Instrumented Vehicles as a Research Tool
A histerical review

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richly illustrated by the author

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Introduction

Initially my intention for today was to present the ultimate integrative *exposé* on the use of instrumented vehicles in traffic research. On second thought, however, I felt that since this workshop appears to be a convention of the world's fleet owners of instrumented cars—all four of them—such a review will have to be the output of the workshop rather than its input.

All this crossed my mind last Saturday while I was waiting at Zürich International Airport at 6.15 in the morning, cursing my travel agent: I had just found out that he had booked me on a flight of fancy. Never has an international airport carried a more appropriate name!

Sitting there with two solid hours of waiting before me, I decided on preparing what I think is proper for an opening paper. And so I have dug up the available evidence about the Instrumented Vehicle (IV) of the past and I shall undertake to interpret some current IV-related problems in the light of this evidence. In short, I intend to present you with a brief histerical review of the development and uses of IV's.

The Instrumented Vehicle (IV) in pre- and protohistory

The dawn of history is shrouded in fog. From the point of view of traffic safety fog is about the worst possible state of the world, and as a consequence many of the prehistorical IV's must have crashed miserably in the course of the centuries. It is not surprising that they have left absolutely no trace whatsoever. Consequently it is extremely difficult to establish unequivocally where and when the origin of the IV is to be found.

Nevertheless, we should probably look for the real beginnings of the IV up in the air rather than down on the roads. We know for instance that the deities of ancient Greece originally did only sporadically use road vehicles but instead

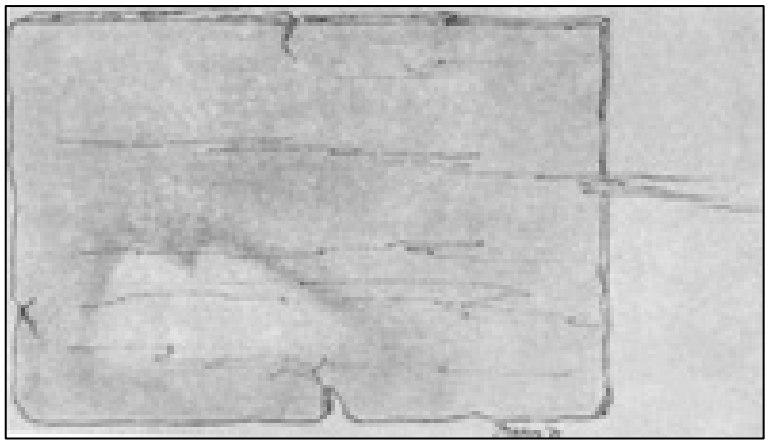

Fig. 1: The IV seen to be shrouded in fog at the dawn of history.

they preferred Olympic Airways instead, which is not at all surprising if we take into consideration the appalling quality of the highways in those days.

Until the present day our most educated guess is that the IV was invented by Stephen DAEDALUS, a senior research engineer from the Minoan Royal Transport Laboratories, Knossos, Crete, in the 17th century BCE. This conjecture is supported by the fact that a certain make of IV is universally known as ICARUS. Greek mythology introduced ICARUS—a word that is actually only an acronym for Instrumented CAr for Road User Studies— as the son of DAEDALUS. This ICARUS, according to the myth, crashed when he performed a ride and handling test with a new wing of the so called "tar 'n feather" type in which certain principles, both engineering and ergonomical, had been neglected. The classical story claims that this accident was primarily due to adverse environmental conditions, in fact to the phenomenon of temperature reversal high up in the atmosphere, which caused waning of the wax cohesion.

However, modern physics has convincingly shown that temperatures that will melt wax products, as used by ICARUS, will not occur in the earth's

atmosphere at high altitude. Consequently we may recognize the historicity of the event, but only in the sense that DAEDALUS did not *beget* Icarus. Instead he appears to have *created* one but subsequently have lost it in some sort of accident. We shall have to wait until someday we shall be able to read the early accident records of the Cretan Metropolitan Police.

