Defence Research and Development: Global Trends and Indian Perspective

Pankaj Jha

Profound changes in the international security environment were witnessed in the late 1980s and early 1990s. The Gulf War, the disintegration of the former Soviet Union and the restructuring of Eastern Europe forced a reexamination of defence policies, weapons procurement strategies and also the reframing of research and development agendas around the world.[1] For over forty years after World War II, the security perceptions of Western industrialised states were defined in terms of the bipolar East-West conflict, the Cold War. It was a system predicated upon a clearly identifiable adversary in the form of the Soviet Union, necessitating high and predictably incremental levels of expenditure on defence equipment and manpower.[2] This led to enhanced investments in pursuance of excellence in the field of science and technology, as well as intensified research in the defence sector. The words 'science' and 'technology' are usually combined into a single term in any discussion on global defence research, but there is an elementary difference between the two words.

This difference is by no means obvious, especially in many of the high technology areas which characterise much of the modern military research and development (R&D). Science and technology are such interrelated disciplines, involving such similar practices that they can be used as a single term, as exemplified in Latour's coinage "technoscience".[3] The two can be distinguished by simply defining technology as the "appliance of science". For example, John Garnett states: "The genesis of a weapon system… begins with a piece of theoretical science".[4] In the changed world situation, with the compulsion to

Dr **Pankaj Jha** is Associate Fellow, Institute for Defence Studies and Analyses, New Delhi.

Collaborative weapons development offers a mechanism for pooling defence research, development and production resources.

reduce defence budgets, a number of questions arise over a product's economic performance, as also a number of key questions concerning defence science and technology:

- What influence does the specifically military origins of funding have on the content of technological development?
- Do high levels of defence R&D represent a wasteful use of resources, or do defence technologies generate useful spin-offs?
- What is the potential for conversion of defence industries and what role should governments play in this process?
- With declining defence budgets, incentives may be created to seek cheaper military equipment and components from overseas sources. Under these circumstances, how will the country's economy be affected if aspects of advanced R&D cease to be conducted indigenously?[5]

Collaborative weapons development offers a mechanism for pooling defence research, development and production resources. What role is collaboration likely to play in the post-Cold War defence procurement process?[6] The purported military benefits of defence R&D include the maintenance of a domestic strategic capability to ensure independence and security of supply, together with the ability to develop equipment to meet the requirements of the armed forces. In the technology sphere, it is claimed that defence R&D ensures that a nation remains at the frontiers of technology, enabling it to achieve a comparative advantage over its rivals. There are other economic benefits, such as that defence R& D generates jobs, contributes to the balance of payments and provides a valuable source of new ideas and technology, which can be applied to civic uses. But achieving these benefits has certain costs. Defence R&D in most countries like the UK and the US has been criticised for their failure to achieve more spin-offs for the civil sector. The need is to have parallel lines of knowledge cultivation for meeting future defence requirements of the country. The thumb rule for starting any objective defence R& D is defence planning and charting out the requirements for the future.

Projections for Future

Defence planners also have to make assumptions about the future and about the likely developments in both technology and arms control agreements. Judgements are also required on a society's future willingness to spend more on defence rather than on, say, social welfare and on the future ability to pay for defence as reflected in the economy's growth rate and its international competitiveness. Defence cuts will have an impact on the size, structure, composition and performance of defence industries. Reduced spending on equipment will mean fewer new projects, shorter production runs for projects, more international collaboration and probably a greater willingness to buy from abroad, all of which will have their implications on defence R&D. The result would be smaller defence industries, with likely changes in their composition reflecting modified demands for air, land and sea equipment.

Being self-reliant in defence technology is no longer an option for many countries, owing to the escalating costs of the developing new weapon systems.

The compulsion for a decrease in the defence expenditure also raises two central issues for defence science and technology. Planners are confronted with the task of identifying potential conflict scenarios and formulating appropriate defence science and technology policy responses to meet future equipment requirements. Not only is the assessment of these requirements problematic, but there are other complicating factors. Under new budgetary regimes, Defence Ministries and armed forces face an increasingly difficult range of choices, such as: manpower versus equipment; quantity versus the quality of equipment; nuclear versus conventional forces: and, army versus naval versus air forces. Furthermore, being self-reliant in defence technology is no longer an option for many countries, owing to the escalating costs of the developing new weapon systems. Consequently, the issue that arises is the implications of technological dependence on overseas suppliers if the country seeks to offset defence cuts by opting for defence imports. Then arrives the need to assess the opportunities and costs associated with both international collaboration in the development and production of future defence systems, as also the role defence science and technology will play in regional confidence building, or even entering into R& D alliances.

