WHAT IS CYBERNETICS?

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Salutation

Magnificent and most excellent Rector of the University of Valladolid

Most excellent and most illustrious Authorities

Members of the University Senate

Ladies and gentlemen

I wish that I could speak to you in Castellian, but it is almost thirty years since I last had occasion to use your beautiful language -- and that was in circumstances of such stress that I still find it difficult to speak. On the 11th September 2001 a crime was committed in New York that the world will long commemorate. I hope that the Spanish-speaking world at least commemorates that earlier 11th September in 1973, the day of the Chilean golpe, when my Compañero Presidente Salvador Allende died, and the people of Chile fell subject to decades of brutal suppression.

Today, however, is a happier occasion. I wish to thank the University of Valladolid which, following the proposal made by the Escuela Universitaria Politécnica, has bestowed on me the high honour of Doctor Honoris Causa.

Popular Notions and Genuine Difficulties

The subject to which I have devoted my professional life is cybernetics. I am all too well aware that most people have no more than a hazy idea of what it is all about. I have often been assured that it is about freezing people -- but they were thinking of cryogenics. The more informed realize that it is concerned with systems and their regulation. But even then, there are so many ways in which that notion can be approached.

Some people seem to think that cybernetics is part of engineering -- they reckon that feedback loops are involved, and therefore focus on specific devices described by servo-mechanics. Others have heard of systems of training through behavioural psychology, and think of pigeons, or rats running mazes. Even so, the most advanced type of control machinery we know about is surely found in the central nervous system of the human body. So they may go on to speculate that cybernetics is probably a branch of neurophysiology. All of these intuitions are true enough -- but you might think rather localized. Let's face it, the modern world revolves around money and global markets -- we might conclude that economics should therefore have the clue to its regulation in econometrics.

But wait a minute. There might be broader issues. Maeterlinck talked about the spirit of the hive, and Canetti talked about crowds. These anthropological concepts offer a more general and cohesive notion of system. Behind that idea, in turn, is arrayed a whole range of biological facts that certainly deal with regulatory phenomena. They encompass wide-ranging kinds -- from the specifics of the potassium-sodium pump, to the generalities of pray-predator balances. They discuss the whole epigenetic landscape, which leads in turn to unfolding the course of evolution itself. Mind you, this discussion is still humano-centric; and maybe we should start with ecology -- which one can only suppose ought to be a thoroughly systemic science.....

It is time to stop. The shocking thing is that there is truth in every one of these notions, and the reason is because cybernetics is an *interdisciplinary* subject. It must be complicated. If I may be allowed one joke in a dignified discourse, it concerns three men who are about to be executed. The prison governor calls them to his office, and explains that each will be granted a last request. The first one confesses that he has led a sinful life, and would like to see a priest. The governor says he thinks he can arrange that. And the second man? The second man explains that he is a professor of cybernetics. His last request is to deliver a final and definitive answer to the question: what is cybernetics? The governor accedes to this request also. And the third man? Well, he is a doctoral student of the professor -- his request is to be executed second.

The great schools of a great university are valued -- even revered -- for their scholarship. But they do tend to suffer from a Hardening of the Faculties. This makes it particularly difficult to deal with interdisciplinary science. So that is why I feel doubly honoured to be standing here today. You have heard that I am already a doctor of science, and have received honorary doctorates in both law and in economics. But you are according me something I regard as more special. The doctorate of the University, rather than a particular faculty of the University, somehow recognizes that knowledge is a unity. This is something I have believed all my life, but a fact difficult to bring home in a basically reductionist world.

Origins -- and An Anecdote

Cybernetics had its origins in the early 1940s, when a group of distinguished scientists was gathered together in Mexico to deal with various assignments associated with the second world war. It is well-documented how they discovered that -- precisely because of their eminence in different fields -- they found it difficult to talk to each other about anything serious. So they decided to choose a topic that was nobody's speciality, but of interest to everyone. And their eminence was really important for another reason: they had nothing to prove. They decided to discuss the nature of control.

