Société de Calcul Mathématique SA
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Scientific Assistance for the Definition of Large Projects

The Devil's Advocate

I. Why do projects fail?

Quite often, large projects fail, no matter whether they are public or private. It may be a constellation of satellites (such as Galileo) which, more than fifteen years after decision, costs much more money than expected and is still at the launching stage; it may be a plant, newly built, which is found useless; it may be a highway, supposed to bring generous tolls, which is constantly empty; such examples are numerous and concern most countries.

Why is this so? These projects are supposed to be prepared by highly competent people, with all necessary information at their disposal.

The answer is always the same: these people are perhaps technically competent, but they want the project to succeed, and, consciously or unconsciously, they underestimate the difficulties and the risks.

Their answer to this objection is usually that they ask for the advice of an independent consulting firm. Not quite so, in fact: consciously or not, they asked the consulting firm to support their initial choices. So, the firm gives the answer people want to hear, with no questioning about its validity.

Let us take a very striking example: the Galileo project, which is a constellation of satellites decided by the European Commission. In 2002, we wrote a note to the French "Secrétariat Général de la Défense Nationale" (Prime minister), entitled very clearly: Galileo, chronicle of an announced scandal: https://scmsa.eu/archives/SCM_SGDN_Galileo_2002.pdf (in French)

In 2007, five years later, we received a short note from M. Jacques Barrot, at that time Vice-President of the European Commission: he qualified our work of "premonition". But, in our view, it was simply common sense: anyone looking honestly at the project would conclude that it could not succeed. In fact, there were strong links between three different institutions:

– The Government Agencies: CNES (French Space Agency) and the European Space Agency, which strongly emphasized the need for the project.

– The consultant firm PriceWaterhouseCoopers, which brought all necessary arguments concluding to its validity.

– Many papers and projects written by specialized scientists, which all explained that science in general was in desperate need for the Galileo constellation of satellites.

At no place was the slightest criticism, the slightest doubt, about the economic success of the project.

II. What is a scientific expertise?

A scientific expertise is the act by which someone (a person, an institution, a company), wishes to have more information on a topic of scientific nature. For this, he asks an expert, or a group of experts.

A very simple example is this: you own a piece of land, and you wish to sell this piece of land. Before you do so, you wish to check if the land is affected by any type of pollution, or, on the positive side, if the subsoil contains water, or gas, or any minerals: this may affect the value of the land, positively or negatively. For this, you will ask a geologist; he will come with his instruments and write a report, about what the land contains or does not contain, and, if favorable, you may use this report for your sale.

Of course, you will pay the geologist for his work, but you should make sure that he has access to all data (omitting some would be a fraud) and you should not interfere with his expertise. Trying to make an agreement with the geologist, so he concludes that the land contains gold, selling the land at high price and sharing the profits with him is severely punished by the law.

So, the three basic rules of the expertise are very clear:

– The expert is paid by those who require his expertise.
– He should have access to all data.
– He should be completely free of his findings and conclusions.

Of course, the report is private: people who requested it may not wish to publish it. This is their choice. But, in terms of scientific validity, the expert should write his report so that it can be checked by anyone else: all data, all reasonings should be present. A scientific report is not just a conclusion "we think that…". It must contain all elements, clearly presented, which led to this conclusion.

The best attitude is to consider that the report will be used by some court, so everything must be honest, extremely well presented and justified.

III. Our approach

It is very simple to describe: we only look at facts, observations, data, and omit everything connected with commonly accepted beliefs, wishes, and so on. We eliminate all arguments which are just "politically correct", and we concentrate upon the history and the laws of Nature. This is not so easy to do in practice, because everyone is influenced by general, commonly accepted ideas. But a rough knowledge of the history of ideas shows that doctrines considered as unquestionable by a generation were found dramatically false by the next one.

Let us now turn to specific descriptions:

A. Future of technologies

Quite commonly, people think that, if a new technology appears, everyone will adopt it. This is not so. On one hand, this new technology may quite well show some drawbacks, which will be apparent in the long run: it does not prove as attractive as one thought at the beginning. On the other hand, people have their habits, and usually are not ready to change them. A careful analysis of the fate of new technologies in the past shows that many of them never found their way, and, for those which did, it took many years.

Our task is here to explain quite clearly what the possible drawbacks of the new technology are, what are the advantages of the competition, to give examples of similar nature in which it took time, and so on.

