

FUNDAMENTAL REVIEW OF THE TRADING BOOK



FRTTB

FRTB Market Risk

FRTB CVA

Using AAD for FRTB

FRTB thought leadership

FRTB MARKET RISK

STANDARDISED APPROACH (SA)

The new Standardised Approach (SA) in FRTB includes the risk charges under the sensitivities based method, the default risk charge, and the residual risk add-on. It replaces both the current market risk capital charge measures and the current default capital charge.

CompatibL Platform, part of CompatibL's Risk Technology award-winning XVA and regulatory capital solution, supports full integration of trade, market, and reference data from most of the popular book of record systems, and the ability to price most complex portfolios with front office accuracy and exceptional performance. This makes CompatibL Platform the natural choice for the implementation of FRTB Market Risk.

In addition to meeting the FRTB requirements for trade pricing and effective calculation of sensitivities for the sensitivities-based Standardised Approach (SA), CompatibL has complete data on collateral, hedges, and ISDA/CSA terms necessary to reflect their mitigating effect on FRTB regulatory capital.

As a provider of front office pricing and XVA analytics, CompatibL implemented lightning fast calculation of sensitivities necessary for the Standardised Approach in FRTB market risk. Through its regulatory capital functions, CompatibL Risk was one of the first solutions to offer full support for SA-CCR (the current standardised approach for counterparty credit risk); this implementation has been extended the similar requirement for the default capital charge in FRTB.

Counterparty	Rating	EAD	Pd	RW FTRB	RW AIRB	Capital Requirement
NAUT.MAP110	Internal.A+	2,231,451,492.5363	0.00040	0.11537	0.10564	0.00923
INVESTEC BANK LTD (PBE)	Internal.BBB	37,312,879.14917	0.00143	0.28311	0.21850	0.02265
Netting Set/Unmetted Details						
Details:4813845 SMT		25,999,171.98915	0.87226	21,240,449.57051	18,570,837.13511	0.00000
Details:4813842 SMT		7,252,297.02260	0.81892	6,325,651.28306	5,180,212.15900	0.00000
Details:4846310 SMT		246,523.03709	0.84353	208,752.02356	176,088.45506	0.00000
Details:4846880 SMT		30,699.30130	1.00000	20,875.20236	1,052.87000	0.00000
Details:69911835 CAL		1,674,298.91158	1.00000	892,134.75398	892,134.75398	303,793.04000
Netting Set/Unmetted Details						
NettingSet.INVESTEC BANK LTD (PBE)...		110,353.36278	1,413,920.12038	110,353.36278	0.05015	0.11903
Asset Class						
Hedging Set						
IR.ZAR						
Subset						
Maturity bucket [1, 5]						
Margin Set						

FRTB MARKET RISK

INTERNAL MODELS APPROACH (IMA)

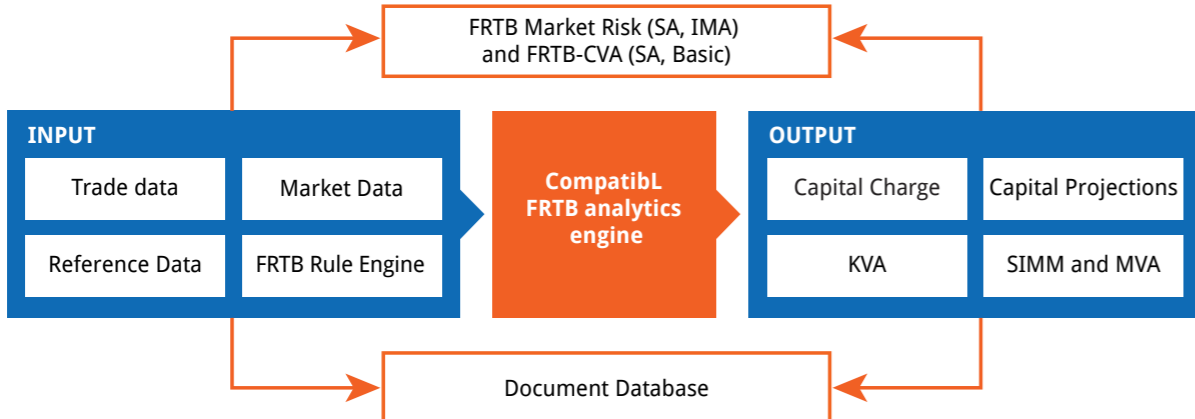
For the implementation of the internal models approach (IMA) for FRTB Market Risk, CompatibL can rely on its high quality pricing library (part of the XVA solution) to ensure that stringent backtest and P&L attribution requirements for IMA are met. This library can be deployed in conjunction with either historical or Monte Carlo based IMA methodology.

