$
or if $E(N^a) > 10$:
$E(Y^a),\ \sigma(Y^a) \;\rightarrow\; k = E(N^a) \cdot \frac{[E(Y^a)]^2}{[sd(Y^a)]^2},\ \theta = \frac{[sd(Y^a)]^2}{E(Y^a)} \;\rightarrow\; r.Gamma(k,\theta) \;\rightarrow\; y_1^a = y_{agg}^a$

Large ground-up claims
$E(N^l) \;\rightarrow\; \lambda = E(N^l) \;\rightarrow\; r.Poisson(\lambda) \;\rightarrow\; n^l$
$x_0,\ \alpha \;\rightarrow\; r.Pareto_{x_0}(\alpha)\ \ [n^l \text{ independent draws}] \;\rightarrow\; y_1^l, \dots, y_{n^l}^l$

6.2.2 Transformation into captive claims

The undiscounted net claims $\tilde{Y}^{CY}$ of the reinsurance captive are obtained by applying the assumed reinsurance and ceded retrocession structures to the ground-up claims. These structures can be modelled by a transformation $f: \mathbb{R}^{\mathbb{N}} \rightarrow \mathbb{R}$ with

$$\tilde{Y}^{CY} = f(N^a, Y_1^a, Y_2^a, \dots, N^l, Y_1^l, Y_2^l, \dots).$$

The following non-exhaustive list of basic operations allows the definition of such a transformation function:

Name of the transformation	Parameters, symbols	Definition
Excess of loss	$f_{XoL}(d,l): \mathbb{R} \to \mathbb{R}$	$f_{XoL}(d,l)(x) = \min(\max(x-d,0), l)$
Excess of loss to n segments* with the same conditions	$f_{XoL,n}(d,l): \mathbb{R}^n \to \mathbb{R}^n$	$f_{XoL,n}(d,l)(x) = \big(f_{XoL}(d,l)(x_1), \dots, f_{XoL}(d,l)(x_n)\big)$
Excess of loss to n segments* with distinct conditions	$f_{XoL,n}(\vec{d},\vec{l}): \mathbb{R}^n \to \mathbb{R}^n$	$f_{XoL,n}(\vec{d},\vec{l})(x) = \big(f_{XoL}(d_1,l_1)(x_1), \dots, f_{XoL}(d_n,l_n)(x_n)\big)$
Trivial embedding	$\pi_1: \mathbb{R}^{n_1} \to \mathbb{R}^{n_1} \times \mathbb{R}^{n_2}$ and $\pi_2: \mathbb{R}^{n_2} \to \mathbb{R}^{n_1} \times \mathbb{R}^{n_2}$	$\pi_1(x) = (x,0),\ \pi_2(y) = (0,y)$ $(\pi_1,\pi_2)(x,y) = \pi_1(x) + \pi_2(y)$
Trivial aggregate from segments*	$f_{sum}: \mathbb{R}^n \to \mathbb{R}$	$f_{sum}(x) = x_1 + \dots + x_n$
Quota share	$f_{QS}(\rho): \mathbb{R} \to \mathbb{R}$	$f_{QS}(\rho)(x) = \rho \cdot x$
* The word "segment" is used generically here, e.g. a segment of an aggregate claim is a single claim.		

The captive model proposes a default transformation defined as follows.

For the underlying parameter segment m, five inputs can be provided by the captive, derived from its assumed reinsurance and ceded retrocession conditions:

- Annual aggregate limit $AAL \in (0,\infty]$;
- Each and every loss limit $EEL \in (0,\infty]$;
- Annual aggregate deductible $AAD \in [0,\infty)$;
- Each and every loss deductible $EED \in [0,\infty)$;
- Quota share $\rho \ \in (0,1]$.

By default, $AAL = \infty,\ EEL = \infty,\ AAD = 0,\ EED = 0$ and $\rho = 1$ when the corresponding input is not provided. The default transformation into the captive claim $\tilde{y} = \tilde{y}_m$ of the underlying parameter segment m and the default aggregation of the parameter segments are defined by

Default transformation into captive claim
Default transformation into captive claim $\tilde{y} = \tilde{y}_m$ of the underlying parameter segment m
$y_1^a, \dots y_{n^a}^a \rightarrow f_{XoL,n^a}(EED, EEL) \rightarrow \pi_a$ $y_1^l, \dots y_{n^l}^l \rightarrow f_{XoL,n^l}(EED, EEL) \rightarrow \pi_l$ $(\pi_a, \pi_l) \rightarrow f_{sum} \rightarrow f_{XoL}(AAD, AAL) \rightarrow f_{QS}(\rho) \rightarrow \tilde{y}$
Default transformation from CY parameter segments claims $\tilde{y}_m$ into the captive CY aggregate claim $\tilde{y}^{CY}$
$\tilde{y}_m$, $m \in$ CY-SEG [m independent segments] $\rightarrow f_{sum} \rightarrow \tilde{y}^{CY}$

Please note that this default transformation may not be applicable in all cases. In particular, the following limitations apply:

- Reinsurance conditions across several LoBs cannot be calculated.
- The effect of reinstatement premiums is neglected (in case these are considerable, they should increase the net loss).
- The effect of sliding scale commissions and profit commissions are neglected.
- The default transformation assumes that the reinsurance contracts are applied in the order given above.
- Applying both assumed reinsurance conditions and ceded retrocession conditions may not be possible.
- EEL and EED conditions cannot be meaningfully applied for aggregate modelling of parameter segments with an expected frequency greater than 10, see also "Ground-up model" above.
- The default transformation concerns plain, traditional reinsurance structures without loss-sensitive features. Loss-dependent conditions in reinsurance structures, like paid reinstatements, swing rates, sliding scale commissions, loss corridors, or multi-year-structures with term limit caps need also to be taken into account.

Companies may use the default transformation to determine the premium risk only if they have ensured that none of the simplifications above or similar lead to a material underestimation of risk.

Within the captive model, a company-defined transformation from ground-up claims (as modelled above) to the net captive claim (after retrocession) is permitted. In such cases, the captive must describe the selected transformation.

If there are dependencies between CY parameters segments such that the independence assumption between CY parameters segments leads to a material underestimation of solvency, the captive has to apply for an adjustment subject to approval according to Art. 9 para. 3 let. a ISO-FINMA, unless these dependencies are sufficiently modelled by *Maximal possible loss modelling* (see below) or by an appropriate IE3 event (see Section 7).

The ground-up modelling has provided a distribution of the aggregate captive claim over all segments $\tilde{Y}^{CY}$, allowing to obtain that of

$$X^{CY} \approx d^{CY} \cdot \left(\tilde{Y}^{CY} - BE_0^{(N)}\left(\tilde{Y}^{CY}\right)\right),$$

where the discount factor d^{CY} is computed from payment patterns provided by the captive. For formulas, see Section 12.4 in the Appendix.

6.3 Maximal possible loss modelling

The captive may choose to apply the following conservative approach for selected CY parameter segments instead of ground-up modelling.

For a given parameter segment m, with a maximal possible net loss to the captive MPL_m and expected net loss EL_m, it is assumed that the loss amount MPL_m is almost surely an upper bound to $\tilde{Y}_m^{CY}$. As a simplification, no discounting effect is taken into account.

The random variable X_m^{CY} in focus is then replaced by a deterministic upper bound:

$$X_m^{CY} \approx MPL_m - EL_m.$$

The captive provides values for MPL_m and EL_m with explanations. It is permissible to model some segments using the MPL approach and other using the ground-up approach.

6.4 URR risk

In principle, the standard model assumes that URR risk is negligible. Nonetheless if URR risk is deemed material, the following approaches may be followed within the CY risk model (chose one by CY parameter segment modelled by the ground-up approach):

- Artificially increase the frequency of a parameter segment;
- Duplicate the parameter segment into separate CY and URR segments;
- Split the segment by underwriting year (e.g. 1 January CY to 30 June CY, and 1 July CY to 30 June CY+1).

If these approaches are insufficient, the captive needs to apply for approval of an adjustment to the standard model according to Art. 9 para. 3 let. a ISO-FINMA.

