THE DEVELOPMENT OF

SYSTEM DYNAMICS IN FRANCE

Michel KARSKY
ELF Aquitaine
Tour ELF Cedex 45
92078 Paris
FRANCE

In this paper, we will sum up the situation, the achievements and successes of System Dynamics in France, but we will also analyze some of the practical difficulties to which it is confronted.

This exposé will include three parts:

- the teaching of S. D.

- its practical applications, particularly within industry

- an example of a successful application, illustrating some of the practical difficulties in using our S. D. models.

I - THE TEACHING

It is not an exaggeration to say that until now, in France, the teaching and the practice of System Dynamics have been out of phase.

Very much appreciated in universities during the 70ies (Universities: Paris Dauphine, IAE, Grenoble, MIAGE Toulouse, etc..., Institutes for Higher Studies: Sup Aero, INSTN, IIE,...), whereas the company ELF Aquitaine was the only one trying to develop its use for internal needs, System Dynamics has lost part of its appeal among students while gaining credit in industry and among some public organisms: Aerospatiale, Renault, EdF, Pechiney, ELF Aquitaine, CNRS.

Between 1983 and 1988, the teaching of S. D. decreased for reasons both structural and conjunctural, of which we will give only some of the most apparent:

a) this phenomenon of phase opposition between offer on the work market (students competent in S. D. and proposing to apply it) and demand (industries on the look-out for specialists) would in itself be enough to explain the unsatisfactory behavior

of any system. Confronted with the lack of competent young "dynamicists", potential users give up and turn towards other methods or ... towards the absence of any serious approach to system analysis. Students having aquired knowledge in S. D. then give up looking for jobs in that field. Their discouragement transmits itself to professors and all those responsible for defining the cursus, who prefer setting up more fashionable and easy-to-sell themes (I myself, as a teacher of S.D. in a well-known university in Paris, have had to compete against a course on "the economic consequences of sport". I was the looser, of course!).

However, the absence of competent specialists does not imply the disappearance of System Dynamics. Indeed, problems subsist (in economy, in management, in sociology), reality continues to evolve in a manner which we cannot always understand, the need of a S.D. type of approach is felt again (it never disappeared, but one thought one could do without it!), "System Dynamicists" are called for again, professors learn about it, ... and the cycle starts up again.

b) considering a situation, apparently quite particular to France, where the development of S. D. is more important in industry than in the academic world, potential teachers having experience in the domain are rarely at hand, except for a conference from time to time. The relative lack of university teachers ready to devote an important amount of time to the creation of a program in S. D. has been, if not an impediment, at least a missing strong element in the structure necessary to the potential development of this science.

c) As an excuse for the absence of teachers, one must aknowledge that it isn't easy to develop a curriculum in System Dynamics. Should there be a general, philosophical, "systemic" course, or on the contrary, should one teach a technique of programming in a specific language, so as to give students the impression that they have acquired a technique they can "sell" on the labor market? Must one especially show real applications-which requires the least effort from a specialist-in order to interest students, yet without giving them the means of acomplishing a similar work?

I do not know of an ideal answer to these questions concerning a program for teaching S.D.. Some of us, in order to escape this dilemna, perhaps also to remain wrapped in glorious-but dangerous - mystery, consider System Dynamics as an art that can only be transmitted from Master (in the sense of the painters of the Middle Ages) to Pupil. Unfortunately, some users, jumping ahead too fast, refuse to see the interest of a science based on an intuitive comprehension of things and consider us mostly as wizards!

What is the present situation of the teaching of System Dynamics in France? We seem to be, once again, in a rising phase of the cycle, as some new courses and conferences are being given at the academic level and in some of the best Higher Education Institutes. For instance (the list is not exhaustive):

IAE Paris
ENSAE (Sup Aero Toulouse)
ENSTA
Ecole Centrale (masters)
Ecole des Mines de (of) Nancy
University of Aix
ESE (Sup Elec Rennes)
IIE

If this tendency continues, if the appearance of young "specialists" in System Dynamics (or people who will, at least, not ignore its existence nor its interest) is confirmed in the near future, we will have to rapidly develop the "demand aspect", that is the development of practical applications of this science within big industries, administration, etc...

