The Games We Play:
the Future of DFA Models' Interfaces

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Abstract

Motivation. (Call for Papers). The author *strongly* believes that future generations of DFA software should employ *cardinally different* interfaces in order to reflect growing *complexity* and provide necessary *flexibility* for the models.

Method. Work by *analogy*. Among existing software products the author found one with the interface almost ideally fitting to the future needs of DFA packages.

Results. *Shocking* (but only at first): the software product with the "ideal" DFA interface is neither analytical nor calculational package, but a game, a computer simulation game. Indeed, computing gaming industry is the most creative and innovative niche of software development, where computer-human interfaces are given *the highest* priority. It is only *logical* to look there for the ideas for the best interface, especially for such *interactively challenged* products as DFA models.

Conclusions. If the author is correct in predicting the communicative requirements of the future DFA models, then DFA developers should look closely at some computer games and borrow ideas for interface design.

Keywords. Actuarial software design.

1 INTRODUCTION

The abbreviation DFA means Dynamic Financial Analysis. But, if you look closely, it is not that *dynamic*. Current DFA products accept some parameters from the user and using predefined algorithms (called model) launch a Monte-Carlo simulations to calculate distributions and some statistics of predefined variables at predefined point(s) in time. It is indeed a great achievement to have working DFA models, but it is *definitely* not the end of the road. Indeed, after user's initial input, the model is *closed for interactions*. Essentially, user is allowed to make decisions, that is, to choose options available to him (parameters) or to define a strategy (model algorithms), only once. There is nothing *dynamic* about it. In real life decisions are made *constantly* as a reaction to the changing environment. For DFA it means that some simulation passes that contribute to the final statistics would have no chance to exist or arrive to different value if user had a change to react during the run. That is, some investments could be sold, some reinsurance could be canceled, some capital reallocated, but only on some passes and not on the others. So, for DFA system to mimic decision making process better, an interface has to be built to allow user monitor simulation passes and interact with them in "real time" and/or modify strategy "on the fly". While these capabilities are unthinkable in Excel/@Risk paradigm, they are quite commonplace in the …

computer gaming universe. Let us show an astonishing *analogy* between an imaginary DFA system and an existing simulation game.

2 ANALOGY: LET THE GAME BEGIN

2.1 Loading…

Historically Personal Computers had two major applications ("killer apps"): VisiCalc and Tetris. People were buying PCs just to run a spreadsheet or a game, in other words, a powerful "what-if" analysis tool and a visually appealing entertainment program. Since the early 1980s both categories improved dramatically: Nowadays spreadsheets (extended by internal programming languages and connected to external databases) are housing quite sophisticated models, while games (enhanced by impressive 3-D graphics and intuitive interfaces) are featuring believably immersive environments. Nevertheless, both categories remain the main reason for buying a computer: their utility is still unsurpassed by other types of applications.

Now imagine an application that combines the visual appeal and intuitive interface of a game with the analytical power of a spreadsheet. It may be achieved either by adding visual interfaces to a spreadsheet or by adding analytical calculations to a game. The latter, apparently, seems more realistic: it is possible to find an existing game (or a genre) that may serve as a visual shell for the existing dynamic risk models.

2.2 Visual Metaphor

Dynamic Risk Modeling (in one way or another) deals with the random processes, i.e., studies values changing in time. It attempts to reflect numerous economic aspects in the life of an insurance company. And the more sophisticated the model is, the more complicated it is for the user to grasp how it functions and even less so interact with it.

These models usually simulate the growth of losses, flow of investments, changes in pricing conditions and consequences of catastrophes, all the while trying to properly deal with the time component as well as with geographical dissemination of the risk…

Amazing, but that is **exactly** the subject of the numerous city/empire/railroad simulation games. Indeed, these games visualize the growth of the buildings, flow of funds, changes in trade conditions and consequences of disasters. To think about it, 'growing buildings' may be interpreted as losses, different 'zoning areas' as different lines of business, 'bulldozing cost' as brokerage fees and 'earthquakes' as (evidently) earthquakes.