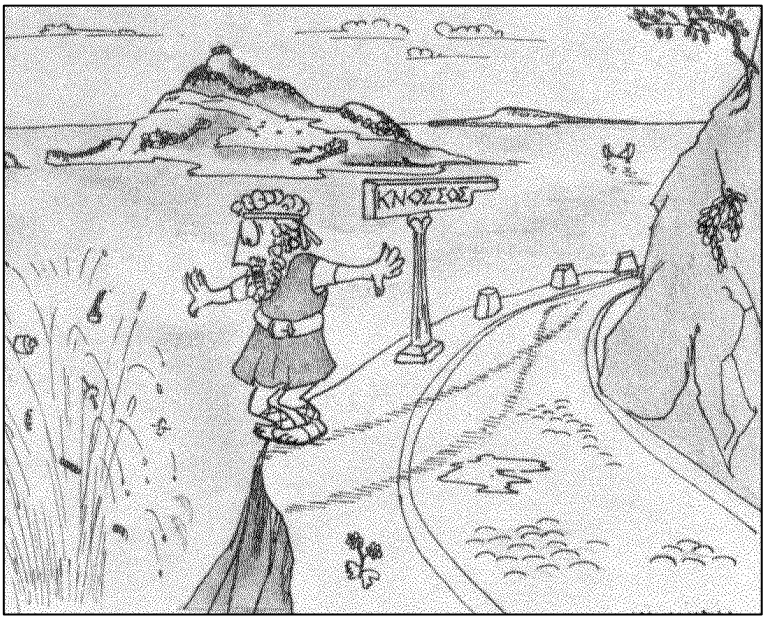

Fig. 2: The fall of ICARUS (Der Sturz des IKAROS). Illustration from the first Latin papyrus-cover edition of the complete works of HERODOTUS (Roma: Pressa Academica, 428 Ab Urbe Condita).

Essentially the difficulty we are facing is that we have not yet been able to decipher the Minoan script called Linear C, the dialect habitually used by the Cretan police force in those days. I suspect that this may be simply because Linear C will ultimately turn out to be non-linear after all. Moreover, we do not know whether these accident records are pertinent from the Human Factors point of view. If the police in those days held the same opinion with respect to the need for accurate accident statistics as they frequently seem to hold in

modern times, I have little hope we will ever know what precisely happened to poor Stephen DAEDALUS and his IV, the ICARUS.

The big Graeco-Roman IV step forward

Coming down to historical times, we observe that the IV in classical Greece and Rome did primarily serve as an instrument of classification and achievement testing, rather than for straightforward experimental work. In fact IV's were used to discriminate between good and bad drivers, charioteers as the were called in those days.

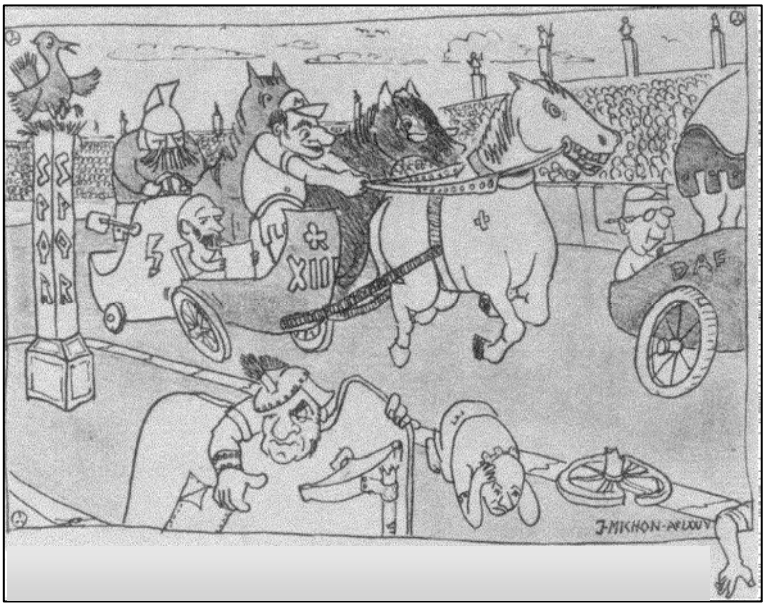

Fig. 3: Roman Style IV-experiments. Copy of mural originally ascribed to Julius VOLVO (210 AD). The centre charioteer is said to portray Ben HURRY.
Recently the authenticity of this painting has been questioned by Dr. Rudolf G. MORTIMER (courtesy Dott. Sp. BOLOGNESE, Pizza).