7 Individual events risk (IE3)

Each captive is exposed to specific risks arising from the economic activities of the group that owns it. These risks are often not adequately covered by historical data or by the methods of the standard model for insurance risk described above for X^{PY} and X^{CY} in Sections 5 and 6. In this Section we introduce an additional random variable X^{IE3} as follows.

To address this, the captive company has to define one to three scenarios reflecting its own exposure and evaluate these by their occurrence probability and impact related to insurance risk. These scenarios will be aggregated WITHIN the insurance risk (see Section 8) and form part of the captive model under the name *individual events* (IE3; "3" is to differentiate them from the IE1 and IE2 scenarios used in StandRe).

IE3 scenarios can be defined as a classical event (e.g. an industrial accident), but may also be understood in a broader sense, e.g. that a limit is reached (whatever is the underlying event) or that a court decision has an impact on the company insurance business. IE3 scenarios typically cover events with low occurrence probability and severe impact but may also cover events with larger occurrence probability. The key criterion is that IE3 risk covers insurance risk that is not (enough) captured by the premium risk model or the reserve risk model, e.g. events not yet observed in the data which used for the calibration of the model parameters.

The overarching scenarios of the SST (as described in the *Technische Beschreibung Szenarien / Description technique scénarios)* remain outside the scope of the captive model. Their aggregation, respectively non aggregation, into target capital is explained there, most notably concerning concentrations. An IE3 scenario modelled within the insurance risk should not be aggregated again as a scenario to the overall one-year risk.

The distribution of three IE3 scenarios S_1, S_2 and S_3 is discrete and specified by the probabilities and impacts of the seven combinations. For each scenario, the captive must provide the occurrence probabilities p_1, p_2 and p_3 as well as the impacts when no other scenario occurs $\check{c}_1, \check{c}_2$ and $\check{c}_3$ (losses expressed as positive values). Default formulas given below assume independent scenarios and no special reinsurance conditions, but the captive may provide alternative inputs. In particular, if the probabilities p_1, p_2 and p_3 are sufficiently small, it may be assumed that at most one scenario occurs, by setting $w_1 = p_1$, $w_2 = p_2$, $w_3 = p_3$ and all combined $w_{i,j}$ to nil.

Name of the IE3 scenario combination	IE3 scenario combination	occurrence probability of the combination	impact of the combination
S_1 only	$S_1 \setminus (S_2 \cup S_3)$	$w_1 = p_1 \cdot (1 - p_2) \cdot (1 - p_3)$	$\check{c}_1 = -c_1$
S_2 only	$S_2 \setminus (S_1 \cup S_3)$	$w_2 = (1 - p_1) \cdot p_2 \cdot (1 - p_3)$	$\check{c}_2 = -c_2$
S_3 only	$S_3 \setminus (S_1 \cup S_2)$	$w_3 = (1 - p_1) \cdot (1 - p_2) \cdot p_3$	$\check{c}_3 = -c_3$
S_1 and S_2 only	$(S_1 \cap S_2) \setminus S_3$	$w_{1,2} = p_1 \cdot p_2 \cdot (1 - p_3)$	$\check{c}_{1,2} = \check{c}_1 + \check{c}_2$

S_1 and S_3 only	$(S_1 \cap S_3) \setminus S_2$	$w_{1,3} = p_1 \cdot (1 - p_2) \cdot p_3$	$\check{c}_{1,3} = \check{c}_1 + \check{c}_3$
S_2 and S_3 only	$(S_2 \cap S_3) \setminus S_1$	$w_{2,3} = (1 - p_1) \cdot p_2 \cdot p_3$	$\check{c}_{2,3} = \check{c}_2 + \check{c}_3$
S_1 and S_2 and S_3	$S_1 \cap S_2 \cap S_3$	$w_{1,2,3} = p_1 \cdot p_2 \cdot p_3$	$\check{c}_{1,2,3} = \check{c}_1 + \check{c}_2 + \check{c}_3$

The IE3 scenarios are represented by a discrete random variable X^{IE3}, with a distribution defined by eight values and probabilities: the seven above and $\check{c}_0 = 0$, corresponding to the case that no IE3 events occurs, with probability $w_0 = 1 - \left(w_1 + w_2 + w_3 + w_{1,2} + w_{1,3} + w_{2,3} + w_{1,2,3}\right)$.

8 Aggregation into the non-life insurance risk

From the previous sections we have the decomposition

$$Z^{\text{NL-insurance-risk}} = -X^{PY} - X^{CY} - \epsilon^{PY} - \epsilon^{CY} - \epsilon^{URR},$$

where $\epsilon^{PY}, \epsilon^{CY}$ and ϵ^{URR} represent the risks not modelled by the reserve risk model (see Section 5) or by the premium risk model (see Section 6), respectively.

The individual events enhance the reserve risk model and premium risk model. This is done by assuming the relation:

$$\epsilon^{PY} + \epsilon^{CY} + \epsilon^{URR} = X^{IE3} + \epsilon^{\text{NL-insurance-risk}},$$

i.e.

$$Z^{\text{NL-insurance-risk}} = -X^{PY} - X^{CY} - X^{IE3} - \epsilon^{\text{NL-insurance-risk}},$$

where $\epsilon^{NL\text{-}insurance\text{-}risk}$ is a random variable for the remaining error term independent of $X^{PY} + X^{CY} + X^{IE3}$ and which remains neglected in the model.

In the special case where all CY parameter segments are modelled with the MPL approach (see Section 6.3) for X^{CY}, one can neglect X^{IE3} in the above relation if it can be justified that the risk of X^{IE3} is sufficiently covered.

The previous sections provided a distribution to each of the random variables X^{PY}, X^{CY} and X^{IE3}. For the required distribution of the sum $-X^{PY} - X^{CY} - X^{IE3}$, the captive model assumes:

- X^{PY} and X^{CY} are comonotone;
- X^{IE3} is independent of $X^{PY} + X^{CY}$.

Writing F_0 for the cumulative probability distribution of $-X^{PY} - X^{CY}$, the convolution with the discrete distribution of $-X^{IE3}$ yields the cumulative probability distribution F of $-X^{PY} - X^{CY} - X^{IE3}$:

$$\begin{aligned} F(z) = {} & w_0 \cdot F_0(z) + w_1 \cdot F_0(z - c_1) + w_2 \cdot F_0(z - c_2) + w_3 \cdot F_0(z - c_3) \\ & + w_{1,2} \cdot F_0\left(z - c_{1,2}\right) + w_{1,3} \cdot F_0\left(z - c_{1,3}\right) + w_{2,3} \cdot F_0\left(z - c_{2,3}\right) + w_{1,2,3} \cdot F_0\left(z - c_{1,2,3}\right), \end{aligned}$$

where the ws and the $c = -\check{c}$s are given by the individual events IE3 specification of Section 7.

In the particular case where IE3 scenarios are assumed to be pairwise mutually exclusive (i.e. at most one scenario can occur within the year), the second line becomes zero. This corresponds to the SST standard aggregation method for scenarios, although applied here at the level of insurance risk distribution, see the *technical description for the SST standard model aggregation and market value margin*[5].

In the general case, let S_1', S_2', S_3', S_4', S_5', S_6' and S_7' denote new scenarios, each representing a mutually exclusive combination of S_1, S_2 and S_3. Applying the SST standard aggregation method to these S' scenarios provides the above formula for $F(z)$. This extended aggregation method is especially useful when an IE3 scenario is assigned a relatively high probability, making the assumption that at most one scenario occurs within a year likely to be violated.

The stand-alone non-life insurance risk provided by the captive model distribution F is given by

$$-ES_\alpha\left(Z^{\text{NL-insurance-risk}}\right) = ES^{1-\alpha}(X^{PY} + X^{CY} + X^{IE3}),$$

where the expected shortfall ES_α is defined on the left side of a profit loss random variable, see Annex 3 ISO-FINMA, and $ES^{1-\alpha}(S) := -ES_\alpha(-S)$ for a random variable S defines the right-hand expected shortfall. Moreover, by comonotonicity assumption

$$ES^{1-\alpha}(X^{PY} + X^{CY}) = ES^{1-\alpha}(X^{PY}) + ES^{1-\alpha}(X^{CY}).$$

9 Expected insurance result of new business

Recall that from the one-year change in scope (see Section 4.3), the expected insurance result was defined as

- expected non-life insurance result = net expected premiums minus net expected discounted losses minus expected expenses of the new business,

reflecting only the business which is not in the balance sheet at $t = 0$. Here a profit is represented by a positive value.