Once one makes a mental substitution (re-labeling), one should realize he has a tremendously capable visually rich and ready for utilization interface for his risk model. But even more important than visualization is the fact that such an interface is **interactive**.

2.3 Functional Metaphor

Let's continue our "risk model as a city simulation" analogy to the functional level.

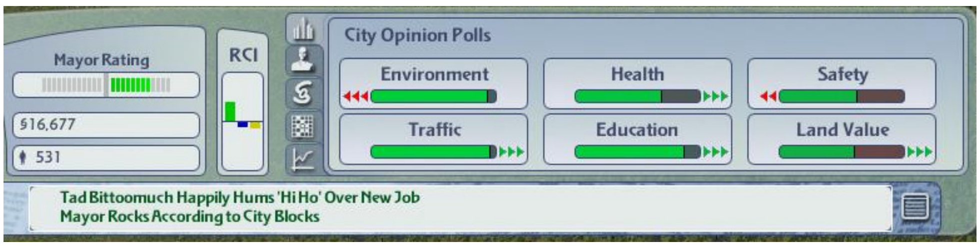
2.3.1 Mayor

User is a Mayor, an Emperor or a Tycoon. He has advisors – AI constructs each covering its area of expertise: expenses, revenues, services, market conditions. Mayor observes life of the city/empire, consults with advisors, makes decisions and **acts** in extraordinary situations. That is very similar to the role of the CEO who has the advice of his Actuary, Accountant and Claim Adjuster at his disposal. The goal of the game to maintain the financial health of the city/empire and the Mayor has quite a few instruments to achieve that.

2.3.2 Monitoring

The quintessential component of correct decision making is accurate and timely information. "Game-like" interfaces provide quite an extensive collection of monitoring tools. The variety of indicators available for observation is stunning. Along with numerous statistics and indicators, "game-like" interfaces usually feature distribution histograms, geographical maps, color-coded diagrams and charts.

Most important, indicators are displayed prominently on the screen so the user may observe the changes in their values in "real" time. To be even more useful "game-like" interfaces display the indicator's values along with their *derivatives*, that is, their direction and speed of change.



In the event when an indicator or some combination of them reaches a benchmarked value an alert is generated. The whole purpose of monitoring mechanisms and alerts is to prompt the user to make decisions and interact with the system.

2.3.3 Making decisions

One should agree that the ability to modify a simulated scenario "on the fly" makes the model truly dynamic. In the gaming paradigm the user may affect the system in different ways. The most straightforward one is to modify values of the system's parameters. A Mayor in the game may cut expenses or borrow money. He may decide to bulldoze some areas which can be interpreted as a commutation of some treaties, or he may cut supplies to an unprofitable region which would represent a switch to run-off mode.

Immediate feedback and rich visual metaphor in a "game-like" environment should help one to achieve a better grasp on the consequences of the user's actions.

2.3.4 Actions

In the game, the user's actions are not limited to setting some parameters values. The user may place structures that have local effect or design infrastructure (like electrical subsystem) that affects whole regions. In this interpretation placing a 'police station' that reduces the crime rate corresponds to hiring a "bill monitoring" firm to reduce medical expenses or replacing a team of lawyers in order to decrease legal fees.

It appears that any action that the management of the real company can possibly make has an acceptable analog in the game paradigm. It means that management's actions can be incorporated into a model as well.