Charioteer training programs usually involved several observation tests, in which the overtaking manoeuvre was one of the most popular. It was also one of the most dangerous, understandably so since the Defensive Charioteering Course had not yet been invented.
Most instrumented vehicles used in this context were characterized by their lack of some of what we nowadays consider a regular, standard IV-outfit. In other words, the abundance of useless contraptions which we implement in our modern IV's was practically unknown at the time. It was unheard of. It was even frowned upon as being the pinnacle of decadence! And Romans knew indeed everything about decadence, especially in the IVth century.

This *myopia* (Eng.: short-sightedness) must have been inflicted upon society in part by their deplorable technological acumen. Sophisticated recording facilities were in short supply: shockproof scribes were few and far apart. Looking at their records it is indeed evident that scribes did not function well on the bad, bumpy roads of the day—not even the sturdy ones who were imported from mainland Greece. Practically without exception scribes were severely accident-prone and, to make things even worse they were especially prone to display the worst symptoms of motion sickness, frequently spoiling the tablets on which they were scribbling their observations.

Because of all this simplicity was the rule for Romans. Not surprisingly road-side observation was preferred over in-vehicle measurements, all this mainly in order to collect data regarding charioteer behaviour during the frequent, often hilarious breakdowns in the steering system, the wheels, or the suspension of their IV's. The Circus Maximus in Rome was the principal venue for these controlled experiments or 'stock chariot games' as they were called by the citizens of Rome, who loved to watch them.

Maybe we can learn something from the Graeco-Roman example. Maybe we should develop valid and reliable indices of driver behaviour that allow us to adequately measure what happens when we disconnect the brake pedal of our IV's or when we let the steering wheel suddenly and unexpectedly come loose. At least the savings in costly sensors would be considerable.

The IV in Eastern Cultures

The great cultures of the East in antiquity developed a taste for IVs of high complexity and they actually realized build some of their designs. Chinese scrolls, Japanese woodcuts, and Indian miniatures show numerous examples of carts, elephants, taxi-bicycles and wagons equipped with extremely elaborate instrumentation. For religious, or at least metaphysical reasons, these IV's were designed in strict adherence to local cosmogonical principles. Consequently they just did not work.

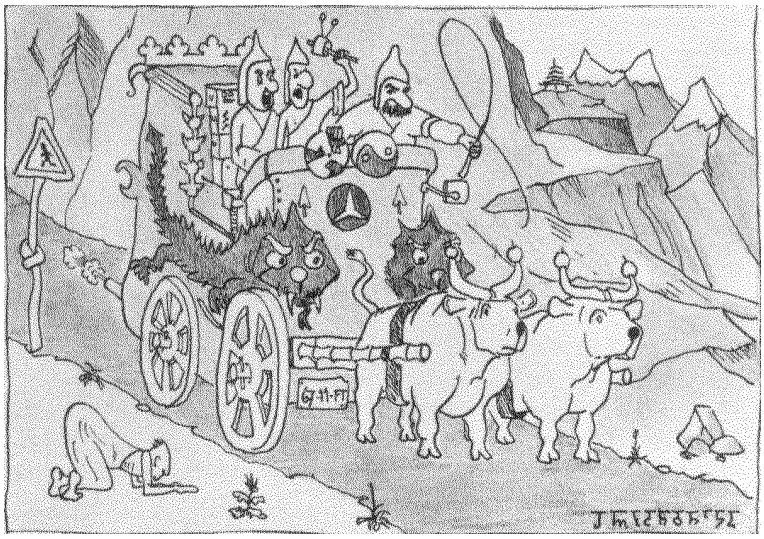

Fig. 4: Metaphysical IV. This miniature from a 16th century Nepalese breviary shows so-called "ritual oxcart". (Courtesy Kathmandu Munic. Mus.; Cat. 2317/GL)

This was hidden from the main sponsor of traffic research, the Ahura Mazda company, and so for a long time we see continuing efforts to develop reliable indices for measuring good and bad traffic behaviour, that were doomed to fail right from the outset. These efforts were so utterly unsuccessful

overall, that finally Ahura Mazda[1] withdrew his support and retired. This was considered extremely unfortunate by the scientific community and it led to the familiar Buddhist concept of bad Karma. This sad history warns us for the consequences of developing extremely elaborate IV's for purely ritual purposes, the costs of which stand in no relation to their expected returns.