II - PRACTICAL APPLICATIONS

In France, they can be found essentially within great industrial groups: Aerospatiale, EdF, ELF Aquitaine, Péchiney, Renault.

S.D. has been introduced first of all by ELF Aquitaine in 1974, and has been used in various fields, such as:

ECONOMY:
- dynamics of the
  - oil
  - agro-food markets
  - etc...
- development of new products (composite materials, etc...)

SOCIO-ECONOMY: work relations in a specific industrial context (oil-refineries)

MANAGEMENT:
- project management
- information structures
- exploration and production of oil

There too, cycles of development and recession seem to exist, with a period of apparently 10 to 12 years: rising phase from 1976 to 82, declining phase from 82 to 88, recovery in 89.

In 1982 for instance, 4 scientists (helped by 3 doctoral students and a dozen trainees) each developed and/or applied 2 to 3 projects/year. In 1988 this number had fallen to 1/2 scientist for 1.5 project. At present, the recovery of S. D. can be seen in the development of 3 new projects and the use of 2 older models. Here are some of the subjects approached:

Economy:	- world market of crude oil (operational) - chemical product market (in development) - phosphate market (ready to be used)
Psycho-sociology:	- motivation dynamic (ready to be used)
Pharmacology:	- enzymatic regulation of hypertension of the arteries (in development)
Environment:	- Ecotoxicology of water (developed in colaboration with the CNRS)

We shall only quote here the subjects to which S. D. has been or is being applied in other companies or organisations:

AEROSPATIALE:	- market analyses for airplanes and helicopters
RENAULT:	- car market analyses - model life expectancy
PECHINEY:	- Aluminium market dynamics
ELECTRICITE DE FRANCE	- Bi-energy equipment development - de-sulphurisation policies and constraints
CNRS:	- water pollution models

Unfortunately, even successful analyses of the dynamics of a given system are not all of them systematically exploited, far from it. I do not know of a sure receipe permitting to go from development stage to an efficient, frequent and systematic use of

the corresponding models. Let us mention some of the difficulties we met while "selling" some of our studies and models, all of which had the reputation of being trustworthy.

1 - S. D. models are complex because they represent not one, but many successive realities. There is a gap between the conceiver who tends to want to show all the possibilities of his model, all its capabilities, its "tricks", all the scenarios one can imagine, and the potential user, linked to the present, who gets quickly lost in the meanders of the variables, the causal relations and the hundreds of results that are potentially fascinating but that quickly end up by all resembling each other.

2 - This complex character of S. D. models is particularly true with industrial problems, where utmost simplification for didactic reasons is not accepted. And it is true that for the time being, one lacks the tools which would permit a more supple use, a simpler explanation of the operating mode and which would help to transmit in an easy and trustworthy way the contents and the results of our models.

3 - The latter seem all the more complicated that they had been destined until now to be used, not as immediate tools with simple indications, but as a help to understanding, to the comprehension of phenomenons, to reasoned decisions. The example given later on is a good illustration of the difficulties we are confronted with in diffusing and exploiting our work.

Let us say, to sum up this point, that what most decision-makers secretly regret is that our models are not destined to play the roles of soothsayers, to simply answer the question: "what will happen tomorrow ?". Although our analyses do indeed contribute in an important way to the comprehension of dynamic processes (in that domain, the perenity of System Dynamics - be it under that name or another one - is certain), their essential role is to oblige to define the right questions, those which may influence the dynamics of evolution, those which one too often does not dare, or does not know how to ask.

This theme of the "right questions" is the one that is going to be developed, in the third part of our exposé, through the example of a recent use of one of our models.

III - AN EXAMPLE OF APPLICATION

One of the oldest models achieved within ELF Aquitaine is called MARPET and represents the dynamics of the crude oil market. This work has been presented in other papers and will soon appear in a detailed and no doubt final publication. Therefore, we will simply give a very general and brief presentation, but we will present the last results which are a

rather good illustration of certain difficulties met with in the use of such a model.