In fact, the 1990/91 Gulf War was a landmark in the history of wars because of the extensive use of the state-of-the-art 'intelligent' weapon systems, which gave the winning side a technological superiority and operational advantage. The immediate lesson for all those participating, as well as observers of the conflict,

Shrinking of the defence budgets in most Western countries has reinforced the need to commercialise defence technologies, and has increased the value of defence R&D expenditures.

was clear: the 'emerging' or smart weapons technologies about which many had been writing and speculating over the previous decade had not merely arrived, but with adequate logistic support, preparation time and intelligence, they had also demonstrated that they could perform, and perform effectively, against designated targets.[7]

Role of Defence R&D

Defence R&D is a mission-oriented activity comprising basic and applied research for the development, testing and experimental production of new weapons and weapon systems. The term also covers improvement and modernisation of existing weapons.[8] In the prevalent 'quality or quantity' dilemma, it is R&D that improves the quality of armed forces' systems. Nowadays, advanced technologies, coupled with highly trained personnel, are perceived as the *sine qua non* of the military. While successfully deployed technologies have transformed modern armed forces, and changed the ways in which wars are fought and conflicts solved, their development is a lengthy, risky and expensive process. Some major weapon systems may take 10 to 20 years and billions of dollars.[9]

Several notable trends characterise defence R&D at the beginning of the 21st century. The first is that the revolution in military affairs (RMA) has evolved into "network-centric warfare" (NCW), as exemplified in the Iraq War. The use of integrative technologies allows armed forces to fight more effectively and flexibly, deploy smaller numbers of soldiers, thus, minimising casualties. The USA has placed NCW and integrative technologies at the centre of its military transformation plan and its allies have found it necessary to implement changes in its force structure, so as to maintain military interoperability. Second, the US war on terrorism post-September 11, 2001 attack has brought into its ambit engagement in military campaigns worldwide, requiring super efficient intelligence gathering and a new set of weapon systems suitable for confronting urban, guerrilla-type warfare of the terrorists. In a parallel move, increased investments are being made in developing and deploying defence measures that prevent terror attacks and reduce their damage, thus, fortifying the security of citizens. Third, the strategic change due to the evolution of RMA into NCW and the ensuing increase in US defence R&D spending have widened the chasm between the technological capabilities of the USA and the rest of the world, forcing them to reconsider their defence strategies. Finally, shrinking of the defence budgets in most Western countries has reinforced the need to commercialise defence technologies, and has increased the value of defence R&D expenditures.

Defence R&D: Global Trends

Defence R&D comprises valuable sources of information for assessing a nation's military technological capability and its commitment to a national defence industrial base. It increases a nation's military capability, thus, enhancing its national security through improving technology rather than increasing the quantity of arms. Such R&D might also contribute to a technological arms race and add to the rising costs of defence equipment, increasing the pressure for greater defence spending. Furthermore, such R&D creates uncertainty for arms limitation agreements and leads concerned groups of scientists and engineers to resist cuts in defence spending. International comparisons require a standard definition of defence R&D. This is based on the Frascati definition, on which the Organisation of Economic Cooperation and Development (OECD) nations reached an agreement in 1963, but later revised into basic research, applied research and experimental development. Frascati defined R&D in terms of an "appreciable element of novelty". Such definition provides opportunities for discretion by both national Defence Ministries and defence industries when reporting their defence data.[10] Apart from this, there is another problem in coming up with a precise definition because the increasing use of civil technology in military equipment has blurred the distinction between military and non-military R&D, begging the question as to whether such civil R&D should be included in defence R&D and, if so, in what manner.[11]

The published data on government R&D do not include any non-government funds (e.g. privately funded defence R&D), nor do they allow for firms that charge for their R&D in product pricing (i.e. where prices of the product include the 'mark-up' for recovering privately funded R&D). It needs to be kept in mind that, in analysing data, defence R&D can vary substantially from year to year (e.g. reflecting peaks and troughs in procurement programmes), that long, slow years of work are involved and successfully completing R&D programmes sometimes takes even up to 10 years or more for developing the targeted defence equipment. Moreover, an industry's performance in defence R&D will reflect a variety of factors such as: the efficiency of the national procurement agency; defence budget problems; whether the programme is a collaborative venture; and, the efficiency of the industry concerned. Performance in defence R&D should also be viewed as the result of a stock of knowledge and not on the basis of one year's annual flow of knowledge. Finally, of all the military areas, defence R&D is subject to major security/secrecy problems. Most of the Western countries have covert research programmes.[12]

As per Table 1, it is clear that the level of R&D expenditure in non-military area is far greater than that in the military area. The statistics with regard to countries like Germany, Italy, Japan, and South Korea show that they are investing more in the civil sector. This comes in the wake of the fact that the differentiation between the civil and military technology is getting narrower and the dividends with regard to civilian technologies are more pronounced. On the other hand, countries like Israel, Russia, and the USA and to a certain extent France and the UK are investing a sizeable percentage on defence research, mainly because of their strong defence industrial base and the demand for their products in the world market. This shows that the defence conversion strategies are being put in place because of lesser threat perceptions, as also because it means greater economy in research spending.