Our recent achievements:

- Secrétariat Général de la Défense Nationale (French Prime minister), 2002: Galiléo, chronique d'un scandale annoncé (Galileo, chronicle of an announced scandal)
- DGEMP (French Ministry of Finances), 2006: General study of the needs and imports about natural gas
- Axa Private Equity (French private investor), 2009 and 2010: The business model of satellite constellations
- Axa Private Equity (French private investor), 2009: The business model of a broadcast company
- Axa Private Equity (French private investor), 2010: Critical analysis of the investments in solar energy
- Axa Private Equity (French private investor), 2010: Critical analysis of the investments in high technology
- Axa Private Equity (French private investor), 2010: Critical analysis of the investments in wind energy
- Axa Private Equity (French private investor), 2010-2011: Critical analysis of the investments in the nuclear sector and recommendations
- DCNS (French Company, building military ships and submarines), 2012: How to present the "Flexblue" project to investors?
- RTE (French Electricity Transportation Network), 2012: Comparison between several designs of transportation networks

- EDF (French Electricity), 2015: Definition of a new generation of computational codes, to be used for safety demonstrations
- ANDRA (French Agency for Radioactive Waste Management), 2016, 2017, 2018, 2019: Best definition of sensors for the surveillance of a site

B. Economic validity

Economic conclusions are usually drawn from assumptions, which are not clearly presented or stated. For instance, during some years, people considered as obvious that the price of energy would grow; in fact, it is presently going up and down. The same way, people usually consider that the price for housing may only climb. This may be true over long periods but is clearly false during some years.

When this concerns a technology, one should take into account the subsidies given by the governments (which alter the competition but may disappear instantly) and the capacities of other technologies. For instance, our reports (see above) showed that the bright future predicted for wind and solar energies was quite a mistake. In fact, these technologies exist only from the help they receive.

Our task is here to make apparent all the assumptions which are usually kept in the dark, so that the dependence upon subsidies, increase of prices, and so on, becomes clear.

Our recent achievements

- RTE (French Electricity Transportation Network), 2008: Guidelines for investment decisions, taking into account the increase of population, the aging of equipment, and the increasing part of renewable energies.
- FEHAP (Federation of Hospitals), 2010: Tools in order to simulate and investigate the possible modifications in reimbursements.
- Société Sodebo, 2008-2009: Probabilistic methods in order to anticipate price evolution for cereals.
- Réseau Ferré de France (French Railways), 2008-2013: Why are the trains, in the Paris Region, so often late, and how to spend the money to improve this?
- RTE (French Electricity Transportation Network), 2008: Robust probabilistic models, in order to help an investment decision in a French region.
- Rhodia, then Solvay, 2009: Construction of a prospective indicator about worldwide car sales (updated in 2011 and 2014).
- Siemens France, 2011: Comparative analysis of several systems of transportation in the framework of the Extended Paris Region. We wrote a "white paper for decision".
- International Stainless-Steel Forum (Belgium), 2011: Probabilistic tools for the forecast of Nickel prices and Nickel sales
- Global Warming, White Paper drawn up by SCM SA, 2015; Second Volume: Social Consequences of the fight against global warming. Updated, 2023.
- SNF, 2015: Analysis of price dependence between several raw materials related to crude oil.
- CTIP (Technical Center for Provident Societies), 2016: Analysis of the future of the economical equilibrium of these societies, under various assumptions.

- SNCF (French Railways), 2016: Analysis of the economic status of a new line for high speed train.
- Monceau Assurances (French Insurance Company), 2017, 2018: Impact of natural events upon the portfolio.
- Private Investor, 2020: Critical analysis of the "biogas" sector

C. Risk analysis

When dealing with a large project, a careful risk analysis should be made. Our experience is that this is rarely done correctly. Let us take some very striking examples:

A company which builds nuclear plants relies upon the data given by the country where the plant will be constructed, to estimate seismic hazards. But (as the Japanese example showed), these data may be incorrect. So, the company should have their own set of data, to provide their own estimate.

On the other hand, some governments (typically, the French government, over the last 30 years) overestimate all types of risks, using the so-called "precautionary principle". Every possible risk is overestimated, usually from a large number of dishonest publications and scientific papers: we will die the next day, from pollution, from several epidemics; we suffer from permanent stress, diseases, and so on. The result is that the government constantly takes new regulations, which immediately affect the industrial activity. There is absolutely no peace in mind for any industry in France nowadays.

Our task is here:

- To question all existing studies in terms of scientific validity.
- To help the Industry propose a stable environment, in terms of regulations.