In recent industry conferences and regulatory forums, one of the most frequently made points about FRTB IMA is that a traditional market risk pricing library typically relies on a simplified trade representation to implement the IMM in the current market risk framework. Such simplified trade representation will prove inadequate for the stringent backtest and P&L attribution requirements in FRTB. For example, many market risk engines simplify the averaging swap by using an approximation not involving averaging, or a linear approximation to trades that are nonlinear. Using such approximations for FRTB will likely cause backtest and P&L attribution breaks beyond the IMA thresholds, causing the trading desk to revert to more capital intensive SA method as per

the required response to such breaks provided by the final FRTB regulation. CompatibL with its deep knowledge of the fast and accurate large scale portfolio modelling proven by its multiple awards for XVA and Risk, is able to provide high quality analytics that will pass the stringent IMA backtests and P&L attribution tests.

CompatibL implemented the functionality required to FRTB IMA using either historical or Monte Carlo methodology, including 97.5% stressed expected shortfall (ES); backtest and P&L attribution reports; market data observability standards and the non-modellable risk factor (NMRF) add-on charge; using stressed period for calibration; granular liquidity horizons per asset class; and regulatory limits in recognizing the benefits of cross asset diversification and hedges. CompatibL Platform includes both historical ES model and a Monte Carlo ES model in real world measure, as required for IMA. An example of the Expected Shortfall report under the real world Monte Carlo IMA model is provided below.

