

spread to the community. A few years ago the headline in a quality paper read: “Computer disasters have cost billions” [1]. More recently the software crisis has given way to a ‘systems crisis’: cause for even more general concern. Last year, a whole television series was devoted to major disasters in complex systems, and by no means were all attributable to the computer. The source of the trouble is a phenomenon identified in the famous book of T.S. Kuhn [2] as ‘scientific crisis’. A scientific crisis exists when even the best professional practices persistently prove inadequate for solving some intrinsically important problems.

Kuhn shows that the way out of a scientific crisis is ‘scientific revolution’: a fundamentally new approach, calling for the definition of new concepts, and for the development of new methods and tools. In Kuhn’s sense, such a comprehensive conceptual and methodological framework constitutes a ‘*paradigm*’ [3]. At the heart of a paradigm is an overall concept accepted by most people in a community because of its effectiveness in solving important problems and explaining ideas or observations. A new scientific paradigm:

- provides scientific foundations for tackling problems that previously defied solution,
- is progressive: it provides a new, more powerful platform for problem solving, while also preserving accumulated knowledge and experience, and harnessing existing scientific disciplines.

The numerous and varied unsuccessful projects and unsolved problems have some important characteristics in common. They involve complicated adverse situations whose resolution calls for the coordinated effort of experts from different fields. The situations are multifaceted, and the solutions are made up of many intricately interrelated parts. The generic term for such an assembly is ‘system’. The current day scientific crisis calls for a *systems paradigm*.

1.2 A ‘systems paradigm’

As all scientific paradigms, a systems paradigm is not just a single concept but a comprehensive collection of mutually complementary ideas, some already well established, others still under development. One may list the key features:

- A systems paradigm must build on the *established disciplines* of science, computing, engineering and management.
- A systems paradigm must be widely *accessible*: comprehensible by any interested person, including members of the Board of the organizations involved with the project, senior management and technical staff, subcontractors and specialist experts, personnel, customers, the public, local politicians and members of Government. For this, the concepts of the paradigm must be clearly defined, the *definitions* must be consistent, and must form a coherent structure. It is helpful if the paradigm incorporates some kind of formal *notation* to aid comprehension and avoid ambiguity.
- The systems paradigm must utilize the advanced principles of *quality*. According to these, a project must not only satisfy the client – the paying

customer –, but must respect the environment and have regard for all interested parties as well as the needs of the wider community [4].

- Those responsible for the project are *accountable*. The systems paradigm must facilitate accountability: use appropriate *models* and *methods* for specification, unambiguous representation, design, implementation and project management. It must assist rigorous analysis and assure traceability, thus facilitating the delivery of a solution in due time and within budget. For this, the models must be *timed* and characterized by *measures* which can be checked objectively. The models must also aid the management of *risk*, the formulation of informed *decisions* and the articulation of *value judgements*.
- Problems might arise from any application domain and may demand any mixture of expertise. This means that the systems paradigm must be *general*: common to the largest possible class of problems great and small, based on the philosophy of systems theory, and must build on 'system' as a universal notion. By these means, the systems paradigm must provide a '*systems world outlook*', embracing the 'hard' problems of classical science and engineering, the 'softer' problems of computing, communication and management, some of the associated 'soft' problems of cognition and comprehension, and any combination of these.

1.3 Who needs a systems paradigm?

A systems paradigm is to the advantage of all. To illustrate this, let us use a simple analogy.

Imagine that you live in Country A where all the doctors are highly skilled specialists. Should you have some ailment, it is up to you as the patient to decide which specialist to see. You have a persistent headache. Whom should you consult: the ophthalmologist? the ear-nose-and-throat specialist? the neurologist? the psychiatrist? At the end of a sequence of four consultations you will have spent a great deal of time and money, and may still have the headache. What to do now?

In the neighbouring Country B, healthcare is organized around General Practitioners: family doctors trained to focus on the whole person rather than on specific organs of the body. GPs know the patient, are experts in identifying the likely seat of the trouble, can call upon a network of specialists, and are skilled to coordinate specialist contributions. While listening to the patient with the headache, the GP observes that the man has poor teeth and his neck has limited mobility. Most likely he suffers from arthritis of the spine, and may also have a latent abscess on one of his teeth. Since these are also possible causes of headache, the GP might direct the patient to a rheumatologist or a dentist, just as much as to an ophthalmologist, ear-nose-and-throat specialist, neurologist or psychiatrist. Should the ailment require the simultaneous attention of two or more specialists, care of the patient stays with the GP throughout.