2.4 Extras

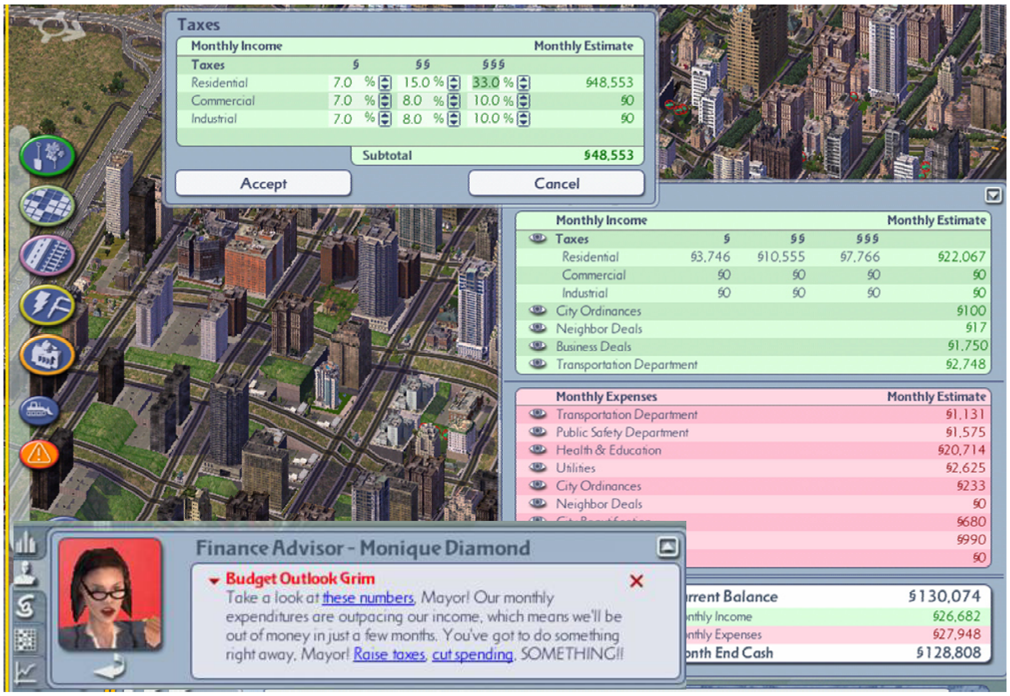
Modern games of the "city/empire simulation" genre implement many useful aspects that are seamlessly incorporated into their interface. Designers of the risk models who decide to utilize a "game-like" interface may consider these features as a free bonus.

2.4.1 Catastrophes, geography

In order to look as life-like as possible games simulate natural disasters. Not only do they incorporate visual representations of hurricanes, foods, earthquakes and tornados, but they represent damage in a geographically accurate manner. In fact, the object-oriented nature of these games allows the user to extend them and import unique real life structures, cities and even whole regions.

2.4.2 Financials

The games of this genre usually have a module responsible for simulating economic conditions. Their interface presents pro-forma like accounting reports and an ability to manipulate with economic parameters. In fact, these games have become so sophisticated in monitoring financials that they have even implemented AI advisors in this area.



2.4.3 Traffic

Some games feature quite advanced traffic simulators. The traffic patterns in these games take into account the time of the day, seasons, road capacities and even simulated routes from residential to industrial and commercial areas. That is a little bit more sophisticated than just finding a factor in a rating table.

2.5 Initial Setup

2.5.1 Terra-form

A very rich visual environment of the game requires a very powerful mechanism for its initial setup. Modern games have a convenient interface even for setting up starting values of the model parameters, distributions and maps. It is implemented as just an additional mode; game designers call it (quite suitably) "God mode". Being "God" the user can specify initial values for all economic parameters, outlay model settings, and define distributions, that is, (in a "game-like" metaphor) "terra-form" business landscape.

3 BENEFITS: NOT A GAME ANYMORE

Evidently, games provide a richer visual environment for the risk modeling, but this is only a small part of the story. Switching to a "game-like" interface complemented by improved modeling approaches may bring numerous benefits.

3.1 Training

3.1.1 Thinking with images

The way we think about concepts and operate with them heavily depends on the method we use to represent them. Rules of manipulation with the string of algebraic symbols significantly differ from the rules of manipulation with geometric shapes and curves. In one environment we may look for the values x that makes an integral such as $\int_x^{\infty} \frac{\beta}{\theta(1+\beta)^2} \exp\left(-\frac{x}{\theta(1+\beta)}\right) dx$ smaller than 5%, in another we may look for the vertical lines that make an area under the (distribution density) curve smaller than 5%. In one paradigm we may talk about first and second derivatives, in another we may discuss growth and convexity.

