

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.

The healthcare system of Country B is clearly superior. It dispenses medicine cheaply and more reliably than that of Country A, and it may even save lives. This is no reflection on the expertise of the specialists of Country A: the specialists of the two countries may be equally skilled and well qualified. The contribution of the GP benefits all concerned. The patient gains a fast track to the remedy. The public gains a cheaper and better health service. There are fewer grounds for dissatisfaction, and the medical profession gains better appreciation.

The skills of the GP are not more valuable than those of the specialists: they are simply different in *kind*. Using Kuhn's terminology [¹], we might say that the GP works in a different *paradigm* from that of the specialists, dispensing patient-centred rather than specialist medicine, being expert in developing the systems view rather than dealing with the problem detail by detail, and being skilled at interacting with the patient – the 'owner' of the problem – as well as with the full array of specialists – the ultimate custodians of the solution.

1.4 Role of the specialist and of the systems professional

After the polymaths of early science, in the nineteenth and twentieth centuries the professions of science and engineering evolved into distinct areas of *specialization*. Specialists are highly respected, each specialist having been educated and skilled to handle problems that lie within the accumulated wisdom of his/her particular field of expertise. Each discipline, and within this each specialist branch, has developed its own body of knowledge, theories, methods and codes of practice, its own tools, its language and symbolism, its own outlook, and its proud traditions. Applying the methods and tools of the discipline, the specialist handles the problems of a well defined field, and where the problem challenges accumulated wisdom, develops the specialist methodology, enhancing or perfecting the established framework of the discipline. Specialization in science and engineering has inspired research and fuelled progress. Only specialization could have given rise to today's powerful technologies.

As part of their code of practice, specialists adhere to strict professional ethics. Professionals are keenly aware of the difference between *expertise* and *awareness*, between *knowing* something and merely knowing *about* something. Scorning amateurism and unwilling to dabble in matters beyond their own field of expertise, where the problem is outside the established professional framework, the specialist declines to deal with it. Driven by regard to such professional ethics, the specialist focuses on the methods of *solution* offered by the discipline, rather than on the *problem*.

The adverse side of this commendably high-minded approach is that specialization carries its own limitations. By definition, the scope of each specialist field is strictly circumscribed, whereas practical problems are seldom well articulated, and rarely fall neatly into one or another field of specialization. A complex project engages professionals of different specialist disciplines who must *communicate* with their clients and with each other, and *cooperate* effectively in search of the solution. The systems crisis offers plenty of evidence that established educational curricula and professional development experience do not prepare specialist experts adequately for the challenges of interdisciplinary and multidisciplinary cooperation in complex