It took a long time to get anywhere, because each specialist had an idiosyncratic view of the matter. We have already seen how popular misconceptions arise 60 years later; at the beginning, there was nothing to go on. What did control actually mean? An astrophysicist might think about laws of gravitation and cosmic repulsion as controllers, whereas a neurophysiologist might think about brains. The concepts, and certainly the vocabulary, do

not coincide. I shall focus on one famous and fully authenticated incident, because it seems to embody both the form of interdisciplinary work, and also the excitement it can generate.

Two members of the group had been designing a machine which would enable the blind to read with their ears. A bank of photocells would scan a line of print. As each letter passed, it would sound an audible group of notes. It is not difficult to imagine that a common word, such as the definite article, would sound a short chord that would soon be recognized as such. The main difficulty would be to cope with different sizes of print. After all, the snag already encountered with Braille, whereby every book has to be reprinted in a special format, needs to be avoided if at all possible. What these two scientists were discussing was the prospect of having the machine adjust itself automatically to the appropriate print size. They developed their idea by arguing through a schematic diagram -- not an electrical circuit -- which they left on the common room table when they went to bed. The next man to come into the room, who was a famous neurophysiologist, picked up the diagram. He asked: "Who is trying to draw a diagram of the fourth layer of the visual cortex of the brain?"

If you do not already find this story exciting, then consider the sequel. Any scanning process will have a characteristic cycle time for its periodic sweep. That will depend on its input rates. The great mathematician Norbert Wiener asked if anyone knew the rates at which the occipital lobe of the brain registers visual information from the retina. It is a complicated question, because several minicomputers operate between the two as the optic nerve is transversed. But the brain people knew the answers, and the mathematician was able to calculate the scanning rhythm. So the question was: if the human brain actually worked like the schematic diagram, what would its rhythm be? The answer was ten cycles per second -- which is of course the resting rhythm of the brain. If the whole story leaves you unmoved, it's possible that you may never acquire an interest in the subject of cybernetics.

Derivations and Definitions

Of the many distinguished scientists involved in those early days, the one I have mentioned by name was the ranking mathematician Norbert Wiener. That is because he actually named the subject. Why then did he call it **cybernetics**? Probably the firs clear insight into the deep nature of control reached by the group, was that it is not about pulling levers to produce intended and inexorable results. This notion of control applies only to trivial machines. It never applies to a total system that includes any kind of probabilistic element -- from the weather, to people; from markets, to the political economy. No: the characteristic of a non-trivial system that is under control, is that despite dealing with variables too many to count, too uncertain to express, and too difficult even to understand, something can be done to generate a predictable goal.

Wiener found just the word he wanted in the operation of the long ships of ancient Greece. At sea, the long ships battled with rain, wind and tides -- matters in no way predictable. However, if the man operating the rudder kept his eye on a distant lighthouse, he could manipulate the tiller, adjusting continuously in real-time towards the light. This is the function of steersmanship. As far back as Homer, the Greek word for steersman was

kubernetes, which transliterates into English as *cybernetes.* Note that on the way, via Rome, the same word in latin transformed into *gubernator*, which in English is *governor.* We should also acknowledge that long ago the French scientist Ampere, in his general classification of all knowledge, chose the word *la cybernetique* to describe government.

I like the word cybernetics in the managerial context, because it shifts the emphasis from the biblical "do this and he doeth it", and places it instead on the word governance. What a pity that popular usage has hijacked the root to cover everything from cybermen and cyberdogs to cybercafes, and in general to cyberspace. Anyway, not only did Wiener title his book cybernetics, he provided an illuminating subtitle in two parts. The first added the descriptor: **"communication and control".**

The pointed and direct linkage of these two words was astonishing at the time of publication, 1948. It was in no one's minds. Today, the connection is more obvious -- but I do not find that it is properly understood nor exploited. For example, it is nowadays clear that the control of crime is greatly dependent on good communication. It is also clear that the global economy depends on the fast reactions of money and markets. But forgive my saying that to observe these things is merely truistic. In the absence of deep insight into systemic purposes, and their quantification.