MARPET, which has just celebrated its tenth birthday and which is still maintained, updated and exploited, was conceived shortly after the Iranian Revolution, during a rapid rise of the price of oil. This mono-market model (one type of producer, one consumer and a single product) represents in detail the process and the constraints that influence or restrain the evolution of prices, of production, of consumption, of stocks and coverage, of production capacities, of anticipations, of speculative buyings or sellings, etc..., these variables, being of very different types, all influencing each other and forming a "system" with dynamics varying from a few days to many years (see Fig.1).

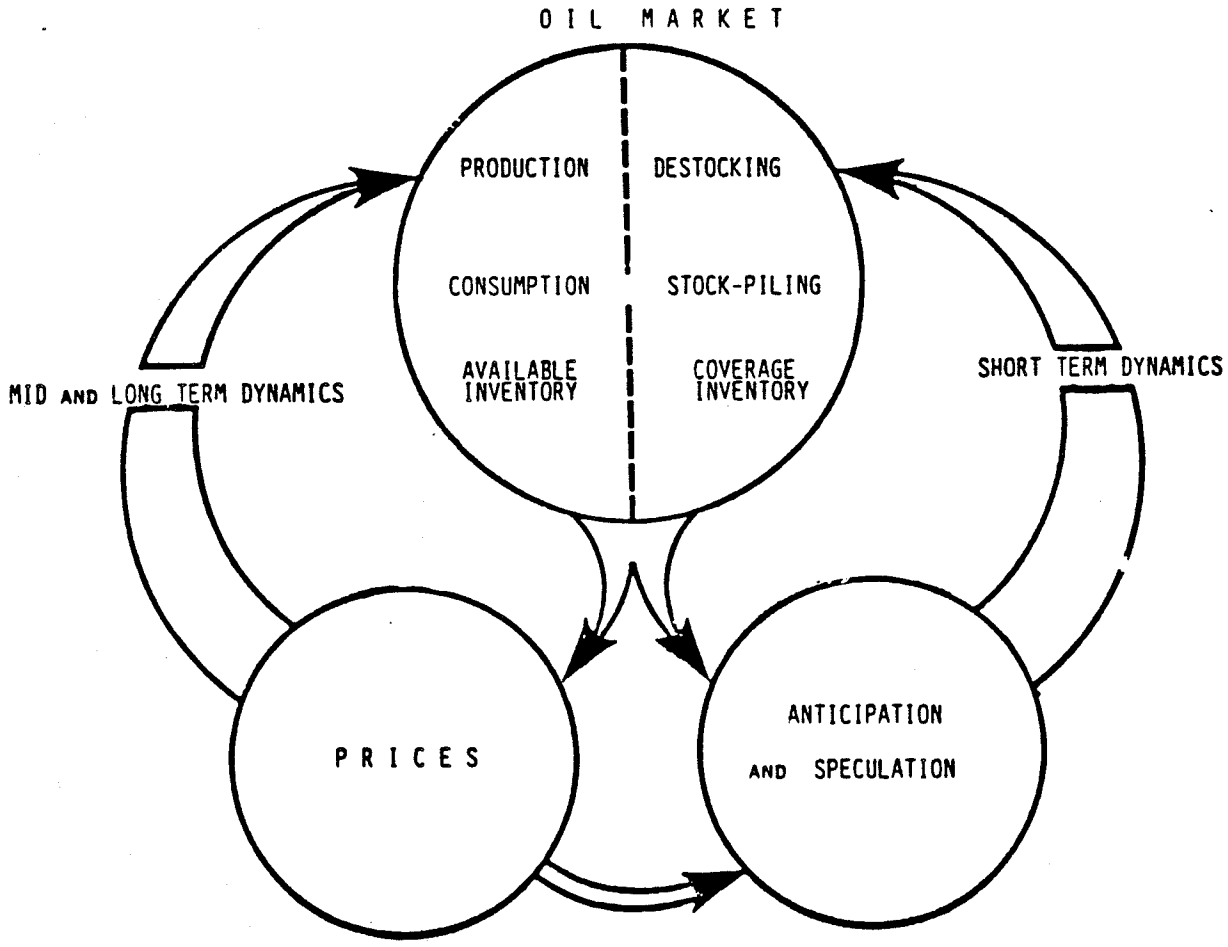

Fig 1

To represent correctly the tendencies of the crude oil market (see fig. 2), the model needed, for the last 10 years, only very few input data:

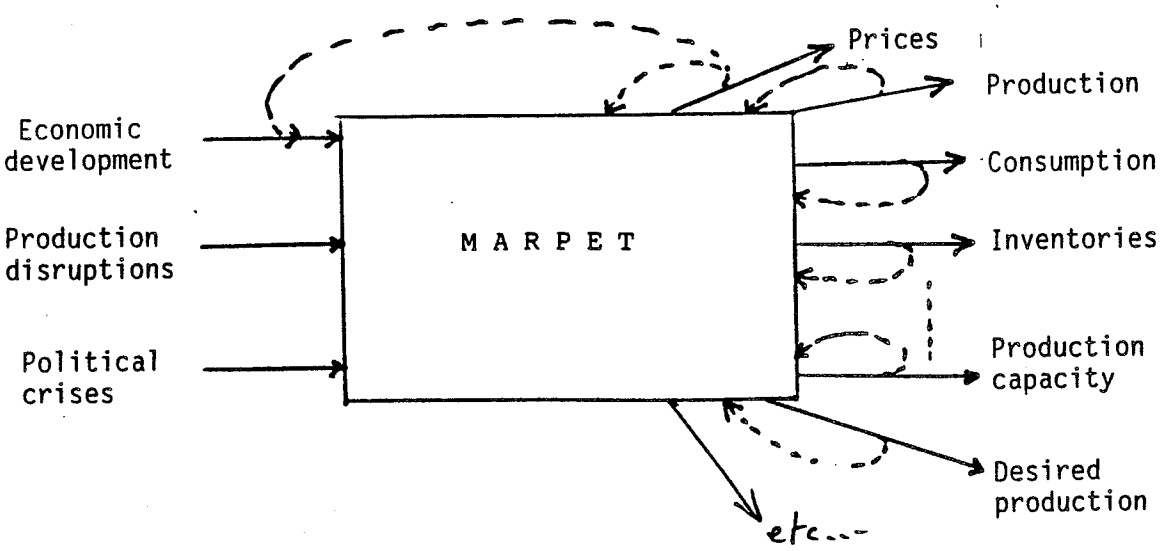

Fig 2

1 - The -real or anticipated- gaps in production

- 5% during and after the Iranian Revolution,
- 3% during the first months of the war between Iran and Irak
  + 5% during the Saudi-Arabia's attempt to take over the market (1985)

2 - the outbursts of political fear during the Iranian Revolution and the war between Iran and Irak.

3 - economic growth, resulting in a slow evolution of the demand of oil (the oil market itself reacting, up to a certain point, on the world's economic growth).

Of course, one could also test various scenarios on the numerous "output" variables of the model (price, production, consumption, stocks, production capacities, anticipated variables, speculative buying, etc...), but only if one keeps in mind the fact that these variables react on the functioning of the model and that every action carried out on these variables leads more or less rapidly to a reaction (ex: to modify prices arbitrarily - if one has the means of doing it -causes the market to react on the production and on the buying, and this, in time, has an influence on prices).

In October 1988, a new series of simulations showed the probable consequences of a cut in the production such as OPEP periodically decides. In December of that same year, new simulations confirmed the probable evolution of the market, considering the decisions taken by OPEP during a meeting held in the beginning of the month (see fig. 3).

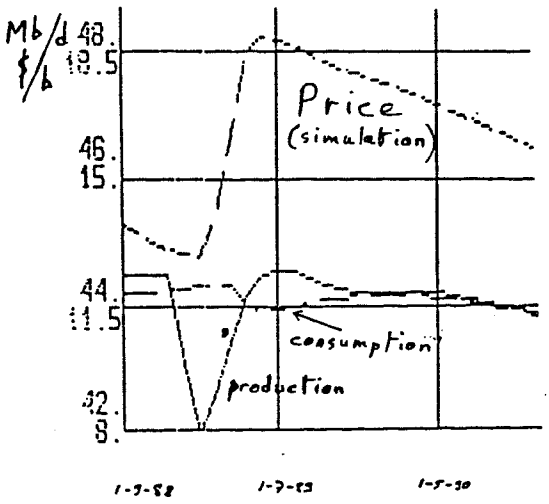

Fig 3

Nine months later, we decided to verify the validity of our "predictions". This verification was done in three stages:

1 - <u>comparison reality - forecasts</u>

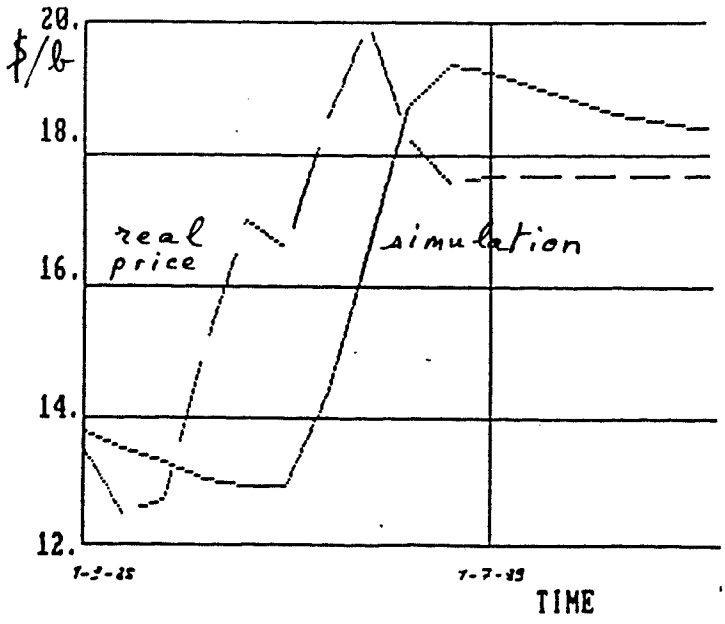

Fig 4

The forecast was good in tendency and level, but there is a time span of almost three months. Why?

2 - Analysis of the simulation hypotheses

The simulation carried out in the beginning of December 88 was based on expert's perception of OPEP's decisions and of the corresponding reactions of the market. After a careful look at the historical data, this perception turns out to have been incomplete:

- OPEP's decision of lowering the production quotas was only effective after a month (January 89 instead of December 88)

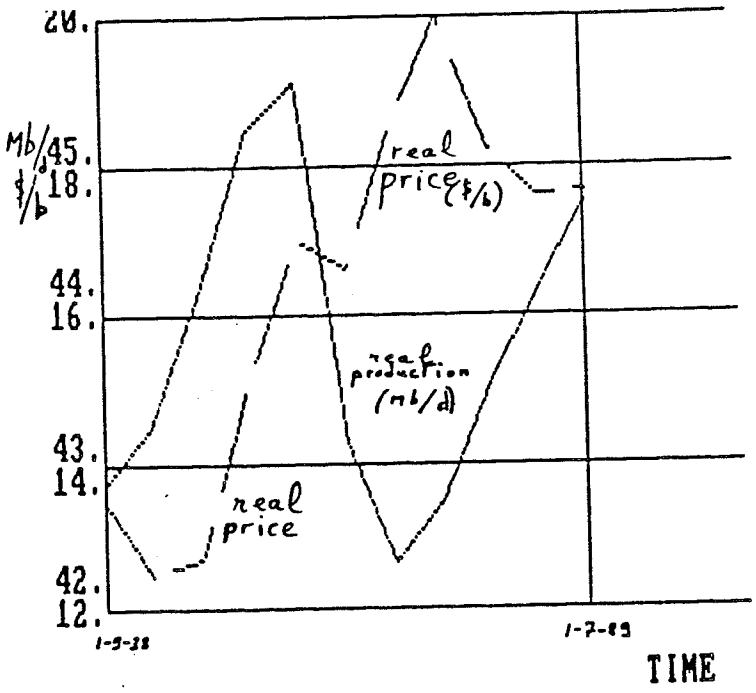

Fig 5

- however, this OPEP meeting and the corresponding decisions were anticipated by the "oil market": the price of crude oil started going up two full months before the December meeting, thus reacting to an anticipated cut in production. Our simulation, however, had been carried out without introducing any anticipation whatsoever.