Trade	TradeCurve	Product	Portfolio	NettingSet	TradeCounterparty	Trader	Desk	MTM PV	Sim PV	ES 100 95%	ES 100 97.5%	ES 100 99%	ES 1Y 95%	Mvar 10D 95%		
1	FRAS2592822	Cpty01 FRA	Portfolio.6	Cpty01 Cpty01	Lance Tucker	Desk.2	1,551.77	1,551.77	(17,377.26)	(20,005.33)	(22,744.40)	(120,514.05)	(13,610.61)			
2	FRAS2256090	Cpty01 FRA	Portfolio.7	Cpty01 Cpty01	Cesar Garcia	Desk.5	(78,313.76)	(78,313.74)	(37,166.55)	(42,691.65)	(50,298.10)	(260,787.47)	(29,041.78)			
3	FRA716850253	Cpty01 FRA	Portfolio.4	Cpty01 Cpty01	Care O'Donnell	Desk.1	(8,948.73)	(9,383.78)	(13,990.60)	(15,504.74)	(17,260.03)	(96,244.30)	(11,506.06)			
4	FRA961709648	Cpty01 FRA	Portfolio.4	Cpty01 Cpty01	Michael Tucker	Desk.1	3,295.74	3,270.29	(5,816.80)	(6,505.89)	(7,430.84)	0.0000	(4,696.69)			
5	FRA746654148	Cpty01 FRA	Portfolio.5	Cpty01 Cpty01	Hugo Garcia	Desk.1	(32,562.14)	(32,354.19)	(31,811.62)	(36,606.18)	(41,596.36)	(173,373.46)	(24,936.04)			
6	IRS270211422	Cpty01 IR Swap	Portfolio.7	Cpty01 Cpty01	Care O'Donnell	Desk.5	(111,990.52)	(116,464.93)	(107,803.23)	(119,953.66)	(132,763.02)	(622,678.00)	(88,685.52)			
7	IRS161666965	Cpty01 IR Swap	Portfolio.4	Cpty01 Cpty01	Fadi Fakhouri	Desk.4	(153,752.21)	(153,752.24)	(163,935.40)	(182,896.52)	(208,224.40)	(1,005,375.12)	(133,082.96)			
8	IRS302862819	Cpty01 IR Swap	Portfolio.5	Cpty01 Cpty01	Li Khan	Desk.5	515,331.45	515,331.49	(173,980.82)	(200,918.87)	(229,146.98)	(1,410,653.87)	(135,464.47)			
9	IRS651842079	Cpty01 IR Swap	Portfolio.1	Cpty01 Cpty01	Fadi Fakhouri	Desk.5	(12,241.12)	(14,624.82)	(227,205.87)	(256,193.66)	(289,017.31)	(1,439,862.66)	(177,036.80)			
10	IRS585304083	Cpty01 IR Swap	Portfolio.6	Cpty01 Cpty01	Hanying Feng	Desk.5	14,201.79	13,618.91	(61,818.91)	(69,103.70)	(78,071.31)	(314,063.58)	(49,991.47)			
11	IRS505971413	Cpty01 IR Swap	Portfolio.5	Cpty01 Cpty01	Hugo Garcia	Desk.5	115,659.49	115,659.86	(189,383.99)	(217,027.14)	(259,186.69)	(1,424,071.79)	(150,595.69)			
12	IRS417145114	Cpty01 IR Swap	Portfolio.3	Cpty01 Cpty01	Sven Mortensen	Desk.2	(163,309.99)	(159,637.39)	(68,501.41)	(68,097.40)	(76,911.91)	(278,100.14)	(48,461.22)			
13	CS686137906	Cpty01 Xccy Swap	Portfolio.1	Cpty01 Cpty01	Li Khan	Desk.1	15,648.09	20,784.50	(15,285.18)	(16,885.18)	(18,646.20)	(115,199.26)	(12,745.61)			
14	IRS678403669	Cpty01 IR Swap	Portfolio.2	Cpty01 Cpty01	Hugo Garcia	Desk.1	(17,569.00)	(18,557.49)	(66,408.34)	(74,083.04)	(82,133.98)	(362,064.15)	(54,485.44)			
15	IRS101797833	Cpty01 IR Swap	Portfolio.2	Cpty01 Cpty01	Sven Mortensen	Desk.5	(170,120.33)	(176,127.48)	(117,220.88)	(130,701.33)	(148,687.35)	(772,056.66)	(95,271.47)			
16	FXF704973212	Cpty01 FX Fwd	Portfolio.3	Cpty01 Cpty01	Svetlana Omelchenko	Desk.2	18,148.06	18,148.33	(297,286.96)	(334,926.52)	(383,232.62)	0.0000	(239,462.92)			
17	FXF597910683	Cpty01 FX Fwd	Portfolio.3	Cpty01 Cpty01	Eugene Zabokrtski	Desk.5	(110,547.93)	(118,547.92)	(111,795.09)	(124,994.95)	(134,547.05)	0.0000	(91,828.17)			
18	FXF561407154	Cpty01 FX Fwd	Portfolio.4	Cpty01 Cpty01	Sven Mortensen	Desk.3	234,946.04	234,946.23	(309,326.12)	(347,119.05)	(392,160.23)	0.0000	(245,394.31)			
19	FXF113958283	Cpty01 FX Fwd	Portfolio.4	Cpty01 Cpty01	Hanying Feng	Desk.5	242,119.69	242,120.03	(375,100.18)	(421,345.24)	(485,633.38)	0.0000	(300,865.24)			
20	FXF111689324	Cpty01 FX Fwd	Portfolio.4	Cpty01 Cpty01	Eugene Zabokrtski	Desk.5	97,916.12	97,916.16	(73,883.76)	(82,901.75)	(93,664.75)	0.0000	(58,616.83)			
21	FXO420578080	Cpty01 FX Option	Portfolio.4	Cpty01 Cpty01	Eugene Zabokrtski	Desk.3		(4,685.05)	(8,364.17)	(9,922.99)	(12,037.00)	(72,658.71)	(6,058.46)			
22	FXO819332561	Cpty01 FX Option	Portfolio.2	Cpty01 Cpty01	Svetlana Omelchenko	Desk.3		3,562.97	(2,347.93)	(2,528.19)	(2,652.62)	0.0000	(2,042.49)			
23	FXO630002471	Cpty01 FX Option	Portfolio.7	Cpty01 Cpty01	Fadi Fakhouri	Desk.4		20,497.14	(9,087.34)	(10,020.02)	(11,247.60)	0.0000	(7,549.67)			
24	FXO315669814	Cpty01 FX Option	Portfolio.3	Cpty01 Cpty01	Lance Tucker	Desk.4		(9,003.94)	(11,763.22)	(13,739.58)	(16,350.36)	(79,774.51)	(6,779.06)			
Nonlinear										1,351,660.66	1,533,608.99	1,770,227.61	6,627,180.14	1,029,725.99		
Total										399,462.51	406,097.20	(1,139,466.76)	(1,273,491.75)	(1,426,031.51)	(1,923,159.24)	(962,823.20)