The "game-like" interface adds yet another form of imagery and various ways to manipulate it, which are predominantly more intuitive and convenient than formulas and charts.

3.1.2 Gaining decision making experience

Given that behind the glamorous interface lies a decent simulation engine, a risk model may serve as a management training tool. By visualizing consequences of every decision such an environment may help to polish the management style of key decision makers. It may also serve as a test-bed for new strategies and tactical innovations.

3.1.3 Modeling disastrous or unusual events

"Game-like" interfaces may prove to be an ideal playground for so-called stress testing. It is much more useful to study scenarios that include natural disasters or macroeconomic shifts in an **interactive** environment, performing actions exactly when (and where) they are needed most.

3.2 Fine-Tuning

It is conceivable that "game-like" interfaces will not replace, but rather assist in enhancing existing risk models. They can be used to fine-tune some aspects and design decisions of existing DRMs.

3.2.1 Choosing criteria

Risk models oftentimes rely on a set of benchmarks and criteria that seem to be chosen more or less arbitrarily. It would be very educational to **see** what happens if, for example, confidence intervals are shrunken or probability-to-ruin is replaced by some other evaluation criteria. Designers may drastically improve a model's relevance just by observing what combination of indicators triggers a user's action.

3.2.2 Refining strategies definitions

By allowing users to perform a multitude of actions model designers may refine the list of available strategies. They may build into the model automatic responses in order to improve the validity of scenarios. Without such corrective mechanisms some scenarios may never happen. In essence, designers have to "teach" their models When (and Where) to do What.

3.2.3 Business Processes

Observing people "playing" with "game-like" models may help to identify sequences of actions in different situations: in other words, management style. It may also help to analyze business processes and the chain of command to pinpoint problems and deficiencies.

3.2.4 Assumptions Testing

A "game-like" environment may also serve as a testing ground for numerous assumptions that are incorporated into the model. Incorrect assumptions and improbable parameter values may produce improbable situations that could be easier to spot in a visual environment.

3.3 Self-Education

Models with "game-like" interfaces may record and analyze a user's responses in order to use them later in a run of simulated scenarios. Oftentimes it is difficult for an expert to explain his actions in a formalized manner suitable for modeling. By watching him play designers or the software itself may try to determine rules that govern the user's behavior. In other words, "game-like" interfaces may assist in an attempt to build a self-educating model, that is, "evolving AI" system.

3.4 Monitoring

Interactivity (one of the main benefits of the "game-like" interface) is useless without parameter monitoring. Indeed, interaction has to be **triggered** by events or alerts that are either text-based or visual.

3.4.1 Multiple factors at once

"Game-like" interfaces provide an ability to choose which indicators are to be permanently monitored. User may observe the behavior of a single or multiple parameters, scalars or maps, charts or diagrams, or all at once, in "real time".

3.4.2 "Real time"

One of the most important features of "game-like" interfaces is animation. User may observe how a particular scenario runs as time passes. Surely, the user is given full control over the timeline: he can speed things up or slow the animation down or even pause for detailed investigations and a thorough analysis. Observing the system in a dynamic setting, though, adds a whole another dimension to one's perception and comprehension of the system. If a picture is worth a thousand words, than an animation is worth a thousand pictures!

3.4.3 Visual cues

In some situations diagrams and maps work much better than numbers and text. Two-dimensional maps, for example, much better represent such notions as "concentration" or "dissemination" than any singular value or sentence.

In addition, "game-like" interfaces may utilize visual hints to attract user's attention: fire icons, blinking symbols or color change may do the trick.

3.5 Dynamic Response

3.5.1 Time is visualized

The capacity to comprehend is greatly improved by using animation to represent time. Unlike traditional DRMs, "game-like" interface provides direct access to a timeline for dynamic responses.

3.5.2 Non-linear strategies

"Game-like" interfaces provide an environment in which responses and their timing are completely flexible and, presumably, more suitable to each particular situation. No preset strategy, no matter how sophisticated, can match the effectiveness of the dynamic response system.