In line with art. 30 para. 1 ISO, the expected non-life insurance result is required to include all costs (including administrative and overhead costs) needed for the own fulfilment of the insurance liabilities written until time $t = 1$ under the assumptions of art. 2 para. 2 and 3 ISO-FINMA ("run-off").

The captive has to estimate its expected insurance result, typically by using budget figures (cf. art. 2 para. 1 ISO-FINMA). As a simplification the expected value stemming from individual events can be set to nil.

[5] *Technische Beschreibung für das SST-Standardmodell Aggregation und Mindestbetrag / Description technique du modèle standard SST pour l'agrégation et le montant minimum.*

The error due to the estimation of the expected non-life insurance result is neglected.

In case of gross instead of net (of ceded retrocession) modelling of the reserve risk and/or premium risk, the expected insurance result has to be computed on a net basis, nonetheless. This is necessary for consistency with the SST balance sheet.

The stand-alone one-year risk capital due to non-life insurance business is given by the stand-alone non-life insurance risk minus the expected non-life insurance result.

10 Input from the captive model into other modules

This section describes the necessary inputs from the insurance business that are required for the calculation of the market risk and that are necessary for the aggregation with the other risk categories, such as market risk and credit risk. This section also explains the computation of the market value margin (MVM) from the inputs of the captive model.

10.1 Cash flows from insurance business

In order to calculate the market risk and its components like FX and spread risk, the cashflows from the insurance business are a necessary input.

This input is derived as follows: The positions of the SST balance sheet as described in Section 3.2 are grouped to produce net figures. Payment patterns of the captive model are then used to produce the suitable cash flows. Alternatively, the company can input its own cash flows if justified. This is the same approach as in StandRe, cf. the detailed explanations given in the technical description for the SST standard model reinsurance (StandRe), Section 8.2.

10.2 Market value margin (MVM)

According to the *technical description for the SST standard model aggregation and market value margin*, the market value margin at time $t = 0$ is a sum of components. For captives, the component related to non-hedgeable market risks is neglected as a simplifying assumption.

Following the *technical description for the SST standard model aggregation and market value margin*, the component $MVM_{Captive}$ is defined as

$$MVM_{Captive} = \sum_{k \geq 1} \frac{\eta_{CoC} \cdot SCR_k^{Captive}}{\left(1 + r_{0,k+1}\right)^{k+1}}$$

where η_{CoC} is the cost of capital rate prescribed by FINMA and $SCR_k^{Captive} = ZK_k^{(0,k)\text{Captive}}$ is the component of the target capital at time $t = k$ for year $k + 1$, covering non-life insurance risk, credit risk of insurance positions (incl. ceded retrocession) and scenarios. The year $k + 1$ refers to the period from $t = k$ [exclusive] to $t = k + 1$ [inclusive].

The following provides a method to compute $SCR_k^{Captive}$ for $k \geq 1$.

Assumption (MVM-1): $SCR_k^{Captive}$ for $k \geq 1$ is decomposed into a sum of segment-specific risk charges SCR_k^{seg}, i.e.

$$SCR_k^{Captive} = \sum_{seg} SCR_k^{seg}$$

where the risk segments seg are defined hereafter, with the help of the following table:

<table>
<tr><th colspan="5">Partition of the business in scope of SST along existing business at $t = 0$ (i.e. incepted until $t = 0$)
and new business between $t = 0$ (exclusive) and $t = 1$ (inclusive)</th></tr>
<tr><th colspan="3">regarding time $t = 0$, for one-year risk of year 1</th><th colspan="2">regarding time $k \geq 1$ for one-year risk of year $k + 1$</th></tr>
<tr><td>Reserve risk</td><td>PY_0</td><td>existing at $t = 0$ and
earned at $t = 0$</td><td>same as on the left</td><td rowspan="5">PY_k</td></tr>
<tr><td rowspan="7">Premium risk</td><td rowspan="2">CY_0</td><td>existing at $t = 0$ and
unearned at $t = 0$ but earned at $t = 1$</td><td>same as on the left</td></tr>
<tr><td>new between $t = 0$ and $t = 1$ and
earned at $t = 1$</td><td>same as on the left</td></tr>
<tr><td rowspan="5">FY_0
(URR risk)</td><td rowspan="5">existing at $t = 0$ and
unearned at $t = 1$

new between $t = 0$ and $t = 1$ and
unearned at $t = 1$</td><td>existing at $t = 0$ and
unearned at $t = 1$ but earned at $t = k$</td></tr>
<tr><td>new between $t = 0$ and $t = 1$ and
unearned at $t = 1$ but earned at $t = k$</td></tr>
<tr><td>existing at $t = 0$ and
unearned at $t = k$ but earned at $t = k + 1$</td><td rowspan="2">CY_k</td></tr>
<tr><td>new between $t = 0$ and $t = 1$ and
unearned at $t = k$ but earned at $t = k + 1$</td></tr>
<tr><td>existing at $t = 0$ and
unearned at $t = k + 1$</td><td>FY_k</td></tr>
</table>

The cash flows after $t = 1$ are partitioned into

- $PY = \bigcup_{k\geq 1} PY_k = \bigcup_{k\geq 1}\left(PY_k^{(PY_0)} \cup PY_k^{(CY_0)} \cup PY_k^{(FY_0)}\right) = PY^{(PY_0)} \cup PY^{(CY_0)} \cup PY^{(FY_0)}$;
- $CY = \bigcup_{k\geq 1} CY_k$;
- $FY = \bigcup_{k\geq 1} FY_k$;
- ICR defined by the difference between cash flows without and with retrocession default;
- $Scen$ defined by selected scenarios.

Assumption (MVM-2): For simplification, the captive model neglects:

- credit risk of insurance positions (incl. ceded retrocession), i.e. $ICR = \emptyset$;
- possible scenarios, i.e. $Scen = \emptyset$;
- risk related to the business unearned at $t = 1$ (except if a workaround was used to model URR risk within CY risk, see Section 6.4), i.e. $PY^{(FY_0)} = \emptyset,\ CY = \emptyset$ and $FY = \emptyset$.

Whence, $PY^{(PY_0)}$ and $PY^{(CY_0)}$ remain and are further partitioned into

$$PY^{(PY_0)} = \bigcup_{seg\in\text{PY-SEG}} seg \quad \text{and} \quad PY^{(CY_0)} = \bigcup_{seg\in\text{CY-SEG}} seg\,,$$

where PY-SEG and CY-SEG are the segments of the reserve risk model and of the premium risk model in the captive model, defining the segments seg for the computation of SCR_k^{seg}.