The problem lies in the belief that massive data bases are the clue to success. But mere data are useless in themselves. They have the same relationship to information as gossip has to sustained argument. What is missing in both cases is the construction, or model, that underwrites intention -- the purposes for which data are collected. Next, we need to quantify the complexity involved, to check that the model we are using has requisite variety. Ashby´s Law of Requisite Variety states that *only variety can absorb variety*. I see this law of cybernetics as of equal importance to the law of gravity in physics. Much reflection is needed to understand the law, and some people see it as tautological. By the same token, however, the whole of mathematics is either tautological or wrong! However, that may be, most people would agree that mathematics turns out to be quite useful...

The second pointed and direct linkage included in Wiener's original definition states: **"In the animal and the machine".** I fear that this continues to be astonishing to many people, and it is not surprising. For hundreds of years the categorization of knowledge drew a fundamental distinction between the living and the inanimate, and we still live with that. Well, some progress is apparent. People are fairly comfortable with such a term as biophysics, although we might wonder how many biologists think that physics has much to say to them, or vice versa. We need a lingua franca in which to talk cybernetics -- and unfortunately that involves mastering new terms and new usages.

In my own work, I have been careful to minimize the number of neologisms, and to define them with copious examples. Then, in appealing to the new kind of conversation generated by cybernetics, I am accustomed to appeal across the boundaries of specialties by proposing a rethorical question to the audience. It is this: Do you think God knows the difference between physics and chemistry? It has always seemed to me a provoking thought, as a way of questioning our reductionist ways of thinking. But perhaps this piece of intellectual seduction does not work in Spanish. When I tossed the question to a large audience in

Columbia five years ago, they seemed to get the point. But a leading periodical awarded me this headline: *Cybernetic Guru challenges God. [Guru de la cibernética reta a Dios]*. I do hope that you did not imagine that I had any such effrontery.

Intrinsic control

Anyone who examines an alleged control system, rapidly realizes that a great deal depends on the speed of response. The most successful kind of control is one built into the very process of going out of control. In that case the response time is instantaneous. Because of the impressive age of this university, I was looking for an ancient example of what I call intrinsic control. I found it in the weather vane as depicted by the Dutch artist Escher. His woodcut of the ancient example includes a dedication in old Dutch, which my friends in Holland were able to translate for me. The fact that the weather vane 'must veer endlessly' is pointed out. But the weather vane asks us whether we scorn its capriciousness -- and gives the answer that it is the vane's loyal task.

There is a cybernetic sermon to preach on this text. We have here an intrinsic control system that necessarily measures wind direction -- which is entirely its value. It is the wind that is capricious; the measurement does not make mistakes. Compare this with the most finely honed instrument we have for measuring the capriciousness of the economy in both the United States and Britain. The best complete record of economic performance is nine months out of date. Suppose that such a delay applied to the weather vane! Because such an historical record is quite useless, treasuries are accustomed to make rather wild guesses at current figures, and they often prove to be embarrassingly and dangerously wrong.

The next question to ask is this: are we interested only in maintaining and measuring the status quo, and in foreseeable issues? Not so, of course. We are interested in recognizing whatever may concern us -- regardless of whether we can foresee it or not. This is precisely the issue that confronts any future scenario. Unless we have a crystal ball, we do not know what to do. The cybernetic answer to this is the detection of *ultrastability.* Allow me to explain. Suppose that there is a very big computer, in which we detect the risk that it may overheat. In that case, we shall install a sensitive thermostat, and deal with its overheating. Suppose that we detect a risk that the computer will be stolen. Then we shall appoint guards. These moves protect against instability. How do we deal with the unknown? We set up a programme of critical factors, and continuously test the computer's effectiveness against those factors. If the test fails, we switch on the motors that will run the computer out of the building. We do not know why the building has been evacuated -- but we do know that the computer is safe.

