

EXPERIENCES OF NDT TECHNOLOGY TRANSFER AT HARWELL

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I very much appreciate the opportunity of being able to come over to this meeting. I was a bit surprised when Don Thompson phoned me up and said, "Come and talk about technology transfer to a meeting on quantitative NDT," but having sat attentively during the past day and a half here, I think I can now appreciate the need for urgent discussion and debate on the subject.

Now, when you are scheduled to speak on the last day like this, you usually find that you have got to completely rewrite your talk the evening before to fit in with what's been said before, and this is certainly the case in my situation. Having listened to some of those who talked last evening, I thought indeed that it might be as well to go right back to the beginning and tell you a little bit about how the whole project at Harwell started.

I should perhaps say at the outset that I have interpreted technology transfer to mean: How does one bridge the gap between, on the one hand, the high technology end of the NDT spectrum that we have been discussing at this Conference (and most of which I gather is funded on DoD contracts for advanced defense programmes) and, on the other hand, the large spectrum of engineering and manufacturing industries where the general quality of products could undoubtedly be improved, given the efficient transfer and the effective application of this knowledge and know-how?

Our experience at Harwell is, I am sure, relevant here, although the detailed pattern of evolution and development of the technology transfer process obviously relates in our case to the particular requirements of the UK scene.

The formal motivation for diversification from nuclear to non-nuclear activity within the UKAEA arose from Parliamentary legislation embodied in the Science and Technology Act dated 23rd March, 1965. This Act resulted in the setting up of a number of non-nuclear Projects (the majority at Harwell) based on areas of scientific expertise which were clearly translatable to technological needs in Industry. This statement itself of course embodies one of the prime requirements for technology transfer to be successful, since without the industrial 'pull' based on current need, no amount of hard 'pushing' by the scientist is likely to have any noticeable effect - except perhaps a hardening of the resistance!

Perhaps not surprisingly (bearing in mind the 'clearly translatable' criterion), one of the two Projects initially set up in this way at Harwell was the NDT Centre. Since that date a wide range of industrially orientated Projects has been established (Fig. 1) and these now absorb about 400 UKAEA professional staff (involving incidentally approximately 1/3 of the current Harwell scientific complement) and have a total operating expenditure of around £10M. At the present time the NDT Centre

is the largest of these industrial projects, constituting about 10% of the total effort deployed on Authority non-nuclear work.

- NDT Centre
- Ceramics Centre
- High Temperature Chemical Technology
- Heat Transfer & Fluid Flow Service
- Industrial Electro-Technology
- Tribology
- Systems Design & Computer Optimisation
- Systems Reliability Service
- Laser Applications
- Carbon Fibres
- Advanced Metal Forming
- Macro-Molecular Separation Processes
- Sodium Sulphur Batteries
- Analytical R & D Unit
- Physico-Chemical Measurements Unit
- Separation Processes
- Reverse Osmosis
- Computer Optimisation

(In descending order of complement (1975/76) from 40 to 5)

Figure 1. Projects forming Harwell's industrial programme.

Recruitment into these projects has been achieved almost entirely by internal movements of staff to match the overall changes in programme priorities. Staff mobility has been aided by a matrix management structure at Harwell based on the co-existence of Divisions which control staff and careers, and Projects which manage and operate the inter-divisional programmes (Fig. 2).

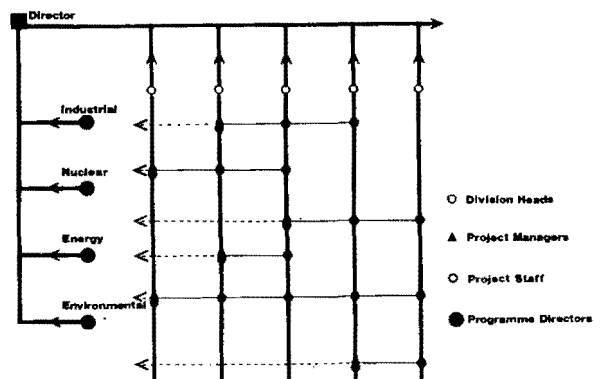


Figure 2. The Matrix management structure at Harwell.

So much for motivation, statistics and management. Let us now look at the objectives of the NDT Centre and the operation that has been set up to achieve them. The four objectives originally defined (Fig. 3) are still the basis on which the programme is built up and the criteria on which its success, or otherwise, is judged. The operating pattern that has evolved to achieve these objectives revolves around the central funding role of the Department of Industry's Mechanical Engineering and Machine Tools Requirements Board (MEMTRB) to which the Centre reports.