Assumption (MVM-3): With $CUR = CUR_{seg}$, the following approximations hold:

$$\left(1 + r_{0,k+1}\right)^{-(k+1)} \cdot SCR_k^{seg} \approx \left(1 + r_{0,k}\right)^{-k} \cdot SCR_k^{seg}$$

and

$$\frac{\left(1 + r_{0,k}\right)^{-k} \cdot SCR_k^{seg}}{BE_{0,(>k)}^{seg}} = \frac{\overline{SCR}_0^{seg}}{BE_0^{seg}},$$

i.e. $\left(1 + r_{0,k+1}\right)^{-(k+1)} \cdot SCR_k^{seg} = \delta_k^{seg} \cdot \overline{SCR}_0^{seg}$, where δ_k^{seg} is a decay factor at time $k \geq 1$ given by:

$$\delta_k^{seg} = \frac{\left(1 + r_{0,k}\right)^{-k} \cdot E\left[BE_k^{seg}\right]}{BE_0^{seg}} = \frac{BE_{0,(>k)}^{seg}}{BE_0^{seg}} = \frac{\sum_{j>k}\left(1 + r_{0,j}^{CUR}\right)^{-j} \cdot \pi_j^{seg}}{\sum_{j>0}\left(1 + r_{0,j}^{CUR}\right)^{-j} \cdot \pi_j^{seg}} = 1 - \frac{\sum_{j=1}^{k}\left(1 + r_{0,j}^{CUR}\right)^{-j} \cdot \pi_j^{seg}}{d^{seg}},$$

where the π_j^{seg} are the patterns given by the captive model,

and

$\overline{SCR}_0^{seg}$ is a capital charge referring to the period from $t = 0$ to $t = 1$, defined by the captive model as:

$$\overline{SCR}_0^{seg} = [f_{1-\alpha}(CV_{seg}) - 1] \cdot \mu_{seg} \cdot d^{seg},$$

where CV_{seg} and μ_{seg} are parameters given by the captive model and, with Φ denoting the standard normal cumulative distribution,

$$f_{1-\alpha}(CV) = \frac{1}{\alpha} \cdot \left(1 - \Phi\left(\Phi^{-1}(1-\alpha) - \sqrt{\log(1 + CV^2)}\right)\right).$$

The above definition of $\overline{SCR}_0^{seg}$ is motivated by the properties of a lognormal random variable, see Section 12.2.1 in Appendix.

Summarised:

$$MVM_{Captive} = \eta_{CoC} \cdot \sum_{k\geq 1} \sum_{seg} \frac{SCR_k^{seg}}{(1 + r_{0,k+1})^{k+1}},$$

where the risk segments seg are defined by the segments of the reserve risk model and of the premium risk model and

$$\frac{SCR_k^{seg}}{(1 + r_{0,k+1})^{k+1}} = \mu_{seg} \cdot [f_{1-\alpha}(CV_{seg}) - 1] \cdot \sum_{j>k} (1 + r_{0,j}^{CUR})^{-j} \cdot \pi_j^{seg}.$$

Alternatively, the captive can compute $MVM_{Captive}$ by the StandRe method, following its assumptions, see the *technical description for the SST standard model reinsurance (StandRe)*.

11 IT implementation

11.1 Description of the *SST-Captive-Template.xlsx*

The Excel workbook *SST-Captive-Template* is intended to collect all parameters and to support some computations related to the captive model. We explain the purpose and possible special feature of each worksheet below.

All values must be entered in millions of SST currency throughout the template.

11.1.1 Intro_SM_Captive

This sheet states the purpose of the template and asks for a few company specific general inputs used throughout the template.

11.1.2 CA_update

Contains the change log of the template.

11.1.3 CA_prescribed_parameters

This sheet contains the FINMA prescribed parameters, such as yield curves and FX exchange rates. Parameters relating to 31 December are updated in January. In case JPY is used, please copy the yield curve from the *SST-StandRe-Template* here.

11.1.4 CA_calculation_documentation

This sheet is intended to explain how the captive model was specifically applied by the company.

A selection of topics is listed (cf. columns "Field" and "Description/question"). Computations from different sheets are provided as information and helper for consistency checks (cf. column "Value").

Where explanations are needed for a third person familiar with the topic to understand the approach, please provide comments (art. 24 para. 3 let. e ISO-FINMA). In particular, this applies to places where the model allows for company-specific inputs or alternative approaches.

Explanations can be provided directly in this sheet (in the column "Comments/explanations"), or a precise reference to the SST report (e.g. page, section) can be given instead.

11.1.5 CA_reserves_and_premiums

This is a reporting sheet to provide a standardised overview of the captive portfolio. It is based on a similar sheet already used in StandRe. The data must be entered by the company from column N onwards. The information in this sheet is not directly linked to the risk calculation.

11.1.6 CA_reserve_risk

This sheet reports the parameters of the reserve risk model. The reserve risk parameters must be entered by the company per parameter segment.

Undiscounted reserves, column *alternative*: If a full limit loss has been reached for a segment, there is likely no more reserve risk: the reserve in the balance sheet is considered as deterministic. In that case, it is possible to write the value 0 instead of the effective reserve value.

Coefficient of variation, column *alternative*. If the company uses its own coefficients of variation, they have to be entered here.

11.1.7 CA_premium_risk

This sheet reports the parameters of the premium risk model. The premium risk parameters must be entered by parameter segment by the company.

For parameter segments with a frequency of attritional claims greater than 10, the transformation of parameters for an aggregate loss model instead of a frequency-severity model is implemented in the sheet *CA_input_SST_Template.*

11.1.8 CA_expected_result

In this sheet, the company needs to enter all the relevant information for the calculation of the expected insurance result. The expected insurance result of the new business, i.e. incepting between $t = 0$ and $t = 1$, is computed. An additional input for the calculation of the market value margin (MVM) is also entered in this sheet.

11.1.9 CA_IE3_risk

The company must propose one to three business-specific scenarios for insurance risks that have not been modelled (such as previously unobserved or emerging risks) or have been insufficiently modelled in the reserve risk or premium risk models. Occurrence probabilities and impacts are specific to the captive company and have to be explained. More than one of these so-called individual event (IE3) scenarios can occur within one year (this should typically be the case if an occurrence probability is "high", e.g. 10%), and the aggregation is within insurance risk, i.e. with reserve risk and premium risk.

11.1.10 CA_discount_factors

In this sheet, the payment patterns by parameter segment have to be entered. This sheet provides the information needed in other sheets using pattern information, and in particular computes the PY discount factor for reserve risk and the CY discount factor for premium risk.

11.1.11 CA_MVM

Computes the MVM. The necessary inputs are linked from the other sheets. There is no additional input required by the company.

11.1.12 CA_insurance_cash_flows

In this sheet, the cash flows stemming from the insurance business of the captive are calculated for the market risk model.

The company has to enter the positions of the SST balance sheet (to be found in the *SST-Template*) which are related to the insurance business. The breakdown into currency and into cash flows is linked from inputs of the other sheets used for the captive model. The company may provide alternatives to these default-calculated cash flows, with explanations.

11.1.13 CA_input_SST_Template

This sheet collects inputs from other sheets which are required by the *SST-Template* from the captive model, and which have to be copied into the *SST-Template*.

Each section of this sheet corresponds to a specific sheet of the *SST-Template*. Further explanations can be found, in particular regarding the aggregation of reserve risk, premium risk and IE3 risk into insurance risk, and regarding the decomposition of insurance risk into PY and CY as shown in the FDS.

If all CY parameter segments have been modelled with the MPL approach and the IE3 risk can be neglected, see Section 8, it is permitted to change the probabilities of the IE3 scenarios to nil in that sheet.

As the non-hedgeable market risk is neglected for captives, see *Technical Description Aggregation and Market Value Margin*, the value $\chi_{Captive}$ is set to nil – and $\widetilde{BE}_{Captive} \coloneqq BE_{Captive}$ has no relevance.

11.2 Features in *R-tool*

For the implementation of the *R-Tool* please consult the section *System requirements of the executable version* in the document *IT Notes*.

The captive specific features in the *R-Tool* for the calculation of the insurance risk include the following

- Modelling of CY risk by CY parameter segment (with indicator for the CY parameter segment model: ground-up loss or maximal possible loss, see Section 6)
  - by CY parameter segment modelled by ground-up loss approach according to the specification in the template:
    - As frequency severity model for attritional claims with frequency (Poisson), mean and standard deviation for the gamma distribution as inputs
    - As frequency severity model for large claims with frequency (Poisson), shape and threshold (scale) for the Pareto distribution as inputs
    - Transformation into a yearly loss distribution CY parameter segment according to the standard transformation defined in Section 6.2.2.
  - by CY parameter segment of maximal possible loss model as a deterministic distribution with maximum net loss and expected net loss as input
- Aggregation of the net losses across the parameter segments for CY independently, see Section 6
- Aggregation of PY risk and CY risk comonotonic, before IE3 risk, see Section 8

To run the above features with the *R-Tool,* select « captive » in the sheet *Non Life* of the *SST-Template.* Else, in particular if the standard transformation cannot be used, select « simulations » or « cumulative distribution function », and enter the corresponding simulations or cumulative distribution function obtained by your external tool in this sheet.