In this ultrastability is the key to viable performance. I have defined a viable system as a system that is self-sustaining, or survival worthy, in just the way that a human being is viable when it can survive outside the womb. It is not totally independent -- nothing in this world ever is -- but it is autonomous within limits that are defined in terms of its own physiology. The model of any viable system is the basis for my major work in industry, in transportation, in education, in health, and in every other system that seeks to survive. Three of my books are devoted to explaining the detailed theory of viability, and you will

hardly expect me to summarize them in this short address. But speed of response is a major clue. In fact, we should be directing such large systems as the economy in real-time.

The second clue I offer concerns recursivity. If you can envision a model of viability that is universal, then it will be effective recursively. It will apply to whole industries, and to individual firms. It will apply to large towns, and to small villages. Putting together the issue of real-time and of recursivity, we may conceive of a model in which continuous sampling recognizes incipient change before it occurs -- and is therefore subject to modification. So as I said earlier, we do not try to build massive data bases, but selective and immediate responses. This can in effect break the time barrier, pushing forward into likely futures.

Socio-Economic Governance in Real-time

In the beginning of the 1970s, I was invited by President Salvador Allende to redesign the social economy of Chile. I was scientific director of Project Cybersyn. There were eleven levels of recursion ranging from the State as such down to villages and enterprises. Since every model conformed to the viable system as defined, all the models were structurally identical. This explains why it was possible to have two-thirds of the work completed -- two-thirds of the social economy covered -- in the two years that were available.

In particular, all the measures were made in real-time. No management information could be more than 24 hours out of date at any level, from the President down to the most local places. At each level there was disseminated regulation. All the measurements related to flowlines inside the Viable System Model, at each appropriate level of recursion. So by converting all measurements into uniform indices, and then filtering them continuously using Bayesian statistical theory, massive amounts of data could be processed, and presented daily to the appropriate level of management in the form of information. And I have a special definition of information: that which changes us. We do not want to engulf management with trivia; we want to isolate incipient dangers on which management can instantly act.

It was intended that every management, at every level, should be equipped with an operations room. This would facilitate collegial management, and make it independent of paperwork. The prototype of this room was built in the Avenida Santa María, and became operational in 1972. A key to collegial management is put forward by the cybernetic concept that we call the Redundancy of Potential Command. According to this, the interaction of key managers in the operations room enables a much stronger management action, based upon the availability and recognition of information, than is ever possible by orthodox managerial practices.

The most vivid illustration of this in my own experience, happened in Chile in October 1972. A powerful attempt to overthrow the government was made by the political opposition, with the help of the CIA. Small business, in the form of the *gremios,* were financed to mount a blockade. The idea was to take the ordinary requirements of people [food, cigarettes, petrol...] out of circulation, and blame the government. We already had a communications centre in working order, although nothing specific had been designed to

regulate distribution. But evidently that was required, and evidently a number of ministers and key staffs were involved. We had only one computer for everything we were doing -- all other communications had to work through Telex, a network that we had already appropriated. Eight teams were self-organized, and within 24 hours messages were flowing, non-stop, round-the-clock, at the rate of 2000 Telexes a day. Ministers slept on the floor, in the middle of the hubbub.

This demonstration of the redundancy of potential command in action, and in real time, truly convinced many people in the government who had hitherto been merely intellectually acquiescent in the approach. Something as dramatic as this, perhaps, is needed to break the paradigm. One senior minister said flatly that the government would have collapsed without the cybernetic tools available to it. As it was, President Allende was allowed to live for another year. Sadly, the absence of paradigm shift, not to mention the vested interests of all concerned in operating the standard systems of management, mean that the Chilean operation has never been repeated. Bits and pieces of the holistic approach have been adopted in various other countries, but by definition they lack cohesion. The whole story is crisply explained in the last five chapters of my book *Brain of the Firm*.

The recent horror

With the complete range of cybernetic discoveries to hand, it is always possible to analyze a situation from the point of view of its regulatory phenomena. According to the cybernetician, the purpose of a system is what it does. This is a basic dictum. It stands for a bald fact, which makes a better starting point in seeking understanding than the familiar attributions of good intentions, prejudices about expectations, moral judgements, or sheer ignorance of circumstances.