3 - Readjusting our hypotheses

Delaying the production cut by one month, but especially introducing a two month anticipation of this same cut, led us to an excellent accuracy of simulation results as compared with reality:

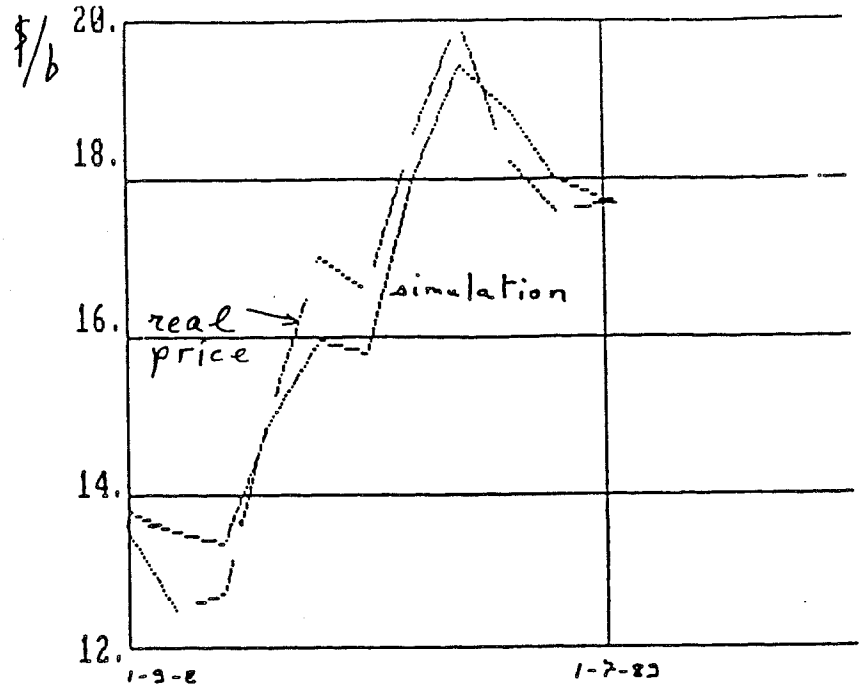

Fig 6

4 - A forecasting tool?

It seems that we could have achieved an almost perfect short-mid term forecast (6 months),by introducing certain hypotheses of events (scenarios), perfectly realistic and which in fact happened in reality, but which call for questions and answers that experts and decision-makers have not been used to consider, even less to answer. These questions, of which some, indeed, have been asked, were the following:

- when will OPEP apply its decision of cutting the production?

- will all the members of OPEP act in a disciplined way? (the model allows many types of OPEP reactions).

- how far in advance do you forecast OPEP's decision?

For most experts, and although the market did expect such a cut in production and did react accordingly, this last question is particularly embarrassing and, although it proves to be one of the major assets of our discipline, it also shows one of the present practical limits to the use and development of S. D. models.

A major assett : to help pose the right question, a prerequisite to the right answer.

A limitation : "what to do" with our models, how to use them correctly, how to bring users to ask the right questions ?

In our example, a good understanding of the phenomenons of anticipation (evolution of market variables, future decisions,...) is essential; it is probably inherent to many decisions taken in the domain of the oil market. And yet, these notions of anticipation are not openly and clearly expressed, nor are they quantified, if only in a fuzzy way, and when refered to, they lead to astonished and evasive answers.

Much effort is still needed - and it is probably essential to the development and the acceptance of S. D. - in order to bring home to potential users of our works one of the essential contributions of S. D.: a help to the generation of the right but often hidden questions.

Conclusion

In France, System Dynamics has a cyclic development where teaching and application are often, mostly for structural reasons, in phase opposition.

Providing we analyse correctly this oscillatory system, it should be possible for system dynamicists to fundamentaly modify its dynamic behavior so as to bring teaching and application in phase. In order to achieve this, we should, for the least, clearly point out through constantly renewed examples and frequently evolving development tools, the specific contributions of S. D..

Among such contributions, foremost is the definition of important questions which are essential to the good comprehension of phenomenons. This definition is at the same time a handicap to the diffusion of our approach and potentially one of its best assets.assets.