Our recent achievements

- SNCF (French Railways), 2004 – 2005: Analysis of the risks associated with longer freight trains
- CEA, Site de Saclay (French Atomic Energy), 2005-2006: Analysis of the risks connected with dangerous material transportation near the site and planes flying over the site
- Delegation for Nuclear Safety for Defense Installations, 2007-2008: Probabilistic risk assessment for nuclear weapons systems
- Agence Nationale des Titres Sécurisés (Homeland Security), 2008 and then 2013: Vulnerability analysis connected with the biometric passport and analysis of frauds
- Vinci Construction Grands Projets (High Speed Train between Paris and Bordeaux), 2013: Estimates for the return period of extreme flooding (rivers crossed by the line).
- EDF (French Electricity), 2015: Critical analysis of probabilistic studies used for the safety of nuclear reactors.
- IRSN (French Institute for Radioprotection and Nuclear Safety), 2014-2016: Critical analysis of a network of sensors, measuring radioactivity in the environment.
- Framatome, 2018-2020: Writing of a safety demonstration for a control card.
- RATP, 2021: Modeling the behavior of trains in an emergency braking situation.

- SNCF, 2021-2022: Safety File for "Hydrogen Trains"
- Léon Grosse, 2022: "Hail" risk analysis

D. Technical assistance to the definition of a project

Our task is here to make sure that all uncertainties are taken into account, with appropriate consideration. Usually, there are uncertainties upon the data, upon the laws, upon the objectives. We try to come up with robust approaches, usually of probabilistic nature; they often turn to be much simpler and much more efficient than deterministic tools, which end in extremely complex software.

Our recent achievements

- Ministry of Defense, 2004-2009: The Naval Shield - protecting a vessel against a terrorist attack. In cooperation with Thales and TDA Armements. SCM was in charge of the preliminary definition of the system and was responsible of its overall capabilities.
- Veolia Transport, 2005-2006: Mathematical methods and software tools for a quick definition of an urban transportation network, and for the improvement of its rentability.
- European Environment Agency, 2007-2011, renewed 2011-2015: SCM won an international competition for the construction of an Information System connected with quality of water in Europe. Our task was to provide the necessary probabilistic tools in order to handle the uncertainties and the important heterogeneities between countries.
- ANDRA (French National Agency for Nuclear Waste), 2007-2012: Mathematical models for radionuclides propagation in the soil, probabilistic tools for long term management of nuclear waste, improvements of models related to multilayer transfers of radionuclides.
- IRSN (French Institute for Radioprotection and Nuclear Safety), 2007-2014: SCM has an ongoing collaboration, under the framework "Probabilistic Methods for Nuclear Safety". Our task is to help take the uncertainties into account, for instance in the accounting of nuclear substances, to improve the detection systems (sensors located in various French cities), and to question the safety systems of nuclear reactors.
- Snecma Propulsion Solide, 2009: Probabilistic methods for reliability. We helped the Company write their documents for the Safety Authorities.
- Caisse Centrale de Réassurance (French Reinsurance Agency), 2009, 2011, 2013: We defined a new mathematical approach for extreme phenomena, which is much more robust and does not use any parametric model.
- Nuclear Energy Agency (OCDE), 2010, 2012, 2014, 2015, 2016, 2017: We conceived and then implemented probabilistic methods for the detection of erroneous data in large nuclear databases.
- IFSTTAR (French Research Agency for Transportation), 2011-2012, and then 2014-2015: Improving GPS positioning in an urban environment.
- ArcelorMittal, 2011-2012: Probabilistic methods for the improvement of the quality of an industrial process related to steel fabrication.
- Air Liquide, 2011: Definition of a hierarchy of parameters having an influence upon the quality of an industrial process.
- Areva, 2012 and 2013: Probabilistic methods for the evaluation of mechanical properties of components in nuclear plants.

- DCNS, Indret, 2013: We showed how to establish a hierarchy of parameters in an industrial process, thus allowing a better overall control of the quality.
- ANDRA (French National Agency for Nuclear Waste), 2016, 2017, 2018, 2019: Technical assistance for the definition of the sensors monitoring a site for nuclear waste.
- Befesa Valéra, 2022: Prioritization of the parameters involved in the adjustment of a furnace.

E. Counter expertise

This is especially common in epidemiology. Some studies show that some danger exists, due to some installation, for instance that childhood leukemia is more frequent near high voltage electricity lines. We were asked to make a counter expertise about such studies, and the result was very clear: they do not obey the basic rules of scientific research. Usually, the authors do not take into account the natural variability of the phenomena: before accusing the electricity lines, one should first check for the natural variations of childhood leukemia, from one place to the next, from one year to the next.