Last month, the tragic events in New York, as cybernetically interpreted, look quite different from the interpretation supplied by world leaders -- and therefore the strategies now pursued are quite mistaken in cybernetic eyes. In the first place, we heard the usual description from world leaders of an outrage perceived as "mindless", "senseless" and "cowardly". We should always react with dismay to these prior judgments -- because they simply mean that the speaker has no idea what is really happening or why.

The real reasons are not difficult to comprehend on a systemic basis, although they are deeply offensive to the United States. In the Twin Towers, a bastion and symbol of international dominance has been overthrown. This dominance is regarded by millions, especially in the Third World, as wielding an indefensible use of economic, cultural and political power. In many countries, people have seen their compatriots slaughtered with US bombs and starved by US blockades. Their legitimate and democratic governments have often been overthrown, and replaced by US puppets who are also despots, ruling by terror and torture. The West has made little attempt to understand that point of view, because their dogma has no systemic foundation.

When it comes to modus operandi, the cybernetician knows that information is power if properly deployed. It seems that 50 or 60 countries are involved in the networks that mobilized this informational power in September. It is not simply a question of "having a

database". The cybernetician knows that resources can be amplified through the process he calls intrinsic control. A large assailant charging a judo adept, finds himself thrown over the adept's shoulder, and crashing into a corner -- destroyed by his own strength. This amplification of system turned the hijacked planes into guided missiles.

I am not approving this heinous crime, merely trying to understand it with cybernetic insight. I see nothing here that is either meaningless or mindless. On the contrary, I see a stroke of strategic brilliance, backed by ingenious tactics, and supported by thoroughgoing logistics. As to the men who sacrificed themselves in the endeavour, in other circumstances they would not be called cowardly, but heroic.

The purpose of a system is what it does. That was the cybernetic dictum. What the system inaugurated on September 11th has actually done is to provoke retaliation against yet another poor country, Afghanistan, on the principle that might is right. In doing so, the United States may well seem to have abandoned the principles of justice that it has proclaimed. The outcome, which was predictable, is that the opponents of the United States are in the position to proclaim a *jihad*, a holy war. It is safest to assume that this was the objective from the beginning. The purpose of the system is what it does.

How actually to deal with the crisis provokes further disquiet. Attempts to guard against an infinite number of inexplicit threats do not have Requisite Variety. Deeper solutions must be sought. It is vitally necessary that the United States [and its associated global capitalism] faces it bad image. It could begin by rescinding all the key propositions of the Bush era, beginning by reinstating the Kyoto agreements -- feeble enough though they were. It should next begin to treat international debt seriously, starting from a recognition that for every dollar of "aid" extended to the third world, $14 of interest is extracted by way of usury. They could move on to take action on behalf of the 40.000 children who die daily from starvation and the lack of clean water, which could be put right for the cost spent on tobacco advertising....

Conclusion

But these are deep waters. I set out half an hour ago to answer the question "What is Cybernetics?", and part of that undertaking includes trying to show not only how novel the approaches become, but their relevance to what is called real-life. Whether we look back thirty years to the Chilean golpe, or come up to date with the New York disaster, we still face regulatory catastrophes well understood in cybernetic terms. And I am forced to note that in both these instances we did not fail to diagnose correctly. In both cases there is a gross disproportion of wealth and prosperity. There is no more expectation that the regulatory balances will be adjusted today than there were in Chile.

President Allende said to me often: "How can we run a socialist economy in a capitalist milieu?" He took his case to the United Nations, and they cheered him to the echo. But nothing happened. Today, we have invented a war which does not exist. There is no foe, and no way of defining victory. Allies are expected to go into battle against an abstract noun, and to assault any nation unwilling to mobilize in such folly. But still the cheers echo.

We shall continue to seek answers, and I would like to emphasize that orthodox solutions are unlikely to be successful. We have tried them over and over again, and they do not work. And so we try to make them work, by spending more money or force to do again those things that do not work. We need not stereotypic solutions but new pathways.

I am personally very fond of the poem Cantares, and I commend this couplet to you:

caminante, no hay camino
se hace camino al andar.