The first to realize the complete lack of functionality in the eastern approach were, not entirely unexpectedly the Chinese. As a concomitant of their early concern for overpopulation they gave up the experimental approach and lapsed back into personality and assessment testing, things they understood better at least in these times than the generalities of their Cultural Revolution. Their tests, known as koans, contained such irrelevant questions as: how long is the Great Wall? To appreciate this, one should realize that in those days the Great Wall became longer almost every day, and that it might therefore take a novice many years of contemplation before hitting upon a correct answer. Hence, it will come as no surprise that the validity of these tests was essentially zero. And so the Chinese finally embraced Zen—indeed an early example of the flight from the laboratory.

A different fate befell the complex IV in the primitive Beepee culture of the Mobil Desert that we know through their shell mosaics. The fragments that have been discovered show highly contorted structures, but we do not know if the Beepee designed their vehicles that way. If so, then it is not surprising this tribe became extinct. However, it may be that the tooth of time has affected the original mosaics, since the Beepee used only hydrated desert sand to cement their shell patterns.

Looking back at these early attempts we are struck by the sincerity and, at the same time, the unfathomable complexity of all these efforts. That in the end so little came of them may be ascribed not just to the intrinsic weakness of theory and method, but also to the lack of international coordination: just

[1] Identifications like that of the god Ahura Mazda with Mazda Motor Company are common in history. A similar deification of Ford Motor Company, was described by Aldous HUXLEY in his novel Brave New World. In his utopia Our Ford has become identified with Our Lord. The reverse process can also be observed, as in the case of the legendary US Army Chief of Staff General MOTORS who gave his name to a well-known vehicle manufacturing firm.

imagine how they might have fared had there been a Committee on the Challenges of Ancient Society, an International Driving Behaviour Research Association (IDBRA), a Kåre RUMAR, or a Conference of Eastern Ministers of Transport (CEMT).

The IV in modern Europe

The IV has found its final form in Modern Europe. With the Renaissance its development gains momentum. We have, in particular, several designs by an engineering consultant to the government of Milan and some other cities in Italy, a Leonardo DA VINCI. Since he was considered a pathological inventor his contemporaries did not pay enough attention, and since he had not enough money himself, nor of his advanced IV's was ever realized.

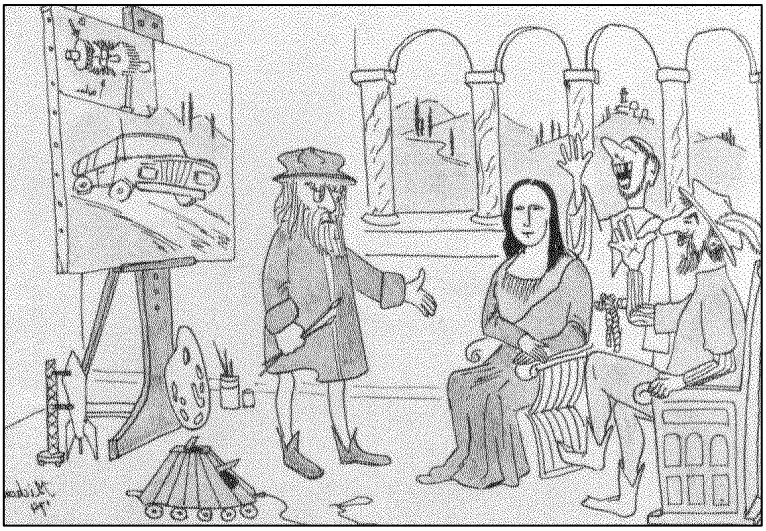

Fig. 5: Contemporary sketch showing Leonardo DA VINCI trying to sell the idea of one of his inventions to the Prince of Milan.