FRTB CVA

The FRTB-CVA capital requirement is calculated as the sensitivity of CVA to market risk factors. Among the pre-requisites for the bank to qualify for the more effective Standardised Approach (SA) in FRTB-CVA is the requirement to compute CVA for financial reporting purposes and to have a CVA desk. The capital-effective standardised approach calculation for FRTB CVA involves computing sensitivities of CVA to regulatory market risk factor shocks.

CompatibL believes that these provisions make its award winning XVA solution the most natural way to implement FRTB-CVA. CompatibL's software relies on its proven XVA Monte Carlo engine to compute the sensitivities required for FRTB-CVA sensitivity based standardised approach (note that IMA-CVA approach has been excluded from the framework by the recent decision of the Basel Committee, leaving only the sensitivity based SA-CVA approach and the unfavorable Basic Framework option). CompatibL XVA solution is capable of performing this calculation in both fair value XVA context, or in FRTB-CVA context including all of the FRTB-CVA rules and limitations on hedge and netting recognition as well as the restrictions on cross asset diversification benefits.

CompatibL deeply understands the criteria for the bank to qualify for the FRTB-CVA sensitivity-based standardized approach (SA), and to avoid the capital-heavy Basic Framework for CVA. Following the recent decision by the Basel committee not to provide the internal models approach (IMA) for CVA, the standardised approach remains the most attractive option for the FRTB-CVA capital charge.

The success in implementing the standardised approach for FRTB-CVA depends on several system capabilities, including the ability to calculate

CVA sensitivities to a sufficiently large range of risk factors, a methodology for generating credit spreads for illiquid counterparties, and support for the margin period of risk for collateralised netting sets. CompatibL XVA has long standing support for these requirements, and its use for fair value XVA reporting and CVA trading will help you firm achieve capital savings through the use of standardised approach (SA) rather than the capital-heavy Basic Framework for CVA.

MODVAL TEST ENVIRONMENT



As a public resource for model validation specialists, CompatibL created a model validation website, ModVal (ModVal.org). A private customized copy of ModVal created for your firm will serve as a test framework for your production implementation of CompatibL FRTB. It will also be used to fulfil the model disclosure requirements of FRTB, which state that all calculation methods must be disclosed to the extent that would make them reproducible by an independent model validation function. The ModVal website includes input and output data for all regulatory calculation tests in Excel and PDF format.

Your model validation specialists and country supervisor can download and run ModVal validation tests to verify the full methodology disclosure required by FRTB and FRTB-CVA model transparency provisions. Because ModVal Library for FRTB is provided in Excel format, it can be easily customized to meet the specific validation requirements of your firm.