- (a) to offer advisory, consultancy and information services to industry as a whole
- (b) to carry out and encourage applied research and development so as to improve and extend NDT techniques within industry
- (c) to undertake investigations into problems of a more general nature and to examine techniques which can be applied to a wide range of industries
- (d) to carry out research and development programmes in co-operation with industry aimed at solving specific industrial problems

Figure 3. Objectives of the Harwell NDT Centre.

Over the years the Centre's programme has shown a healthy expansion as seen in Fig. 4 (although the rate of expansion, using 'historical' prices as I have done, gives a somewhat exaggerated picture, in view of the fortunes - or misfortunes - of the UK economy in recent years!). In addition to the overall expansion there has also been a significant increase in the amount of work carried out under contract compared with that funded directly from the Department of Industry itself (65% at present) and this is perhaps the best measure of any of the success of the technology transfer process.

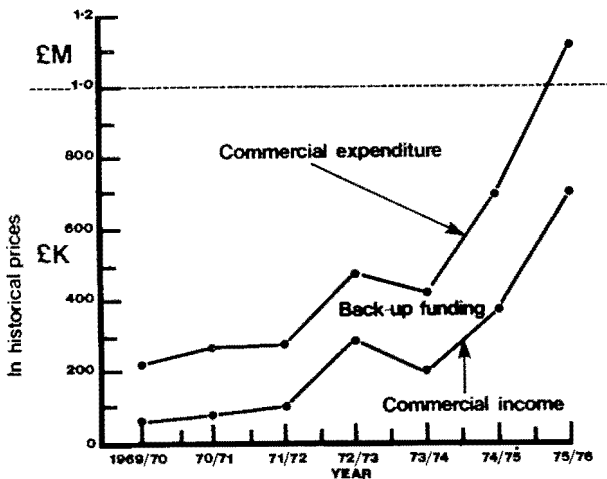


Figure 4. The growth in activity of the Harwell NDT Centre.

Another factor that has served to provide some additional credibility and realism to our activity was the setting up at the outset by Harwell of an independent Advisory Committee for the NDT Centre, with its members drawn largely from industry. This has provided us with a helpful two-way communication: problems and ideas being fed in by members from their own industrial experience and members acting in an ambassadorial role, disseminating information about our activities and programmes to their own circles of industrial contacts.

The Centre, with its primary objective of assisting UK manufacturing industry, has tried to build up both formal and personal links with all of the various organizations contributing to the 'NDT scene' and this perhaps, as much as anything, has engendered confidence in the Centre, its staff and its programmes. It has also allowed and encouraged staff to play an active and constructive role in a wide range of associated activity and, in so doing, this has helped to improve our commercial interaction and strengthen our business connections with industry. Creating active interaction and identifying a complementary role is indeed an essential requisite in ensuring the success of any technology transfer exercise.

The 'NDT Industry' in the UK is by and large made up of a large number of specialist instrument firms, with somewhat limited development potential, plus a broad spread of NDT service firms with staff complements ranging all the way from 200-300 down to 2-3. Expenditure on NDT in the UK was estimated to lie somewhere between £30M and £45M when two surveys were carried out in 1972. This expenditure included the output of the NDT Industry (services and instrumentation firms) and additional in-house spend on NDT within 'user' firms. The total NDT work-force in the UK was estimated then to be between 8000 and 10,000 persons.

One of the constraints put on the NDT Centre from the outset was that it should not 'compete' with the UK NDT Industry in the provision of NDT services or in the manufacture of instrumentation. This pattern of the NDT industry, coupled with this constraint, has meant that apart from our primary role in supplying R & D support (as our terms of reference demand) we have augmented this with 'specialist services', and the provision and introduction of 'prototype' systems in situations where commercially available instruments are unsuitable or in some way inadequate. This seems to have worked satisfactorily and the encouraging links and cross-links shown in Fig. 5 now exist. Another pointer to our success in technology transfer in NDT we feel lies in this conscious attempt over the years to provide a 'total NDT capacity' with abilities and skills available to industry spanning consultancy, applications, systems design, technique evaluation and research. Indeed we think it goes further and we are slowly moving towards the broader umbrella of 'quality technology' which links the 'nuts and bolts' of NDT technology to an understanding of materials properties on the one hand and an appreciation of defect significance and fracture modelling on the other.