- The *R-Tool* aggregates the individual events IE3 given as input in the sheet *Non Life* of the *SST-Template,* regardless of whether « captive », « simulations » or « cumulative distribution function » has been chosen, see Section 8.
- The FDS shows the stand-alone non-life insurance risk with and without IE3 risk. If « captive » has been selected, the PY risk and CY risk shown in the FDS is computed by the *R-Tool* from the parameters of the captive model.

12 Appendix

It may occur that the segmentation used internally by the company does not align with the specific segmentation required for the capital risk model, i.e. the SST standard model for reinsurance captive. In such cases, the properties outlined in Section 12.1 on statistical moments should be applied. Section 12.2 presents commonly used properties of lognormal distributions, including relationships when lognormal assumptions are made at the segment level or for aggregated segments. Section 12.3 shows the parametrisation of the Gamma distribution used in this document. Section 12.4 explains the properties of patterns used in the captive model for discounting and the market value margin, based on patterns provided by the company. Finally, Section 12.5 describes how non-life insurance risk relates to the target capital and connects with the explanations provided in the *technical description for the SST standard model aggregation and market value margin.*

12.1 Moment aggregation and disaggregation

Let $X = X_1 + \cdots + X_n$ be a decomposition into n segments of a random variable X with positive values. Denote the corresponding mean and standard deviation by $\mu = E[X]$, $\sigma = \sqrt{Var(X)}$, $\mu_i = E[X_i]$ and $\sigma_i = \sqrt{Var(X_i)}$, and let Γ_{ij} for $i,j = 1,\ldots,n$ be the components of the corresponding correlation matrix Γ. The related coefficients of variation are $CV = \sigma/\mu$ and $CV_i = \sigma_i / \mu_i$.

12.1.1 Moment aggregation

From mean and standard deviation per segment, aggregated mean and aggregated standard deviation are derived by:

$$\mu = \sum_{i=1}^{n} \mu_i , \qquad \sigma = \sqrt{\sum_{i,j} \sigma_i \cdot \sigma_j \cdot \Gamma_{ij}} = \sqrt{\vec{\sigma}^T \, \Gamma \, \vec{\sigma}}.$$

If $\Gamma_{ij} = \rho$ for $i,j = 1,\ldots,n$ and $i \neq j$, i.e. the same correlation $\rho > 0$ is assumed between distinct pairs, one has

$$\sigma = \sqrt{\rho \cdot \sum_{i \neq j} \sigma_i \cdot \sigma_j + \sum_i \sigma_i^2} = \sqrt{\rho \cdot \sum_{i,j} \sigma_i \cdot \sigma_j + (1-\rho) \cdot \sum_i \sigma_i^2} = \sqrt{\rho \cdot \left(\sum_i \sigma_i\right)^2 + (1-\rho) \cdot \sum_i \sigma_i^2}.$$

12.1.2 Moment disaggregation

Assume we have an aggregated coefficient of variation CV and want to get the coefficients of variation of the segments CV_k. Based on the assumption that all segments have the same coefficient of variation $CV_k = CV_1$, the disaggregated standard deviation σ_k of a segment k is given by

$$\sigma_k = \sigma \cdot \frac{\mu_k}{\sqrt{\sum_{i,j} \mu_i \cdot \mu_j \cdot \Gamma_{ij}}} \quad \text{or equivalently} \quad CV_k = CV \cdot \frac{\sum_{i=1}^{n} \mu_i}{\sqrt{\sum_{i,j} \mu_i \cdot \mu_j \cdot \Gamma_{ij}}}.$$

and the coefficients of variation CV_k of the segments are greater than the aggregated coefficient of variation CV unless all correlations Γ_{ij} are equal to one. In that case, $CV_k = CV$.

Proof. The formula follows from

$$\sigma = \sqrt{\sum_{i,j} \sigma_i \cdot \sigma_j \cdot \Gamma_{ij}} = CV_1 \cdot \sqrt{\sum_{i,j} \frac{\sigma_i}{CV_i} \cdot \frac{\sigma_j}{CV_j} \cdot \Gamma_{ij}} \ .$$

The inequality relation between CVs is due to

$$\sum_{i,j} \mu_i \cdot \mu_j \cdot \Gamma_{ij} = 2 \sum_{i<j} \mu_i \cdot \mu_j \cdot \Gamma_{ij} + \sum_i \mu_i^2 \cdot \Gamma_{ii} \leq 2 \sum_{i<j} \mu_i \cdot \mu_j + \sum_i \mu_i^2 = \left(\sum_i \mu_i \right)^2 ,$$

with equality if and only if $\Gamma_{ij} = 1$ for $i, j = 1, \dots n$ ■

12.2 Properties related to the lognormal distribution

12.2.1 Reminder of properties related to a lognormal random variable

Assume Y is a lognormal distributed random variable with parameters μ_{lnorm} and σ_{lnorm}, i.e. $\frac{(\log(Y) - \mu_{lnorm})}{\sigma_{lnorm}}$ is standard normal distributed.

Writing μ_Y, σ_Y and $CV_Y = \sigma_Y / \mu_Y$ for mean, standard deviation and coefficient of variation of Y, respectively, the parameters of the lognormal distribution are given by $\mu_{lnorm} = \log(\mu_Y) - 0.5 \cdot \sigma_{lnorm}^2$ and $\sigma_{lnorm} = \sqrt{\log(1 + CV_Y^2)}$. Conversely, $\mu_Y = \exp(\mu_{lnorm} + 0.5 \cdot \sigma_{lnorm}^2)$ and $\sigma_Y = \mu_Y \cdot \sqrt{\exp(\sigma_{lnorm}^2) - 1}$. Moreover, if $Y' = d \cdot Y$ with $d > 0$, then Y' is lognormal distributed with parameters $\mu'_{lnorm} = \mu_{lnorm} + \log(d)$ and $\sigma'_{lnorm} = \sigma_{lnorm}$. This property is used for discounting, where $d > 0$ is a deterministic discount factor.

The u-quantile and the right-hand expected shortfall at confidence level $1 - \alpha$ are given respectively by:

$$q_u(Y) = \inf\{y | P(Y \leq y) \geq u\} = exp(\mu_{lnorm} + \sigma_{lnorm} \cdot \Phi^{-1}(u)),$$

$$ES^{1-\alpha}(Y) = \frac{1}{\alpha} \int_{1-\alpha}^{1} q_u(Y) du = f_{1-\alpha}(CV_Y) \cdot \ E(Y),$$

where $f_{1-\alpha}(c) = \frac{1}{\alpha} \cdot \left(1 - \Phi\left(\Phi^{-1}(1-\alpha) - \sqrt{\log(1+c^2)}\right)\right)$ with $\Phi^{-1}(1-\alpha)$ the $1-\alpha$ quantile and Φ the cumulative distribution function of a standard normal distribution.

When discounting with a deterministic discount factor $d > 0$ and centering, the right-hand expected shortfall is given by the formula

$$ES^{1-\alpha}\left[d \cdot \left(Y - E(Y)\right)\right] = d \cdot [f_{1-\alpha}(CV_Y) - 1] \cdot E(Y).$$

12.2.2 Properties of a sum of lognormal random variables

Let $Y_1, \dots, Y_n$ be n lognormal distributed random variables with mean $\mu_k = E(Y_k)$, standard deviation $\sigma_k = sd(Y_k)$ and coefficient of variation $CV_k = \sigma_k / \mu_k$ for $k = 1, \dots, n$, and Γ_{kl} their correlations for $k, l = 1, \dots, n$.

$ES^{1-\alpha}(Y_1) + \dots + ES^{1-\alpha}(Y_n) \geq ES^{1-\alpha}(Y_1 + \dots + Y_n)$ and usually, $Y_1 + \dots + Y_n$ is not lognormal distributed.

If $CV_1 = CV_2 = \dots = CV_n$ and $\Gamma_{kl} = 1$ for $k, l = 1, \dots, n$, then $ES^{1-\alpha}(Y_1) + \dots + ES^{1-\alpha}(Y_n) = ES^{1-\alpha}(Y)$, where Y is a lognormal distributed random variable with mean $\mu = \sum_{k=1}^{n} \mu_k$, standard deviation $\sigma = \sum_k \sigma_k$, and coefficient of variation $CV = CV_1$.