SUMMARY OF CHALLENGES AND SOLUTIONS

Challenge	CompatibL Solution
Data integration	An FRTB system shares a large fraction of its data requirements with an XVA system. Relying on the existing integration layer for CompatibL Platform with most major book of record systems will reduce project risk and cost.
New calculation methods in FRTB	CompatibL supports the new calculation methods (e.g. expected shortfall, stress calibration, etc.) required for FRTB in its platform
Tough P&L attribution and backtest rules in FRTB IMA	CompatibL is well positioned with high quality, fully validated pricing models, originally developed for front office pricing and XVA. Traditional market risk models use approximations that are expected to fail the strict FRTB P&L attribution and backtesting rules. For example, typical market risk model simplifications such as replacing Asian and Bermudan options with European or using linear approximations will not suffice for FRTB. CompatibL does not use such approximations in its pricing models and instead uses front office quality pricing.
Large increase in number of simulations for the IMA approach	Multiple liquidity horizons, stress calibration and asset class diversification effects increase the computational burden of FRTB and FRTB-CVA. As an enterprise XVA vendor, CompatibL offers already optimized system performance to meet FRTB and FRTB-CVA requirements.
IMA approval on a desk-by-desk basis	FRTB IMA approval is granted on a desk-by-desk basis. CompatibL's experience across multiple asset classes ensures that its models can be used across desks covering the most advanced instruments at each desk, increasing you firm's scope to utilize the capital-saving IMA approach.
Consistency of models between trading and risk management	Regulatory rules require that pricing and CVA models for FRTB and FRTB-CVA capital charge are consistent with those used on the trading desk. CompatibL's ability to reconcile the prices with the front office to a high degree of precision will address this requirement and will ensure model consistency between trading and risk.
High project risk of implementing FRTB-CVA starting from a risk system rather than XVA system	Implementing FRTB-CVA by any vendor that does not already have a proven enterprise XVA solution will require long project delivery times and increase project risk. CompatibL eliminates this risk by offering FRTB-CVA as an extension of its proven XVA solution.

USING ADJOINT ALGORITHMIC DIFFERENTIATION (AAD) FOR FRTB

COMPATIBL FRTB THOUGHT LEADERSHIP

Adjoint Algorithmic Differentiation (AAD) is a new computational technique in quantitative finance, used to compute sensitivities at a fraction of the time required by the bump and reprice method. For a typical FRTB and FRTB-CVA calculation, AAD can deliver performance gains for the sensitivity based standardized approach (SA) in excess of x10 times. This is especially significant for FRTB-CVA calculation, where the computational burden is well recognized and acknowledged in the Basel document. It is also highly beneficial for the Standardised Approach in FRTB Market Risk.

CompatibL Vector AAD can operate seamlessly with multiple cores and will work with your existing cluster or cloud infrastructure. It offers the opportunity to significantly reduce hardware or cloud costs for FRTB.

While the final FRTB regulation currently does not explicitly reference AAD, the use of AAD for FRTB and FRTB-CVA is under active discussion by the regulators. Based on the feedback of these discussions communicated at recent industry conferences, it is widely expected that the Basel committee and country supervisors to issue clarification permitting the use of AAD for SA-TB and SA-CVA.

As a leader in AAD, having already integrated Vector AAD into CompatibL Platform, we are best positioned to take advantage of this powerful new calculation technique in FRTB and FRTB-CVA implementation. The screenshot below shows how AAD is used in the CompatibL Platform.

Factor	Scale	Sensitivity
Details.CS686137906 Sim PV	x1	892.75
Details.FRA746854148 Sim PV	x1	(2,156,551.20)
Details.FRA835592822 Sim PV	x1	(899,909.67)
Details.FRA961709648 Sim PV	x1	(691,197.30)
Details.FXF111689324 Sim PV	x1	(3,451,187.31)
Details.FXF113958283 Sim PV	x1	(22,043,962.93)
Details.FXF581407154 Sim PV	x1	(14,400,037.27)
Details.FXF597910683 Sim PV	x1	(6,701,551.96)
Details.FXF704973212 Sim PV	x1	(20,260,559.36)
Details.FXO132708801 Sim PV	x1	154.88
Details.FXO315669814 Sim PV	x1	(477.13)
Details.FXO420578080 Sim PV	x1	(298.05)
Details.FXO630002471 Sim PV	x1	(585,219.91)
Details.FXO819332561 Sim PV	x1	(222,484.19)
Details.IRS101797833 Sim PV	x1	(3,799.12)
Details.IRS161666965 Sim PV	x1	(5,907.54)
Details.IRS302862819 Sim PV	x1	6,366.70
Details.IRS858304083 Sim PV	x1	(4,689.84)