Another example is linked with the so-called "global warming". Before accusing man-made activities, one should consider the natural variations of temperature, all over the Earth. Such variations are well documented for Europe over the last 2000 years and show considerable modifications of the climate in the past.

In such questions, our role is to check that the existing studies obey the general rules for scientific research: all data should be exploited (and not just the ones which support a cause), all results should be presented (and not just the ones which support the initial claim), and every model should be validated, with data different from the ones on which it was built. There is a strong tendency to build a model on a set of data, and then people claim, "it works". But the model has never been tried on another set of data.

There are many other basic rules, often neglected, such as: the uncertainties should be taken into account, the natural variability of the phenomenon should be studied first, and so on.

Our recent achievements

- DGEMP (French Ministry of Finances), 2007-2008: Critical analysis of the software employed by the European Commission about CO2 emissions and "burden sharing" between countries.
- CEA (French Atomic Energy), 2007: Critical study of the models usually used in seismology and definition of more robust models.
- CEA (French Atomic Energy), 2007-2008, RTE (French Electricity), 2011 and 2013, EDF Health Services (French Electricity), 2011-2012: Counter-expertise of several medical studies in epidemiology.
- Vinci, 2008: Critical analysis of a model simulating employment and transportation in a city; improvement of the model.
- GPN, 2008: Critical analysis of some expert reports in seismology.
- FEHAP (French Hospitals), 2011: Critical analysis of a study concerning the costs of some patients with home care.

- Aéroports de Paris (Paris Airports), 2012: Critical analysis of epidemiological studies, relating airplanes noise to sanitary consequences in the nearby housing.
- Agence d'Ecologie Urbaine, Ville de Paris (Paris Agency for Urban Ecology), 2012: Critical analysis of a software about air quality.
- Ligue de Défense des Conducteurs (drivers' league), 2013-2014: Critical analysis of scientific publications connected with the speed of vehicles.
- The battle against global warming: an absurd, costly and pointless crusade. White Paper drawn up by SCM SA, 2015; updated, 2023.
- Critical analysis of a government's project related to soil pollution, 2016.
- COSEA, 2016: Counter-expertise about water pollution.
- SNCF/Transilien (French Railways, Paris Region), 2017, 2018: Critical analysis of some transportation models.

F. Independent evaluation

A typical example is this: some pollution occurred in a harbor, and a few measurements were made. Some of these measurements showed no pollution at all, some a limited amount, and a few showed a high level of pollution. Of course, a legal fight started on these grounds. We were asked to come with an independent estimate.

From the existing measurements, we used our mathematical methods (reconstruction of missing data), which give a probabilistic estimate for the possible amount of pollution at places where no measurement had been made. Our computations, totally public and transparent, were accepted by both sides and the fight stopped.

The quarrels usually come from the fact that different people use different models with different assumptions, so the discussion quickly turns into a war of religion. Our role is here to provide honest mathematical models, in order to answer the problem. Our models are always "minimal", in terms of assumptions, so everyone can agree upon them. For instance, for extreme events, experts often use parametric laws, such as Gumbel or Weibull, and then they fight over the question of the adjustment of these parameters. Our models do not use any parametric law; they just say that the more extreme the phenomenon is, the smaller its probability will be, and everyone agrees to such a statement.

Our recent achievements

- Veolia Environnement, 2005: Analysis of the situations of insufficient water supply in Vendée (west of France).
- Groupe Total, 2010: Probabilistic methods for the evaluation of a pollution in a harbor.
- Réseau de Transport d'Electricité (French Electricity Transportation Network), 2012: Comparison between a connected network and an isolated network, in terms of overall performance, for three indicators: cost, reliability and environmental concerns.
- GDF SUEZ, 2012: Evaluation of uncertainties in natural gas accounting.
- DCNS, 2013: Preliminary analysis of the reasons for insufficient quality on a production site for submarines.
- French Ministry of Ecology, 2015: Links between car traffic and pollution on a highway around Paris.

- Institut de Radioprotection et de Sûreté Nucléaire, 2015: Critical Evaluation of a network of sensors about radioactivity in the environment.
- COSEA (Construction of a high-speed train southwest of France), 2016 and 2017: Independent analysis of a possible deterioration of the quality of drinkable water, after the completion of the works.
- BRGM, 2018-2019: Probabilistic tools relating to soil pollution.
- Critical analysis of the "biogas" sector for an investor, 2020.