Proof. From moment disaggregation above, $CV = CV_1$. With the expected shortfall formula for a lognormal distribution, $\sum_k ES^{1-\alpha}(Y_k) = \sum_k f_{1-\alpha}(CV_k) \cdot \mu_k = f_{1-\alpha}(CV) \cdot \mu = ES^{1-\alpha}(Y)$ ∎

12.3 Gamma distribution

The parameters are $k > 0$ for the shape and $\theta > 0$ for the scale. The probability density function on the support $x \in (0, \infty)$ is given by

$$f(x) = \frac{1}{\Gamma(k) \cdot \theta^k} \cdot x^{k-1} \cdot e^{-\frac{x}{\theta}}$$

and the parameters can be derived from mean m and standard deviation s by $k = \frac{m^2}{s^2}$ and $\theta = \frac{s^2}{m}$.

12.4 Pattern

The **incremental (expected) pattern** at time $t = 0$ of risk segment seg is defined for $s > 0$ as

$$\pi_s^{seg} = \pi_{0,s}^{seg} := \frac{FX_0^{CUR} \cdot E(CF_s^{seg})}{BE_0^{(N),seg}} = \frac{E(CF_s^{seg})}{\sum_{j>0} E(CF_j^{seg})}$$

with the notation of Section 4.2. Whence $\sum_{s \geq 1} \pi_s^{seg} = 1$ and $FX_0^{CUR} \cdot E\left(CF_s^{seg}\right) = BE_0^{(N),seg} \cdot \pi_s^{seg}$ hold. From that and the definitions of Section 4.2, we can write for $t \geq 0$ and $u \geq \max(0, t-1)$:

$$\begin{aligned} BE_{0,(>u)}^{seg} &= \left(1 + r_{0,t}\right)^{-t} \cdot E\left[BE_{t,(>u)}^{seg}\right] = BE_0^{(N),seg} \cdot \sum_{s>u} \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot \pi_s^{seg} \\ &= BE_0^{(N),seg} \cdot \left(d^{seg} - \sum_{s=1}^{u} \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot \pi_s^{seg}\right), \end{aligned}$$

where $d^{seg} := \sum_{s>0} \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot \pi_s^{seg}$ defines the **discount factor** at time $t = 0$ of risk segment seg. In particular

$$BE_0^{seg} = d^{seg} \cdot BE_0^{(N),seg}$$

and

$$BE_{0,(>u)}^{(N),seg} = E\left[BE_{t,(>u)}^{(N),seg}\right] = BE_0^{(N),seg} \cdot \sum_{s>u} \pi_s^{seg} = BE_0^{(N),seg} \cdot \left(1 - \sum_{s=1}^{u} \pi_s^{seg}\right)$$

hold.

The pattern stems from the currency $CUR = CUR_{seg}$ as $E(CF_s^{seg})$ is in that currency but does not depend on the exchange rate FX_0^{CUR}. The pattern is usually known from external or historical source, such that the above formulae can be used for computations.

Over several segments, with $\mu_{seg} = BE_0^{(N),seg}$ the discount factor is defined by $d = \frac{\sum_{seg} d^{seg} \cdot \mu_{seg}}{\sum_{seg} \mu_{seg}}$ and the pattern for $s > 0$ by $\pi_s = \frac{\sum_{seg} \pi_s^{seg} \cdot \mu_{seg}}{\sum_{seg} \mu_{seg}}$.

12.5 Insurance risk as part of the one-year change in risk bearing capital

Generic definitions in this Section are specified for the captive model in Sections 4.6 ff.

12.5.1 Cash flow

$t = 0$ denotes the **SST reference date** and $t = 1$ twelve months later. Usually, we use lower indexes for time-related information, with the time indicating when the information can be known (i.e. is measurable), and upper indexes for additional information, which is described in more detail below.

A **cash flow outstanding** at time $u \geq 0$ is written

$$CF_{(>u)}^{seg} = \{CF_s^{seg}\}_{s>u} = \{CF_{u+1}^{seg}, CF_{u+2}^{seg}, \ldots\},$$

where

- seg is for a segment defined according to the situation, typically defining a specific portfolio, e.g. "Property Damage and Business Interruption US", and its scope, e.g. "the insurance business in the SST balance sheet at a given time $t = v \geq 0$";
- it is assumed that exactly one currency CUR underlies the segment seg; whenever clear from the context the dependency of the segment is omitted in the notation, i.e. $CUR \equiv CUR_{seg}$;
- the cash flow CF_s^{seg} at time s is expressed in the currency CUR and $FX_s^{CUR} \cdot CF_s^{seg}$ expresses the same in SST currency, with FX_s^{CUR} being the exchange rate CUR/SST at time $t = s$, i.e. the value in SST currency of one unit of currency CUR;
- the *nature* and the *type* of the cash flow have to be defined. *Nature* means claims payments and/or premium and/or costs, etc., *type* whether gross or net of ceded reinsurance, whether neglecting or including counterparty default, etc.;
- the *sign convention* has to be defined, i.e. whether a positive value means an inflow or an outflow;
- it is assumed that the cash flows occur exactly at the end of the corresponding one-year period, i.e. $CF_\tau^{seg} = CF_s^{seg}$ for $s - 1 < \tau \leq s$ and $s = 1,2, \ldots$;

and, given a set of segments SEG, we write

$$CF_{(>u)} := \{CF_s\}_{s>u} = \{CF_{u+1}, CF_{u+2}, \dots\},$$

where CF_s is meant for each $s > u$ as a vector of components CF_s^{seg} where $seg \in \mathrm{SEG}$. The total cash flow occuring at time s is given by $\sum_{seg} FX_s^{CUR} \cdot CF_s^{seg}$ in SST currency.

12.5.2 Best estimate

The **best estimate** at time $t \geq 0$ of a cash flow outstanding at time $u \geq \max(0, t-1)$ is given by

$$BE_{t,(>u)} \equiv BE_t\big(CF_{(>u)}\big) := \sum_{seg}\sum_{s>u} FX_t^{CUR} \cdot \big(1 + R_{t,s}^{CUR}\big)^{t-s} \cdot E\big(CF_s^{seg}\big|\mathcal{F}_t\big),$$

where

- $R_{t,s}^{CUR}$ denotes the risk-free interest rate at time t for a nominal value of exactly one unit of currency CUR at time $s \geq t$, i.e. with a maturity of $k = s - t$ years. In some occurrences like the market risk model $R_{t,s}^{CUR}$ is replaced by the use of its continuous version $R_{t,s}^{\text{continuous},CUR}$ where $1 + R_{t,s}^{CUR} = \exp\big(R_{t,s}^{\text{continuous},CUR}\big)$;
- $\mathcal{F}_t$ denotes the information available at time t (filtration). Note that FX_t^{CUR} and $R_{t,s}^{CUR}$ are known at time t (measurable) and for $t > 0$ stochastic from the point of view of the SST reference date $t = 0$. We use $r_{0,s}^{CUR} := R_{0,s}^{CUR}$, emphasizing in the notation that $r_{0,s}^{CUR}$ is a deterministic risk-free curve, and $E(\cdot) := E(\cdot\,|\mathcal{F}_0)$. Without superscript CUR, $FX_t = 1$, $R_{r,s}$ and $r_{0,s}$ are meant in SST currency.

Special cases and deviations of that definition are defined as follows for use in the calculations of risk bearing capital and target capital.

- Best estimate at time $t \geq 0$ of a cash flow outstanding at the same time $u = t$, noted by omitting "$(>u)$":

$$BE_t := BE_{t,(>t)}$$

- Best estimate **in the SST balance sheet** at time t

$$BE_t^{ex_t} := BE_{t,(>t)}^{ex_t},$$

  where the underlying portfolio ex_t is the business in the SST balance sheet at that time t (**existing business** at time t; see art. 3 ISO-FINMA for the scope of the SST balance sheet). Depending on the sign conventions for an inflow, for an outflow, for the assets and for the liabilities, a multiplication by minus one of the above may be required for the value shown in the SST balance sheet. The general definition $BE_{t,(>u)}$ of best estimate in this Section extends the usual definition for a balance sheet $BE^{ex_t}_{t,(>t)}$, in allowing for another definition of the underlying portfolio and in allowing another time for outstanding cash flows.