3.5.3 Feedback

Feedback is used to represent controlling mechanisms as well as the forces that affect dynamic processes. Many economic indicators in an insurance company have a feedback: changes in an indicator's value triggers external actions that in turn change the indicator's value. Essentially, an indicator's "behavior" in time may be dissimilar for different values of the indicator. Analytically speaking $u'(t) = f(t,u)$, that is, an indicator's derivative is a function not only of time, but of the indicator's value as well.

3.5.3.1 Reserves

Once the reserves grow "too large" (ultimate expected loss value exceeds some benchmark) and the pressure from rating agencies becomes unbearable some companies may start writing commutations or switching to run-off mode, thus altering payout patterns and, consequently, changing ultimate expected loss value.

3.5.3.2 Prices

Pricing is also subject to feedback. High premiums may result in larger profits attracting competition which places downward controlling pressure on prices.

3.5.3.3 Investments

Badly performing investment instruments may get reinvested altering in turn their return rate. Another famous macroeconomic example of a system with feedback is inflation. The controlling mechanism in this case is the Federal Reserve Board.

While feedback as a non-homogeneous effect is almost impossible to implement as a closed analytical model, it is usually not such a big obstacle in the design of simulations. Sometimes simulation is the only way to model feedback making a "game-like" interface a natural environment for effective representation of controlling effects.

3.6 Investigations

To quote designers and promoters of the Public Access DFA Model: "In examining the DFA runs, many questions were raised [by managers of the real company] about what might have been causing adverse experience. It was suggested that the program be revised to capture detailed financial data on any simulation where surplus fell below a certain level. Thus, the managers could look at what caused the problems in order to better avoid them". Apparently, an ability to run specific scenarios (in order to identify circumstances causing unacceptable performance) is of great value for decision makers.

3.7 Presentation of Results

One of the main purposes of the "game-like" interfaces is to incorporate the presentation of the results in order to avoid complicated explanations in the end. Results are "built-in" in the interface. They are by-products of the values that were monitored. To the user, who had a chance to observe the process, the results are self-evident. Not only does he get a snapshot of the various monitored indicators, he also gets an idea of the *direction* in which they were moving and their *behavior*. It is one thing to merely observe that an indicator has reached the value of A, it is yet another to learn that it actually "dropped to the value A" or "seesawed to the value A swinging back and forth". The latter feedback is, obviously, much more informative. Results themselves could be of a broader variety too: values, curves, areas, maps, images, alerts.

In essence, "game-like" interfaces provide an opportunity for the modeler to expand the usefulness of his model. Rather than being just an answers generator, the model becomes a *tool* for the decision making, an interactive and pleasant-to-use *tool*.

4 IMPLEMENTATION:THE GAME IS NOT OVER

4.1 An Engine

To implement anything even remotely resembling real-time interactive interface one may start with the existing simulation game engine. Gaming companies readily sell or license their engines to third parties. The older the game the less expensive the engine: engines that are 2-3 generations old are quite affordable. In order to attract more potential buyers gaming companies make game engines fairy flexible and easily modifiable.

Game engines, as a conglomerate of programmable objects, while not designed specifically for *risk* modeling, can be made suitable for it. What's important is that the engine provides *both*: links to the rich interface and an environment for a model's implementation. In essence, by changing a few formulas in the engine and by renaming a few labels in the interface, one may convert a computer game into an interactive risk model.

4.2 Modifications

"Game-like" interfaces place demands on the underlying engine to provide enough information with enough detail to be rendered for visual presentation. Every popular game in a "city/empire" genre already has a quite sophisticated simulation engine. Risk models designers, however, may need to improve it on in several crucial areas.

4.2.1 Simulate economy

Evidently, games designers usually don't bother with supplying their economic models with real-life data: even less so with the process of updating these data and maintaining economic parameters up-to-date. One shouldn't expect a game to have a sophisticated interest rates generator or an accurate implementation of the corporate tax code. However, games **do** have economic simulation modules; they just have to be modified and improved.