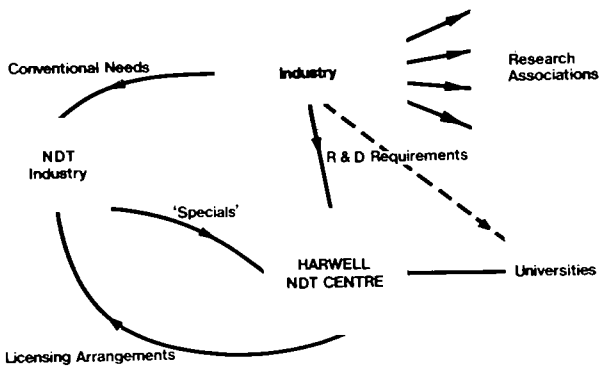


Figure 5. Cross-links between Harwell and industry.

I am conscious that in my talk so far there has been a conspicuous absence of any mention of interaction with NDT in MOD establishments. The situation is that this area of NDT development has, by policy decision, tended to limit itself to its own in-house requirements and not 'spill over' in any significant way to support industrial requirements. Our own nuclear NDT support group within Harwell was of comparable size pre-1967, to these various in-house groups, and it was only the conscious political decision to diversify Harwell into industrial research (rather than any of the MOD establishments) that has led to the present situation.

Given comparable opportunity and encouragement, one or other of the MOD teams could undoubtedly have accepted the challenge and provided an adequate base for similar expansion to a national Centre. As it is we are now being called in from time-to-time to provide some support to the MOD establishments on a contract basis, although the volume of this activity is quite small (only about 2% by value of our total contracts last year). The only formal link to MOD at present is through membership of the Centre's Advisory Committee.

If we now look in more detail at the two parts of our programme, you will see that that part of our programme which is funded directly from MEMTRB is a useful spring-board for providing a scientific 'push' into new NDT fields and, at the same time, providing better scientific understanding of existing techniques (Fig. 6).

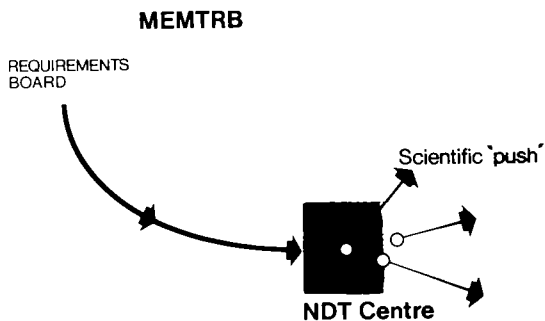


Figure 6. Interaction between the NDT Centre and the Dept. of Industry Requirements Board

Actually, this is by no means a forward push in a vacuum, and much of the progress is in fact provided 'catalytically' by diverting scientific progress in response to an anticipated inspection need as identified through the industrial communications framework in which we operate (Fig. 7).

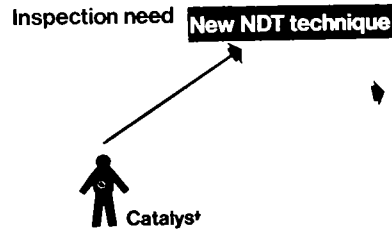


Figure 7. The catalytic function of the NDT Centre.

Our present underlying research programme built up in this way (Fig. 8) is strongly orientated to acoustic and ultrasonic techniques at the present time, but this we feel reflects current interests and requirements.

- Defect Size Assessment
- Ultrasonic Holography
- Sonic Vibration Studies
- Ultrasonic Transducers & Transducer Evaluation
- Acoustic Emission Studies
- Acoustic Impact Testing
- Polymeric Foil Transducers
- Infrared Techniques for Surface Inspection
- Optical Techniques in NDT
- Adhesive Bond Studies
- Concrete Testing
- Positron Annihilation
- High Definition Radiography
- Dynamic Radiography
- Image Analysis

Figure 8. Current underlying research programmes in NDT at Harwell.

The end product of these programmes is often 'hardware' and we are encouraged to develop licensing arrangements with UK firms in order to assist the industry and at the same time ensure the development of full market potential. High definition radiographic equipment developed under this programme has recently been licensed and ultrasonic defect sizing and laser interferometry are techniques where licenses for developed equipment are currently being negotiated. Positron annihilation studies aimed at fatigue monitoring is at a much earlier stage of development and evaluation.

In our contract work with industry we can identify two basic types of technology transfer:

- (a) We act in some of our contracts quite deliberately as a 'research jobbing shop' carrying out sponsored work, offering an applications service or providing hardware under contract to individual customers (Fig. 9). This we regard as true 'technology

transfer'. We have tight time and cost specifications to work to and the knowledge of the process to which it is to be applied really need only be minimal. To be successful at this work one requires adaptable staff willing to apply themselves single-mindedly to the solution of a customer's problem. Normally, the outcome is very specific and our contribution is really towards general industrial innovation by helping to improve a manufacturing process or the quality of a product. The direct and consequential benefits unfortunately are often not disclosed to us and attempts at wider exploitation are indeed often positively discouraged. In this category, hardware systems are designed and supplied to meet particular industrial problems. In this context I would say that our decision early-on to develop a modular range of NDT instrumentation in order to provide a flexible signal processing capability and a means to assemble systems speedily and efficiently, has proved very beneficial in the long run in helping us exploit our technology transfer capability.