In the 17th and 18th century people did not have instrumented vehicles. That is why this period has become known as the age of Enlightenment and Reason. Romanticism in the early 19th century did not fancy IV's either, but for entirely different reasons: people did care for the environment and also were afraid for the consequences of studying traffic safety experimentally. In view of the extremely high rate of suicide in this period of 'Sturm und Drang', experiments would easily lead to casualties and unpleasant consequences for the researcher, such as lawsuit by angry widows.

Fig. 6: "Klavierstunde" (Hour at the Pianoford). This beautiful engraving by the inventor of graphology, Jean-Hippolyte MICHON, shows one of the great masters of the pianoford: Romeo Alfa KARMAN, surrounded by his friends during an experiment (courtesy of owner of strictly private collection). Reclining figure in foreground is the first female president of the Alliance française pour l'Avancement de l'Insécurité Routière of 1872, Mlle Pêche MELBA.

This factor plus the legal practice of the day, analysed so painstakingly by George SAND, Honoré BALZAC, Émile ZOLA and other artists, make it perfectly understandable why so many competent people did not want to work

with IV's, but turned to the pianoford instead: piano's have a very low mortality rate. At worst the performer's fingers may get crushed under the hood.

Both in the design of and the experiments performed with this instrument the 19th century has no parallel. But, while the pianoford gained adulthood, and gave many piano teachers an excuse for prescribing fingering exercises, IV remained the ugly duckling of science. The change came only at the turn of the century: the discovery of the automobile by Mercedes BENZ and the invention of experimental psychology by Wilhelm WUNDT are the milestones of this development.

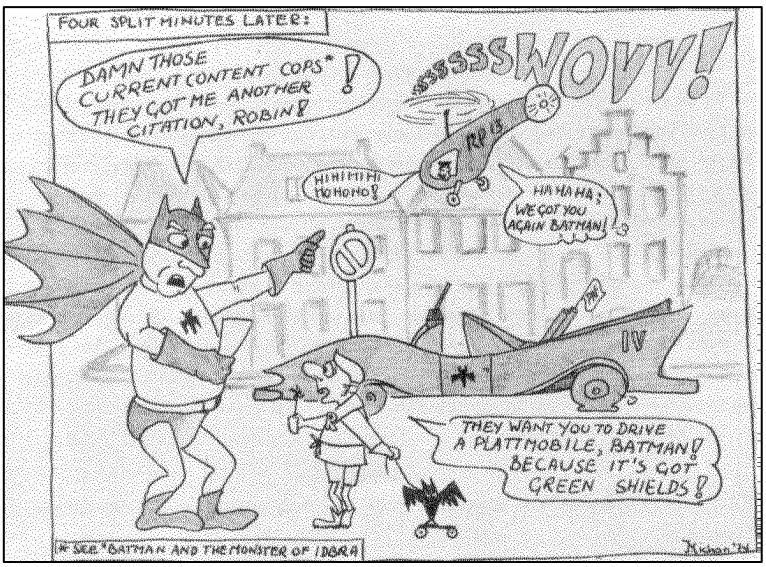

Fig. 7: Modern mythical IV (reproduced by courtesy of Bad Productions, Inc.)

Even then progress was still slow in coming. Hugo MÜNSTERBERG, a leading experimental psychologist was the first to employ an IV in a modern scientific context. He wanted to study reaction processes in vehicle operators. Clearly he considered the early automobile still too unreliable, and so he set out to equip a streetcar with his 'Reaktionsgeräte' instead. Surprisingly he did not entertain

similar suspicions towards his equipment—something he certainly ought to have done. Be this as it is, at least we have here a genuine effort to obtain a set of relevant data, while using all of the paraphernalia of the IV-paradigm that were available at the time.

There is only one cloud in this otherwise bright sky. What led the Chinese to abandon the IV technique and made them turn to vague holistic theories of road traffic[2] may happen once more. Again we see the emergence of elaborate ornamental but essentially mystical IV's such as the Batmobile (not to be confused with the Plattmobile that set the example for the contemporary IV), or the vehicles used by James BOND. And we may all too easily be talked into buying such vehicles to impress newspaper reporters or prospective sponsors, or to secure the success of the yearly 'open house' of our laboratories.

