

# Trust is good, control is better

## Complex model validation

*Over the past 20 years, financial modelling increased in complexity to better describe complex market behaviours and allow market-makers to stay competitive in a maturing world. This maturity led, for example, to the proper handling of volatility surfaces many years ago and, more recently, to the management of relations between spot and volatility levels, between credit and equity markets or even simply to the development of robust interpolation methods that do not break in extreme market conditions*

In a nutshell, financial models have become complex, even for allegedly simple products, simply to better describe the complexity of the underlying world.

As a key software provider in the derivatives space, Murex has invested heavily in the development and constant evolution of such models, focusing on robustness, performance, and accuracy. This constitutes the MACS (or Murex analytics) offering.

In line with its responsibility as a provider to a complex industry, and in order to deliver a much-needed reliability over time, Murex has mandated a separate department with the responsibility of designing and implementing its model validation policy. A direct result was the implementation of an industry-strength quality-control process.

Regulatory and internal control pressures lead Murex to go one step further and initiate a programme of fully transparent independent validation of its analytics.

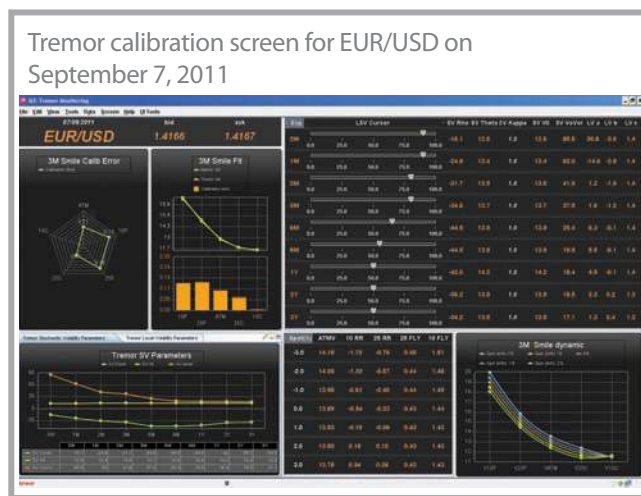
This rigorous approach to validation is illustrated below through the example of Tremor – the Murex foreign exchange options hybrid local stochastic volatility model. The independent validation of Tremor by widely recognised experts in the foreign exchange options world, MathFinance, was completed recently.

### **Tremor – The market view's 'heads-up display' of practitioners**

Introduced in 2008 by Murex to its large foreign exchange options client base, the Tremor model makes the amount of locality versus stochasticity explicit thanks to a unique parameter, the cursor. The cursor is either calibrated to exotics or input directly based on historical analysis or user assumptions about spot/volatility dynamics.

Even during crisis periods, the stability of the cursor over time resisted sudden vanishing of liquidity on exotic options. Tremor is in fact one of the few models used that traders could rely on throughout the very periods in which they were most needed.

Over and above providing 'blue-chip' accuracy for foreign exchange barrier and touch options, Tremor captures and exposes the spot/volatility dynamics in a comprehensive and cohesive way.



Top left: calibration error on a three-month expiry for the five quoted strikes. Top middle: three-month calibration fit between market implied volatility and model re-priced volatility, deviations in the graph below. Top right: Tremor cursor per maturity (0 is pure local volatility 100 pure stochastic volatility), Tremor parameters: SV denotes stochastic volatility and LV local volatility. Bottom left: stochastic volatility parameters term structure (local volatility parameters are available in a second tab). Bottom middle: implied spot/smile dynamics for a spot ladder graphed bottom right

Such dynamics can be used to adapt Black-Scholes greeks of vanilla options, making dynamic hedging of the whole foreign exchange options portfolio both consistent and more efficient.

During recent months, Murex has noted a sudden shift within its customer base, to give up fragile Vanna-Volga Replication-like models and adopt the Tremor model instead.

### **Internal validation made industrial**

The Murex validation department's mission can be summarised by: "end-to-end integration, market benchmarking, operability and repeatability".

### Healing Achilles' heel

The quality of a model's inputs can be as crucial as the model itself, and so are continuous improvements to those inputs (for example, multi-interest rate curves, volatility management and smile dynamics to name a few recent advances). This quality is guaranteed by a tight integration of MACS models into the Murex front-to-back platform, which tracks and implements key market evolutions.

### Facing the truth – The market is always right

A robust model needs to fit liquid market prices, even in turbulent times. For the Tremor model, the moment of truth occurred on September 15, 2008 on the eve of the Lehman Brothers bankruptcy.

For one month, Tremor had been benchmarked on each and every quote sent or received by a Tier I bank, market-maker in foreign exchange options barrier options.