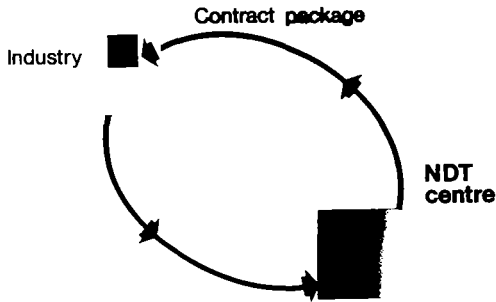


Figure 9. Research 'jobbing shop' activities for industry.

(b) In other contracts we play a much more collaborative role in helping industry develop a new inspection procedure, in many cases quite specifically from ideas which originate from within Harwell (Fig. 10). These contracts require the closest technical interaction with appropriate technical staff in the sponsoring organization. They also require that the NDT Centre staff themselves develop a very detailed knowledge of the problem and its context. This arguably is more 'technology innovation' than 'technology transfer' since our involvement tends to be with large high-technology organizations, rather than with the broad spread of small and medium-sized manufacturing industries. These contracts, because of their size and often somewhat less-urgent time scales, can be tackled more fundamentally and scientifically, and technology can

be pushed forward more aggressively and there is a greater chance of more 'fall out' and more opportunities in related fields or related industries where similar opportunities or problems may present themselves. Commercial sensitivity, however, varies a good deal in these contracts, depending very much on the exploitation potential that results from a technological 'breakthrough'.

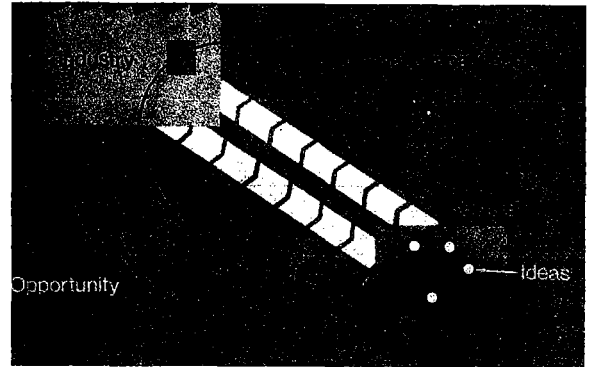


Figure 10. Collaborative innovation with industry.

In support of the programme as a whole, the Centre has been encouraged to set up and operate a computerized NDT information store. This now includes 20,000 documents. Access to this store is freely available to UK industrial enquirers as part of a general advisory service which is encouraged and sponsored by MEMTRB. Overseas organizations can have access to the literature through an annual subscription service.

In providing a strong technological thrust in many NDT techniques, we are continually conscious of the historical trend that consistently seems to send new NDT technology into orbit and produce an unstable 'oversell' situation (Fig. 11). This not only has a very damaging effect on the progress of the particular technique but also on the credibility of NDT as a whole.

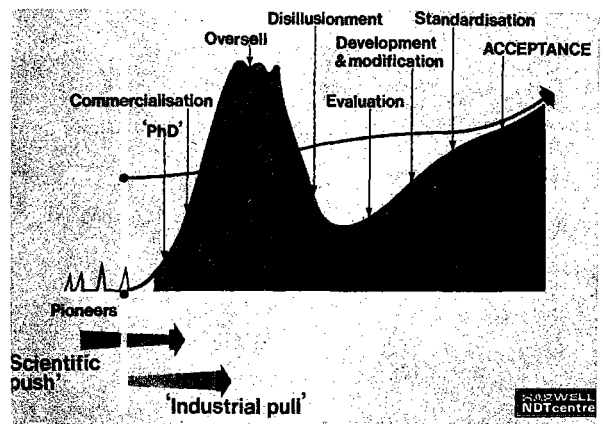


Figure 11. Progress towards innovation in NDT.

In summary, I would say that our experience at Harwell is, we believe, an encouraging example of what can be achieved in stimulating industry to improve its NDT technology by injecting science and transferring know-how - and even persuading it to pay for the privilege of doing so! Figure 12 lists the primary needs that we would identify as important in carrying through such an enterprise and which, with varying degrees of priority depending on the particular context, would be relevant to any similar exercise elsewhere.