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Believe it or not, at that moment my flight was called and I proceeded to the Exit through Gate 9...

Conclusion

The outline of history of the IV as I sketched it offers a number of points that are well worth taking into account, and I feel that the discussions in the present workshop ought to bring out our feelings and insights about these points. The first is the problem of validity, the second relates to the question of general vs. special purpose IV's, the third problem is that of cost effectiveness, and finally there is the question of how we can achieve a certain level of common practice.

(a) Validity

While doing our IV research, either on the road or on a special track, we fear but hardly ever admit publicly that our experimental results may not be valid, because our subjects know they are being observed. In fact observing

[2] E.g., the theory of the Eightfold Path, or that of Mahayana (literally meaning 'Greater Ox-cart').

is hardly the correct expression when the subject is wearing six pairs of electrodes, a three pound helmet and a mouth clamp, while a red light is shining in her eyes, and while she is pressing pedals in response to 590 Hz tones presented in a random order to either ear. Yet in most cases we tend to believe that after a fairly brief period of, say, 30 minutes our subjects loose their apprehensiveness and subsequently will behave in a fairly natural way. This symposium ought to reach an explicit understanding as to whether this assumption is mistaken or not.

In the same vein we should achieve some clarity about the usefulness of certain variables. We can safely say that at least some of the variables that we have measured in the recent past are either irrelevant or defective in the light of modern structural or dynamic models of human behaviour. Perhaps the only reason for measuring these variables is the fact that we are able to measure them. Also the information derived from these variables may be slightly or highly unreliable. Thus for example, the time honoured 'steering wheel' reversal has outlived its useful purpose as a variable in its own independent right, and it should be replaced by more subtle units related to the steering spectrum, or at least be incorporated into more comprehensive measures of driving behaviour.

(b) General or special purpose

The question of general vs. special purpose IV's is largely a matter of taste. The availability of multivariate techniques for data reduction has shifted research in the direction of greater complexity, and this makes the development of special purpose vehicles less adequate for most of us. Only if funds are limited, or damage to car or equipment is likely, the special purpose IV should be given preference over the general purpose vehicle.

(c) Cost-effectiveness

The previous points will only be worth considering when we can convincingly argue that IV's is cost-effective. Can we? This is probably one of the most difficult questions this workshop can ask itself.

A quick calculation can bring out the costs quite easily. Let us assume that we can keep an IV in good working order for 6 years. Further, that operating it in a team requires one person-year every year, during which it will travel some 10 000 km. This will set the yearly operating cost—in the

Netherlands—at approximately Dfl 100 000 including overhead. The cost of vehicle plus equipment will be of the order of f 100 000, and construction will take another Dfl 100 000 including overhead. At a 10 percent interest rate per year this will amount to Dfl 53 000 depreciation per year. The annual operational costs therefore will be of the order Dfl 150 000. The question is simply whether the total returns, after deduction of the other costs related to the research involving the IV will be sufficient to cover this sum [Author's note added in 2002: 1 Dfl = € 0.454].

So, to repeat the question: Can we come to a reliable estimate about the cost-effectiveness of our IV-fleet? This question is, maybe, more important than we are used to as scientists. In the next 2 or 3 years many countries are likely to introduce much stricter procedures of science management very soon. If we can reach a satisfactory common procedure or argumentation we will have optimally anticipated an otherwise possible unpleasant encounter with our patrons and customers.

(d) Common Practice

Finally I feel that the time is there to reach some decisions about common practices, with regards to the previous points as well as to some other points more closely related to the substance of our research. In fact this has been one major objective of the organizers of this workshop. The exchange of information, the in-depth consideration of the basic problems I mentioned— and others as well—should preferably be complemented by the establishment of a data base for methods and programmes, but also for certain bodies of relevant, 'rock bottom' data. The actions of the driver in various manoeuvres, their visual behaviour, such as eye movement patterns under different circumstances, may be deposited in a data base for common reference and use if the formats for collection and processing of the data are standardized. Thus we would finally have learned to avoid the errors and mistakes of the past and to make some real progress towards an integrated and truly international, comparative view of the road user.

Soesterberg, The Netherlands
15 October 1973