- Best estimate at time $t+1$ of a cash flow outstanding at time t:

$$BE^{ex_t+new_{t+1}}_{t+1,(>t)} = \sum_{seg} FX^{CUR}_{t+1} \cdot CF^{ex_t+new_{t+1},seg}_{t+1} + BE^{ex_{t+1}}_{t+1},$$

where new_{t+1} is the business in the SST balance sheet at a time τ with $t < \tau \leq t+1$, but not in the SST balance sheet at time t (**new business** the year $t+1$, i.e. between time t [exclusive] and $t+1$ [inclusive]), and where $ex_t + new_{t+1}$ is the existing business at time t and the new business of twelve months following time t. new_{t+1} may include business with claims settled at time $t+1$, i.e. not in ex_{t+1}, like some travel insurance. The notation ex and new without subscript is meant for $t = 0$ in the sense that $ex = ex_0$ and $new = E(new_1)$, the forecast at time $t=0$ of the new business. This special case is used for the one-year change related to non-life insurance contracts (where the uncertainty between new_1, the new business measurable at time $t=1$, and the forecast at time $t = 0$ of the new contracts is neglected).

- **Undiscounted** best estimate, noted with superscript (N):

$$BE^{(N)}_{t,(>u)} := \sum_{seg} \sum_{s>u} FX^{CUR}_t \cdot E\left(CF^{seg}_s \middle| \mathcal{F}_t\right).$$

The undiscounted best estimate is obtained by setting $R^{CUR}_{t,s} = 0$ in the definition of a best estimate.

- **Insurance risk** best estimate, noted with superscript (IR):

$$BE^{(IR)}_{t,(>u)} := \sum_{seg} \sum_{s>u} E\left[FX^{CUR}_t \cdot \left(1 + R^{CUR}_{t,s}\right)^{t-s}\right] \cdot E\left(CF^{seg}_s \middle| \mathcal{F}_t\right).$$

Here we assume (due to a non-arbitrage argument), for any $s \geq t$ and currency CUR, that

$$E\left[\left(1 + r_{0,t}\right)^{-t} \cdot FX^{CUR}_t \cdot \left(1 + R^{CUR}_{t,s}\right)^{t-s}\right] = FX^{CUR}_0 \cdot \left(1 + r^{CUR}_{0,s}\right)^{-s},$$

providing the equivalent definition

$$\left(1 + r_{0,t}\right)^{-t} \cdot BE^{(IR)}_{t,(>u)} = \sum_{seg} \sum_{s>u} FX^{CUR}_0 \cdot \left(1 + r^{CUR}_{0,s}\right)^{-s} \cdot E\left(CF^{seg}_s \middle| \mathcal{F}_t\right).$$

This case is identical to the definition of best estimate at $t = 0$ given at the beginning of this Section and deviates from that definition for $t > 0$ by considering as deterministic the exchange rates and the interest rates. This is used for the one-year change related to non-life insurance risk. In this Section

12.5, $BE_{t,(>u)}$ may be different from $BE_{t,(>u)}^{(IR)}$. However, as only $BE_{t,(>u)}^{(IR)}$ is used in the rest of the technical documentation, **we write $\boldsymbol{BE_{t,(>u)}}$ for $\boldsymbol{BE_{t,(>u)}^{(IR)}}$ in all other Sections.**

12.5.3 One-year change in scope

The captive model quantifies the one-year change (from time $t = 0$ to time $t = 1$) in the risk-bearing capital related to non-life insurance risk, assuming Section 3.2 *simplifications for the one-year change and formula for the target capital* of the *technical description for the SST standard model aggregation and market value margin*. At that Section, with the convention of a positive value for an inflow or an asset, we had

$$TC_0 = -ES_\alpha\left(\left(1 + r_{0,1}\right)^{-1} \cdot RBC_1 - RBC_0\right) = -ES_\alpha(\Delta RBC_1) = -ES_\alpha\left(\Delta RBC_1^{ins} + \mathrm{rest}\right),$$

where TC_0 is the target capital, ES_α the expected shortfall at occurrence probability $\alpha = 1\%$ and ΔRBC_1 the one-year change of risk bearing capital, additively decomposed into a component ΔRBC_1^{ins} stemming from insurance contracts and other components rest stemming from other objects underlying the balance sheet positions, e.g. bonds.

The one-year change related to non-life insurance contracts of the captive (assumed reinsurance and ceded retrocession) is defined by

$$\begin{aligned}\Delta RBC_1^{ins} &= \left(1 + r_{0,1}\right)^{-1} \cdot \sum_{seg} FX_1^{CUR} \cdot \widetilde{CF}_1^{ex+new,seg} + \left(1 + r_{0,1}\right)^{-1} \cdot BE_1^{ex+new} - BE_0^{ex} \\ &= \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{ex+new} - BE_0^{ex} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{ex+new} + BE_0^{new} - BE_0^{new} - BE_0^{ex} \\ &= \left[\left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{ex+new} - BE_0^{ex+new}\right] + BE_0^{new},\end{aligned}$$

with the underlying cash flow $\widetilde{CF}_s^{ex,seg}$ and $\widetilde{CF}_s^{new,seg}$ net of retrocession, defined by premiums, claims payments and costs, marked with tilde for taking into account credit default of a third party inflow (without tilde it means ignoring credit default) and having a positive value for an inflow and a negative value for an outflow. The last expression allows for a difference of the same outstanding cash flow of the same underlying portfolio, differing by time of valuation, added by the expected result of the new business.

Using in the last expression for ΔRBC_1^{ins} the definition of best estimate given in Section 12.5.2 with the cash flows $\widetilde{CF}_s^{ex+new,seg}$ and $\widetilde{CF}_s^{new,seg}$, we see that there are insurance risk factors in $E\left(CF_s^{ex+new,seg} \middle| \mathcal{F}_1\right)$, market risk factors in FX_1^{CUR} and $\left(1 + R_{1,s}^{CUR}\right)^{1-s}$, and credit risk factors from the inflows of $\widetilde{CF}_s^{ex+new,seg}$, the other terms being deterministic at time $t = 0$.

More exactly for the credit risk,

$$\widetilde{CF}_s^{ex+new,seg} = \sum_{cp}\left[\Lambda_s^{ex+new,seg,cp,in} \cdot CF_s^{ex+new,seg,cp,in}\right] + CF_s^{ex+new,seg,out},$$

where the sum is over the counterparties cp, subscripts in and out are for the inflows, respectively the outflows, and $\Lambda_s^{ex+new,seg,cp,in} := \frac{\widetilde{CF}_s^{ex+new,seg,cp,in}}{CF_s^{ex+new,seg,cp,in}}$ or 1 if the denominator has a value zero. Note that $\Lambda_s^{ex+new,seg,cp,in} \geq 0$ and $\Lambda_s^{ex+new,seg,cp,out} = 1$ as own credit risk is not considered in the SST. The credit risk factors are in $E\left(\Lambda_s^{ex+new,seg,cp,in} \middle| \mathcal{F}_1\right)$.