AAD can deliver performance gains for the sensitivities-based standardised approach (SA) in excess of 10 times

As an integral part of delivering the system capabilities and modelling required for FRTB, CompatibL is at the forefront of the market's discourse on regulatory capital and in particular FRTB and FRTB-CVA. Our active participation in the industry discussions ensures that all CompatibL releases will be fully up to date with the latest regulatory changes. As these changes occur, CompatibL Platform will be promptly updated to comply with the latest FRTB and FRTB-CVA regulations including clarifications and frequently asked question responses by BCBS, as well as any technical guidance from a client's country supervisor.

CONFERENCES

Informa Global Derivatives 2016

Plenary Session by Alexander Sokol on effective ways to satisfy the computational requirements of FRTB Market Risk and FRTB-CVA using Adjoint Algorithmic Differentiation (AAD).

WBS FRTB 2016 Frankfurt

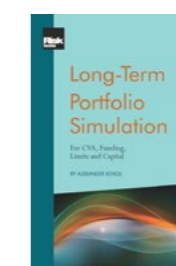
Presentation by Alexander Sokol: "Lightning fast FRTB SA-TB, SA-CVA, and SIMM using Adjoints: can we use them, and what are the benefits."

Cefpro FRTB 2016 and Risk EMEA 2016, London

CompatibL experts actively participated in conference panel discussions on the topic of

implementation experience and challenges of FRTB and FRTB-CVA.

LEADING PUBLICATIONS



Long-term Portfolio Simulation (RiskBooks, 2014)

Alexander Sokol, CEO, CompatibL
The leading reference for quantitative methodologies for long term portfolio simulation used in XVA, FRTB IMA, and FRTB-CVA SA methodologies.

"Rethinking Margin Period of Risk"

Leif B. G. Andersen, Michael Pykhtin, and Alexander Sokol, 2016

SSRN <http://ssrn.com/abstract=2719964>

"Retrofitting AAD to Your Existing C++ Library: A Case Study with TapeScript"

Alexander Sokol, 2015

Global Derivatives Conference, Amsterdam, 2015

"Modelling the Short Rate: The Real and Risk-Neutral Worlds"

John C. Hull, Alexander Sokol, and Alan White, 2014

SSRN <http://ssrn.com/abstract=2403067>
Risk Magazine, October 2014

"Exposure under Systemic Impact"

Michael Pykhtin and Alexander Sokol, 2013

Risk Magazine 26(9), pp. 88-93



Risk analysis with depth

ABOUT THE COMPANY

CompatibL Technologies was founded in 2003 to offer risk technology solutions to banks and asset managers. Since then CompatibL has established itself as the leading provider of quantitative software and solutions for derivatives analytics, limits, and regulatory capital.

CompatibL has over 200 experienced developers and financial engineers and boasts a client base of over 50 banks, central banks, supranationals and asset managers in the US, EMEA and Asia, including 4 out of 5 largest derivatives dealers. Over 70 major projects have been implemented across this client base. CompatibL is headquartered in London (UK) with the main delivery centres located in Warsaw (Poland) and Princeton (United States).

WHY COMPATIBL?

CompatibL offers turnkey solutions for derivatives analytics and regulatory capital as well as full custom development and project delivery services by experienced quants and development teams. In a similar vein, CompatibL's consultancy teams look beyond the delivery of reports and recommendations and bring practical enhancement to the clients operation, often incorporating the delivery of working code with source.

CompatibL is at the forefront of many important industry innovations and trends around the trading and risk space, including vector algorithmic differentiation, a technique that has the potential of delivering massive performance gains for the calculation of sensitivities and capital measures by Monte Carlo, real world measure modelling for more accurate limits and capital, and the quantification of residual counterparty credit risk in the presence of initial margin.

13 years
of experience in trading
and risk management

52 clients
banks, central banks,
supranationals and asset
managers in the US,
EMEA and Asia

4 out of 5
largest derivatives
dealers use CompatibL
platform

**76 major
projects
implemented**

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