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

projects [5]. Specialists engaged in complex projects need a fair measure of understanding of a *systems paradigm.*

The current state of development of science and engineering resembles the case of Country A of our healthcare analogy. The professions, among them the sciences, engineering, management and computing, are made up of highly trained, experienced and valued specialists. These include Information Technology experts, structural, electronic, mechanical, chemical, telecommunications engineers, material scientists, software engineers, quality consultants, financial analysts, industrial psychologists, bankers, lawyers, project management specialists, etc., – all devoting themselves to solving problems of significance. Nevertheless, the catalogue of disasters and failures is growing all the time. When specifying projects of importance, when managing the project – planning, organizing, implementing the solution and leading the project team –, where were the systems professionals: the General Practitioners of science and engineering? Which profession should have supplied the expert listener to the client's problem, the skilled person who should have developed a secure overview of the project, specified the tasks and coordinated the contributions of the various specialists, overseen progress, controlled installation, and assured safe adoption of the new system into service?

Employers are now aware of the need for *systems professionals.* Many jobs are advertised, seeking systems engineers, systems analysis, systems scientist, and the new quality standard advocates a 'system approach to management' [4]. However, at present, there is no 'systems profession': no professional institution, no dedicated courses of instruction. To fill the vacuum, a growing number of universities offer 'interdisciplinary' courses, consisting of a collection of loosely linked topics from two or more branches of engineering, computing and science. Where the need to interrelate the elements of the course is recognized, management topics are introduced, with the hope that these might provide the necessary 'integration' of the various specialist parts of the course. Some of these courses attract high calibre students: young people starting out in higher education, as well as practicing professionals whose work experience makes them realize the need of a new kind of outlook, knowledge and skill. The commitment and personal qualities of the students on these courses compensate, to some extent, for the deficiencies of the curriculum.

Consider the alternative: the pattern akin to Country B of our medical analogy, including in the picture the systems professional, the parallel in science and engineering of the GP in medicine. Just as the GP in the medical world does not invalidate the contribution of the specialist, the system professional would not replace experts in computing, engineering, management, or any other specialist area. Instead, the system professional would operate from a problem-centred 'systems discipline' which aids the formulation of the problem, and integrates existing domains of specialist knowledge in the interest of obtaining a high quality solution quickly and cost effectively. To gain insight into the needs of the client and of the wider community, the systems professional would liaise with the 'owner' of the problem and with experts of the *application domain* – the accountant, the social worker, the local government administrator, the industrialist, etc. The language of communication would be simple enough for all to understand, and yet precise enough to articulate demands unambiguously. Using the same language, the systems professional would then map the client's demands into specifications, and create a framework for the over-all solution, defining the contributions of specialist experts from the various fields of the *solution domain*, among them the specialists

of computing, communications, engineering and management. The framework – comprehensible to the client, the specialists, and even to members of the interested public – would guide the management of the project: its planning, organization and control, the acquisition and development of human and material resources, the oversight of implementation, the management of risk, the assurance of quality.

Such is the approach needed for specifying, procuring, developing, operating and maintaining complex systems of assured quality. It is also the foundation of a *systems profession.*

1.5 Systems for all!

Systems matter not only to the problem solver and the specialist, but also to the whole constituency of any major project:

- the *client* who owns the problem, originates the project, provides the resources, will be the owner of the system, and hence stands to benefit from the success of the undertaking,
- the *systems professional* who cooperates with the client in defining the problem, is in charge of the over-all solution, and coordinates the contribution of the specialist experts,
- the *specialist experts* and *subcontractors* who cooperate in supplying the detailed skills and implement all components of the solution,
- the individuals engaged in the project: the *employees* of the customer who must use and operate the emerging results and whose working life will be changed, of the suppliers who participate in the project, and of the operators and maintainers who will look after the solution to assure its long life in useful service,
- the *'end users':* the people for whom the client's organization provides goods and services, whose indulgence might be requested while work is in progress to change over from the old to the new, and who must be convinced that the new is worthwhile,
- the *informed public:* people who seek insight into the world around them, are willing to invest effort to gain a measure of understanding of issues, and deliberately contribute to the formation of public opinion,
- the *public at large:* the man on the Clapham omnibus, people whose environment might change as a consequence of the new development, and who stand to benefit indirectly from the success of the projects, and whose taxes will be used ultimately to pay for failure or disaster,
- local or national *government* whose task is to guard the interests of the public and see to it that resources are effectively deployed,
- the *academics* in university departments who endeavour to educate the systems professional, and currently offer specialist or interdisciplinary education,
- the *students* on systems courses and on specialist courses.