The Tremor market benchmarking campaign ended up with the following distribution:

- 44% Tremor prices were in the market bid/offer spread.
- 51% Tremor prices were in the confidence interval (i.e. difference to mid-market price were below the bid/offer spread).
- 5% Tremor prices were out of the confidence interval.

Accuracy of both prices and adapted greeks allowed an acute hedging of their foreign exchange options activity.

### Self-testable solutions – MACS models are a glass box

Financial institutions need more than self-endorsement of models provided by a vendor and would usually apply a lengthy internal validation process. In order to reduce the time to market, Murex completes its offer with an exhaustive set of documents and tools:

- A user guide, the underlying mathematics, and a model validation document that provides tests' statuses, descriptions, results and a listing of known weaknesses of the model on an extended test case.
- Full transparency on continuous and automated non-regression tests (functional and performance oriented), whose coverage expands with code evolution itself.
- Monitoring tools to dissect calibration, diffusion and revaluation.
- 'On-the-fly' detailed logs for anomaly analysis and replication purposes.
- A toolkit to deploy mass-testing and report results in one click (including Tremor calibration robustness stress-testing on 100 synthetic smile scenarios on 10 expiries, and five cursor values, on any Murex version).

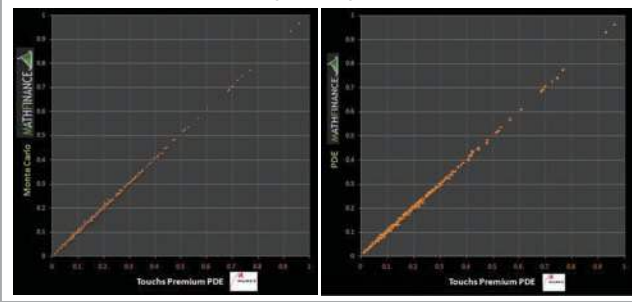
Murex anticipated a powerful market trend by deciding to provide additional transparency to its clients through independent validation. With its recognised expertise in the foreign exchange option market for more than two decades, MathFinance was uniquely positioned to provide the desired level of thorough and in-depth tests to assess the reliability, accuracy and potential of the Tremor model.

### Scope of the independent validation

MathFinance challenged the two-dimensional partial differential equation (PDE) Tremor model with Murex's recommended settings of 301 spot steps, 61 variance steps, and 50 time steps per year, against a Monte Carlo with 16 million paths and a two-dimensional PDE with a grid of 300 spot steps, variance steps and time steps per year on the same diffusion implemented by MathFinance.

Based on Murex calibrated parameters, the MathFinance implementation checked calibration accuracy by pricing the 1,590

Q-Q plot of Murex PDE versus MathFinance PDE and Monte-Carlo on Touch options prices



calibration instruments on 22 currency pairs and 44 historical market data sets.

MathFinance revalued 388 foreign exchange exotic options, including single and/or reverse barriers knock-in/out, single and/or double one-touch and no-touch with expiries ranging from overnight to up to five years.

The stability and accuracy of standard greeks were also tested on a sub-sample of 38 exotics using two different spot/volatility dynamics assumptions: the sticky-delta and the Tremor dynamics.

### Results of the independent validation

The independent report validated 99% of Murex's prices and greeks and provided explanations for the remaining 1% (between 5 basis points (bp) and 10bp difference).

Uwe Wystup, managing director of MathFinance, explains that the differences on exotics were observed for very short maturities and low premium payoffs, mostly due to the constant time discretisation used by the MathFinance Monte Carlo, and two-sided barriers, where the PDE did a better job by design. Sticky delta and Tremor dynamics were also replicated successfully using Monte Carlo.

### Pioneering again –


#### Complex models now available in turnkey mode

Murex offers its clients a comprehensive catalogue of 'best-of-breed' models in all asset classes. These models come with full transparency and detailed documentation and analysis tools delivered after internal validation processes. These models have gone further to a higher level of transparency and quality checks by an independent validation.

The Tremor model is one such example of models adapted to current market dynamics. Its industrial validation will help foreign exchange options desks hedge better and develop their business in a homogeneous way at a reduced overall cost.

Trust is not enough – you also need industry-strength quality control. MACS models are Murex's answer.

The independent validation report, as well as Murex's internal reports, are available on request to any Murex client and will be presented during the Global Derivatives Conference held in Chicago from November 14–17, 2011

|   |                      |
|---|----------------------|
|  | <b>Contact</b>       |
|   | info@mathfinance.com |
|   | www.mathfinance.com  |
|   | macs@murex.com       |
|   | www.murex.com        |