It is possible to decompose additively the insurance risk (*IR*), market risk (*MR*) and credit risk (*CR*) by using a linearisation and ignoring the non-linear part (*REM*) from the following algebraic identity (Taylor expansion)

$$
\begin{aligned}
A \cdot B \cdot C - a \cdot b \cdot c = {} & (A-a) \cdot b \cdot c + a \cdot (B-b) \cdot c + a \cdot b \cdot (C-c) \\
& + (A-a) \cdot (B-b) \cdot c + (A-a) \cdot b \cdot (C-c) + a \cdot (B-b) \cdot (C-c) + (A-a) \\
& \cdot (B-b) \cdot (C-c)
\end{aligned}
$$

applied to $A = E\left(CF_s^{ex+new,seg,cp,in} \middle| \mathcal{F}_1\right)$ or $A = E\left(CF_s^{ex+new,seg,out} \middle| \mathcal{F}_1\right)$, $B = FX_1^{CUR} \cdot \left(1 + r_{0,1}\right)^{-1} \cdot \left(1 + R_{1,s}^{CUR}\right)^{1-s}$, $C = E\left(\Lambda_s^{ex+new,seg,cp,in} \middle| \mathcal{F}_1\right)$ and their respective expectations $a = E\left(CF_s^{ex+new,seg,cp,in}\right)$ or $a = E\left(CF_s^{ex+new,seg,out}\right)$, $b = FX_0^{CUR} \cdot \left(1 + r_{0,s}^{CUR}\right)^{-s}$ and $c = E\left(\Lambda_s^{ex+new,seg,cp,in}\right)$. The derivation is quite straightforward with assumption of non-correlation between $\left(1 + r_{0,1}\right)^{-1} \cdot FX_1^{CUR} \cdot \left(1 + R_{1,s}^{CUR}\right)^{1-s}$ and $E\left(\widetilde{CF}_s^{ex+new,CUR} \middle| \mathcal{F}_1\right)$ and with assumption of non-correlation at time $t = 0$ and at time $t = 1$ between $\Lambda_s^{ex+new,seg,cp,in}$ and $CF_s^{ex+new,seg,cp,in}$, else without these assumptions cumbersome.

This provides an additive expansion

$$\Delta RBC_1^{ins} = \overline{\Delta RBC}_1^{ins,IR} + \overline{\Delta RBC}_1^{ins,MR} + \overline{\Delta RBC}_1^{ins,CR} + REM_1^{ins} + BE_0^{new},$$

where, using the simplifying assumption $E\left(\Lambda_s^{ex+new,seg,cp,in}\right) \approx 1$ we obtain $\overline{\Delta RBC}_1^{ins,IR} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{(IR)} - BE_0^{(IR)}$ which has only insurance risk factors as stochastic, and analogously $\overline{\Delta RBC}_1^{ins,MR}$ has only market risk factors, respectively $\overline{\Delta RBC}_1^{ins,CR}$ only credit risk factors as stochastic. Thus, the definition of the one-year change related to insurance risk in Section 4.3 corresponds to $\left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{(IR)} - BE_0^{(IR)}$ and the definition of expected insurance result to BE_0^{new}.

The *technical description of the SST standard model aggregation and market value margin* provides broader explanations on the expansions related to the one-year change in RBC and their use for computing the target capital. The equivalence of notations is shown in the following table.

Technische Beschreibung für das SST-Standardmodell Aggregation und Mindestbetrag	Technical description of the SST standard model reinsurance captive, Section 12.5
$ZK_0 = -ES_\alpha\left[\left(1 + r_{0,1}\right)^{-1} \cdot RTK_1 - RTK_0\right] = -ES_\alpha[\Delta RTK_1]$	$TC_0 = -ES_\alpha\left(\left(1 + r_{0,1}\right)^{-1} \cdot RBC_1 - RBC_0\right) = -ES_\alpha(\Delta RBC_1)$
$\Delta RTK_1 = \Delta RTK_1^{ins} + \Delta RTK_1^{inv} + \Delta RTK_1^{oth} + \Delta RTK_1^{MVM} + \Delta RTK_1^{ded}$	$\Delta RBC_1 = \Delta RBC_1^{ins} + \text{rest}$
$\Delta RTK_1^{ins} = \overline{\Delta RTK}_1^{ins} + ExpRes_0^{ins}$	ΔRBC_1^{ins}

$\overline{\Delta RTK}_1^{ins} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_1((CF_s^{ex+new})_{s>0}) - BE_0((CF_s^{ex+new})_{s>0})$ $ExpRes_0^{ins} = BE_0((CF_s^{new})_{s>0})$	$\Delta RBC_1^{ins} = \left[\left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{ex+new} - BE_0^{ex+new}\right] + BE_0^{new}$
$BE_t\left(\left(CF_s^{ins,(v),POS}\right)_{s>u}\right) = \sum_{CUR} FX_t^{CUR} \cdot \sum_{s>u} \left(1 + R_{t,s}^{CUR}\right)^{t-s} \cdot E\left[\Lambda_s^{ins,(v),POS,CUR} \mid \mathcal{F}_t\right] \cdot E\left[CF_s^{ins,(v),POS,CUR} \mid \mathcal{F}_t\right]$	$BE_{t,(>u)} = BE_t\left(CF_{(>u)}\right) = \sum_{seg} \sum_{s>u} FX_t^{CUR} \cdot \left(1 + R_{t,s}^{CUR}\right)^{t-s} \cdot E\left(CF_s^{seg} \mid \mathcal{F}_t\right)$
$\left(1 + r_{0,t}\right)^{-t} \cdot BE_{t,0}^{ins,IR} = \sum_{CUR} \sum_{s>0} FX_0^{CUR} \cdot \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot E\left[\Lambda_s^{ex+new,CUR}\right] \cdot E\left[CF_s^{ex+new,CUR} \mid \mathcal{F}_t\right]$	$\left(1 + r_{0,t}\right)^{-t} \cdot BE_{t,(>u)}^{(IR)} = \sum_{seg} \sum_{s>u} FX_0^{CUR} \cdot \left(1 + r_{0,s}^{CUR}\right)^{-s} \cdot E\left(CF_s^{seg} \mid \mathcal{F}_t\right),$ with $u = 0$. **We write $BE_{t,(>u)}$ for $BE_{t,(>u)}^{(IR)}$ in all other Sections**, as only $BE_{t,(>u)}^{(IR)}$ is used in those Sections.
$\overline{\Delta RTK}_1^{ins,IR} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,0}^{ins,IR} - BE_{0,0}^{ins,IR}$	$\overline{\Delta RBC}_1^{ins,IR} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,(>0)}^{(IR)} - BE_0^{(IR)}$
$\overline{\Delta RTK}_1^{ins,MR} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,0}^{ins,MR} - BE_{0,0}^{ins,MR}$	$\overline{\Delta RBC}_1^{ins,MR}$
$\overline{\Delta RTK}_1^{ins,CR} = \left(1 + r_{0,1}\right)^{-1} \cdot BE_{1,0}^{ins,CR} - BE_{0,0}^{ins,CR}$	$\overline{\Delta RBC}_1^{ins,CR}$
$\overline{REM}_1^{ins}$	REM_1^{ins}
BE_0^{ins}	BE_0^{new}

13 Record of changes

Changes of content are listed; editorial corrections are not.

Version 31 October 2025, changes from 31 October 2024

- Former Section 3.2 *Glossary* has been deleted. Its content is now integrated throughout the text.
- Section 4 *The one-year change for insurance risk* has been rewritten. This new version clarifies the treatment of multiple currencies and focuses solely on definitions relevant to the captive model. Detailed explanations have been moved to the Appendix, specifically to the new Section 12.5 *Insurance risk as part of the one-year change in risk bearing capital*.
- Sections 6.2 and 12.3: a square sign was missing in the formula for the shape parameter of the Gamma distribution, this has now been corrected. However, the implementation in the SST-Captive-Template and the R-Tool was already accurate.

- The text concerning the URR risk of Section 6.1 has been moved to a new Section 6.4 for clarity.
- Section 10.2 *Market value margin (MVM)* has been rewritten in a more straightforward way.
- Section 11.2 *Features of the R-Tool* : Regarding the bullet point "Aggregation for the net loss across the parameter segments independently, see Section 6", the discount factor was initially not implemented in the R-Tool. This issue has been corrected and does not require any changes in the present document.
- Section 12.4 *Pattern* in Appendix has been added. Before it was previously partially covered in the main text.

Version 31 October 2024, changes from 31 October 2023

- References and terminology are modified according to the modification of ISO-FINMA (AVO-FINMA/OS-FINMA) abrogating the FINMA Circular 17/3 "SST".
- Alignment of terminology with SST balance sheet and *technical description for the SST standard model aggregation and market value margin* in Section 3.1 and 10.2.