4.2.2 Simulate company

Games simulate building, structures or empires. They do not simulate insurance or reinsurance companies, property/casualty losses or facultative treaties. What is encouraging, though, is the fact that a city is much more complicated entity than insurance (or even reinsurance) company.

4.2.3 Simulate correlations

Another challenge for the model designer is the simulation of correlated random processes. Possible geographic components may only add complexity to the problem.

4.2.4 Simulate the rest

Given enough information a designer may try to simulate and incorporate into the model other random processes such as competition, taxes, geography, weather and catastrophes. It is useful to know that "game-like" interfaces support, visually and interactively, all of these features.

4.2.5 Monitoring

Even if model designers were able to perform all the necessary research, collect all the necessary data and effectively implement all the necessary algorithms for simulation of all internal and external processes surrounding the life of an insurance company, there would still be a lot of work to do. For the model to become a "game-like" decision making tool, one has to decide what statistics to calculate, what indicators to observe, which criteria to use for issuing alerts. "Game-like" interfaces technically may accommodate any number of them. However, to remain truly useful and approachable the interface has to expose only *key* indicators and to issue only *critical* alerts.

4.3 Simulation engines

Luckily, the majority of proposed modifications don't have to be designed from scratch: they are already satisfactorily implemented in the existing packages. The technology can be licensed or borrowed, but the fact remains: it is all doable.

4.3.1 Risk Explorer™

Risk Explorer™ by Ultimate Risk Solutions includes a comprehensive macroeconomic model, an innovative correlation module and many other useful features.

4.3.2 Public Access DFA Model

Public access DFA Model provides insight into insurance company simulations: both on the liability and asset sides.

4.3.3 Custom sims

One can imagine that large and successful reinsurance companies, major rating agencies and hedge funds in one way or another have developed working risk simulation solutions. Inevitably their knowledge will become public and tapping into this resource may prove invaluable for the "game-like" risk model designer.

5 CONCLUSION: AND THE WINNER IS…

Modern simulation games evolved into all-encompassing virtual worlds with rich and interactive interfaces. Game designers proved that modern computers are capable of simulating multiple aspects in the life of complex entities such as a city while keeping the game attractive and **approachable**. At the same time risk modelers faced the problem of explaining the model's findings to decision makers. Eventual integration of game design achievements into the risk models seems inevitable.

Evidently, the productivity rises when a tedious activity is camouflaged as a game, but this is just one of the benefits of such a fusion. Implementation of the "game-like" interfaces for the dynamic models brings so much more to the table: animation, geographical localization, monitoring (with alerts) and, most importantly, **interactivity**. It may drastically emphasize the roles actuaries are playing: model builders, parameter suppliers, algorithm implementers. Their role in a decision-making process would become transparent and self-evident. For the management Dynamic Modeling may stop being a black-box mystery but rather a desirable topic for discussion if not the major instrument for decision making. Decisions would be made on more solid ground. Companies may become more profitable. Shareholders would be rich, policyholders would be happy. Everybody wins!

6 Credits

The author is thankful to Will Wright, Sid Meier, Brian Reynolds and other game designers who helped to create such simulation magnum opuses as SimCity, Civilization, Caesar and similar edutainment masterpieces. This article would be of a much lesser quality without in-depth discussions about risk modeling with Alex Bushel, Vladimir Ladyzhets and Yakov Lantsman.

7 P. S.

Paradigm shifts, significant changes in our system of self-evident truths, don't occur overnight. Rather they happen steadily as carriers of one conceptual worldview are gradually replaced by the carriers of the new way of thinking. Someday we will see an influx of people who will not wonder what does visualization and animation have to do with the actuarial science and for whom Gaming (a.k.a. interactive visual experience) will not only look natural in the boardroom, but will actually be used as indispensable decision making tool. In the meantime, the author bit by bit, module by module, article by article will try to materialize his vision of what he believes is an Ideal Actuarial System.