In conclusion, I would simply say thank you and good luck with your own technology transfer activities.

- Good links into the NDT infrastructure
- Broad base of existing knowledge and experience
- Staff motivated to industrial interaction
- Close links between underlying and commercial programmes
- Links to a broader materials context
- Good scientific stimulation to generate new ideas
- Credibility with industry
(technical and commercial)
- Broad capability across the board
(advice information applications, systems & research)

Figure 12. Requirements of effective technology transfer in NDT.

DISCUSSION

DR. JOHN WALLACE (Westinghouse Research & Development): How far along is your positron work at Harwell?

DR. SHARPE: The positron work in the NDT area has been going for about a year and we haven't written any papers on the work yet. We are linking it with a fatigue program and hopefully in about three months' time we shall be able to publish some initial results.

DR. JOSEPH JOHN (IRT): I have a question about technology transfer. I guess technology transfer means different things to different people.

DR. SHARPE: Yes, it certainly does.

DR. JOHN: I specifically am asking about the attempt you are making, if any, to transfer the technology into private industry at a fairly early stage, to encourage the establishment of both engineering and scientific capability within the private industry. Is that being addressed at all?

DR. SHARPE: There are problems here and we are finding, in fact, that the easiest interaction is still with the larger organizations like British Rail, CEGB, Rolls Royce. Where you have got people in industry who speak the same language, it's much easier to get the technology transfer process moving. We are being encouraged by the Department of Industry to transfer technology to smaller engineering firms, but this is quite a problem and I don't think we have completely found the answer to this problem yet.

DR. JOHN: I have one more comment to that. One of the things that I have heard here the last couple of days talking to different people, is the general feeling of the lack of engineering and scientific capability in the smaller NDT companies, and therefore they are unable to tackle some of the NDT problems.

DR. SHARPE: Well, I certainly don't want to make derogatory comments about the NDT industry. I think it's an historical fact that these firms have developed largely by a process of fragmentation. At one time we did have one fairly large organization covering all of NDT in the UK. Now the industry has got rather split up. So, you do now have these rather small firms whose interest and capability is more in selling specific developed systems rather than in actual development work. We feel that we are helping that part of industry by doing some of this initial hardware development work and then getting it out into their companies for exploitation.

DR. DON THOMPSON (Science Center): I am in total agreement with your comment, Roy, about the necessity of linking materials science to NDT. I think I understood you to indicate that we were in contradiction on that.

DR. SHARPE: No. You showed a slide which identified quantitative NDT as a new science, and I am merely saying that I don't think of it in quite the same way. I think it's more properly an extension of some of the existing and established disciplines.

DR. THOMPSON: It has to extend in some way.

- DR. SHARPE: Yes, I accept that, and I'm sure we're not in any real disagreement. I think, however, that we already have a pre-existing framework in which it can expand.
- MR. PAT RYAN (DOT, Cambridge): Do you have any comment on the problem of getting acceptance of a new technique in industry? It depends ultimately on the industry buying new instrumentation or introducing new procedures, which is going to cost them money. They are reluctant to buy until somebody proves it works, and the only way you can prove it works is in industry, so you're in a chicken and egg situation.
- DR. SHARPE: Well, this is true. The way we involve ourselves with these firms is to build our interaction up fairly slowly. In other words, we often start with the equivalent of a small 1,000 dollar contract, mainly to see whether a technique has got any promise in that area, and then if it does, we attempt to go into the next stage. We will then probably do some evaluation work on typical samples and if it still looks promising, we work towards the development of a system. So we tend to go in slowly and build up confidence to see whether the idea works or not. I think this may be one way of solving this problem of getting acceptance. I should point out, of course, that there is a fundamental difference between your technology transfer problems and mine. You are, I gather, basically talking about transfer of technology into Department of Defense contractors, whereas everything that we're concerned with is getting it into industry at large and, obviously, the problems and solutions are somewhat different.
- DR. R. J. WASLEWSKI (National Science Foundation): To what extent, if any, when you identify a problem do you assign it to a group of people or split it into individual tasks managed overall?
- DR. SHARPE: Well, I can't really give you a categoric answer on this. It depends very much on the problem. For some of the large, what I have called industrial innovation research programmes, we do, in fact, bring together quite large teams. We do, for example, have one involvement on gas pipeline inspection, which I am afraid I can't talk to you about in detail, where we have physically brought together a large, multi-disciplinary team to tackle the problem. The method of attack depends really on the amount of scientific effort that is required to match the problem.
- DR. MOW: Thank you, Dr. Sharpe.