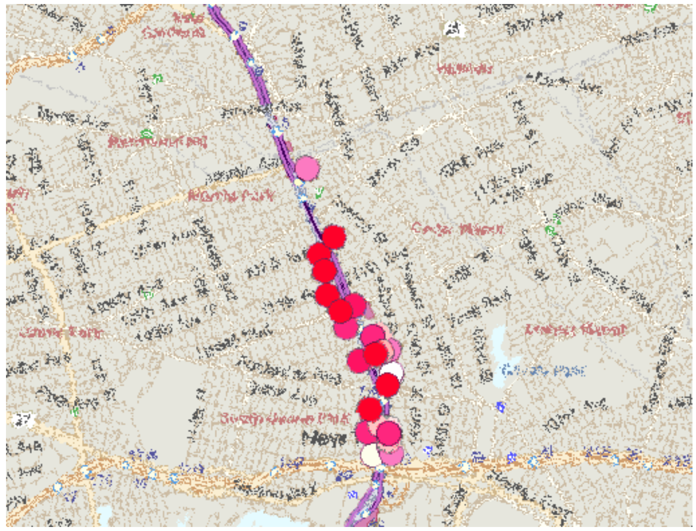
8 Links

[1] Daniel "Wolff" Dobson and Ken Forbus. *Towards Articulate Game Engines.* http://www.lggwg.com/wolff/aicg99/dobson-forbus.html
[2] Jake Simpson. *Game Engine Anatomy 101*. http://www.extremetech.com/article2/0,1558,1156338,00.asp
[3] Averill M. Law, Ph.D. *Eleven Critical Pitfalls in Simulation Modeling.* http://www.averill-law.com/simulation-news-papers.htm
[4] Stephen P. D'Arcy, FCAS, MAAA, Richard W. Gorvett, FCAS, MAAA, Thomas E. Hettinger, ACAS, MAAA, Robert J. Walling III *Using the Public Access DFA Model: A Case Study.* http://www.casact.org/pubs/forum/98sforum/98sf053.pdf
[5] Ultimate Risk Solutions. *Risk Explorer*™. http://www.ultirisk.com/home/aboutus.html
[6] Pinnacle Actuarial Resources Inc. *Public Access DFA Model.* http://www.pinnacleactuaries.com/pages/products/dynamo.asp
[7] Thomas S. Kuhn. *The structure of Scientific Revolutions.* http://www.emory.edu/education/mfp/Kuhn.html

9 Appendix: Expansion Pack

Visualization, animation and gaming are not such foreign notions for the insurance industry after all. Used suitably and cleverly these technologies may bring tangible benefits to areas as diverse as claims management, fraud protection and reserve testing. The author himself had an opportunity to use them in his own real life projects.

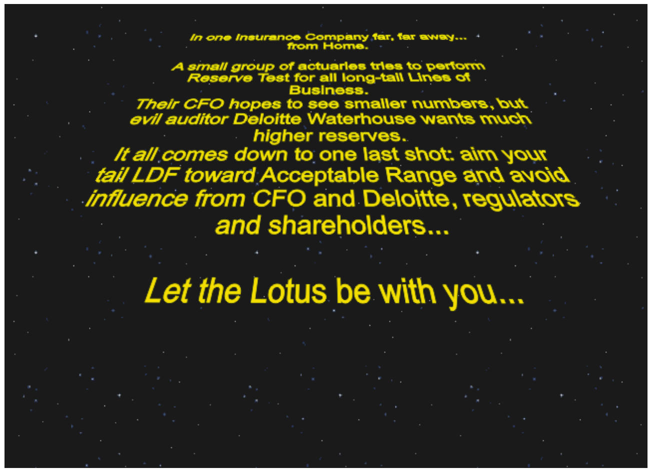
A. Studying GL losses from some treaty by looking at the triangles, vectors and raw data in databases didn't yield any obvious irregularities or suspicions. Everything looked normal until the data was **visualized** by placing the claimants' addresses on the map. The resulting picture (map labels are distorted on purpose) clearly showed an abnormal concentration along a highway.



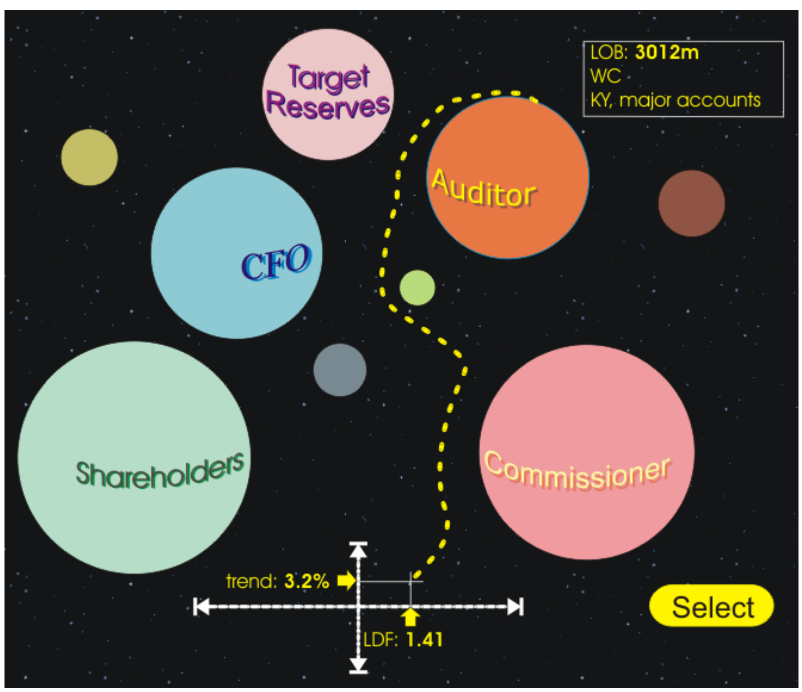
Apparently, these claims were from homeowners whose houses were damaged by the drillings on the nearby elevated railway construction. After combining all of these claims into one occurrence a company was able to recover a few million dollars.

B. Encouraged, this company ordered visualization studies on all of its treaties. Another interesting result was obtained with the help of **animation**. A treaty was found with all of its claims distributed quite homogeneously… but only in spatial dimensions. In a temporal dimension, though, there was a significant spike. During animation a huge chunk of claims appeared almost simultaneously (they suddenly "jumped" out all at once). After some investigation it was found that the majority of these claims were from car owners whose cars were damaged on the same parking lot by the cement pouring from the nearby construction site. Once again: one occurrence and several million in excess recoveries.

C. More than a decade ago the very first actuarial **game** (imaginatively named *"Tail Factor"*) was created.



The player, by selecting a few parameters like trends and LDFs, had to shoot a photon torpedo from his *"Data"* X-wing space-fighter towards an *"Affordable Answers"* Death-Star target. The torpedo had to avoid a gravitational pull from multiple planets labeled *"Auditors"*, *"Policyholders"*, *"Shareholders"*, *"Chief Actuary"* and *"CFO"* making an actuarial selection in the game as difficult and controversial as in real life.



It was a very primitive game, but the metaphor somehow clicked: users were paying attention to development factors and selecting medical cost inflations more thoroughly than they ever did. Selecting a tail factor in a "game" apparently was much more fun than doing the same on the dreary Lotus screen.

Biography of the Author

Aleksey Popelyukhin is a Vice-President of Information Systems with the 2 Wings Risk Services in Stamford, Connecticut and a Senior Vice-President of Technology with the Sam Sebe LLC. He holds a Ph.D. in Mathematics and Mathematical Physics from Moscow University (1989). Aleksey is presently developing an integrated pricing/reserving/DFA computer system for reinsurance and also an action/adventure computer game tentatively called "Actuarial Judgment." Dr. Popelyukhin is an active member of several scientific societies and an author of almost 20 scientific publications. His article "The Big Picture: Actuarial Process from the Data Management point of view" (1996) won the prize for the Data Management Discussion Call Paper Program in 1997.