Table1: R&D Expenditure: Global Trends

Countries/Organisations	**Total R&D Expenditure in US $ billion**	**Military R&D Expenditure in US $ billion**
France	39.7	3.5
Germany	58.7	1.0
Italy	17.7	0.4
Japan	112.7	1.0
Korea	24.3	0.8
UK	33.7	3.4
USA	312.5	54.1
EU-25	211.3	11.2
Total OECD	686.7	69.7
China	102.6	5.0
Russia	16.5	4.0
Israel	5.0	1.5
Other Non-OECD	40.0	4
World	850	85.0

Source: OECD, Main Science and Technology Indicators, 2005, Paris; Israel: European Commission, Key Indicators 2003-2004, Brussels 2005 at http://cordis.europa.eu/

indicators/publications.htm:, Military Expenditures: SIPRI Yearbook 2006. Some selective data is taken from Michael Brozoska's paper presented at an international seminar on "Defence Finance and Economics," November 13-15, 2006, New Delhi.

The number of nations and partner firms involved in cooperation projects has a negative influence on the efficiency of collaboration.

While most of the countries in the post-Cold War phase tried to shift to mission oriented R&D, a sizeable number of them have resorted to contracting with private firms and non-profit organisations (such as universities) to carry out research. The government simply specifies its interest in certain types of technological innovations to private firms and asks them to sponsor the necessary R&D, the costs of which the sponsor will recover by selling the product.

In a collaborative venture, the R&D costs are shared by the participating countries and firms. This leads to reduction in the fixed costs, which are borne by the partner firms or countries. In addition, longer production runs also reduce variable production costs because of increased learning effects. Numerous authorities in the field, however, have argued that cooperation produces specific costs that cancel some of its expected benefits.[13] These costs can be categorised as being mainly organisation costs. In particular, the number of nations and partner firms involved in cooperation projects has a negative influence on the efficiency of collaboration. More precisely, the formula offered is that the total cost of a co-production programme increases by the square root of the number of nations and partner firms involved. Another source of inefficiency identified in co-production projects is the frequent duplication of R&D, or of manufacturing tasks. The most striking example is that of the Concorde airliners. Two separate assembly lines were set up, one in France and one in Britain, to assemble 16 Concorde aircraft. What effect it had on the costs is not open to the public.

Inter-firm collaborations fall into three broad categories:

1. **Unstructured Co-production Projects:** These are the most common projects, launched and developed without any legal entity having been put in place. When an equity joint venture does not exist, the unstructured co-production project's only function is to coordinate the project. It does not perform any of the operational tasks induced by the project. This category includes mature projects like Concorde, Jaguar, Tornado, Transall and many other programmes which are in the R&D stages. The projects are bifurcated

into those that are finalised and those that are to be abandoned.

2. **Semi-Structured Projects:** These are cooperative programmes in which development and manufacturing tasks are distributed among the allied firms as in "unstructured co-production projects". But the important difference is that marketing and sales are carried out by a separate joint venture. This joint venture is generally an equally owned entity, either a common subsidiary or a group of industries like Airbus Industries. In semi-structured projects, the separate marketing and sales organisation is the only interface with the market and customers. This organisation assumes the total responsibility for the commercial success of the product.
3. **Business-Based Joint Ventures:** In these alliances, a separate joint venture, generally dominated by one of the partners, is in charge of the whole business. While both unstructured and semi-structured projects are programme-based and, therefore, limited in time, business-based joint ventures are real corporations and have no preferred time limit.[14]

In most of the cases, the trend has been that the "unstructured co-production projects" category (barring those which are aborted and ongoing projects at the R&D stage) and the "semi-structured projects" category offered a hypothesis linking the commercial success of a project with the organisation of the alliance. Indeed, most matured unstructured projects have been commercially less successful than semi-structured projects. For example, it is hard to contradict the fact that programmes such as the Airbus, ATR, CFM, Milan, Hot and Roland were more commercially successful than the Concorde, BK-117, Transall, Jaguar or Otomat. The main difference between these two classes being the existence of a specific marketing and sales organisation in the semi-structured category and not in the structured one, it is tempting to attribute this success to the wisdom of separating the task of marketing from manufacturing.

Even at the global level, the returns for defence R&D are not as much as has been envisaged prior to the launching of any defence R&D. The UK's defence projects are over-budgeted by £ 2.6 billion, as per the latest report by the National Audit Office (NAO). In its major projects report 2006, 20 large defence projects are found to be still in the assessment phase and there have been significant delays. Projects that are proving wasteful in time and costs include Nimrod MRA4 (89 months late and 25 per cent over-budgeted), the Astute Class submarine (42 months late and 40 per cent over-budgeted), and the Type 45 destroyer (31 months late and 20 per cent over-budgeted). But one good point noted in the same report is that the projects are on track to deliver 98 per cent of the user requirements.[15]

The delay and cost overruns in defence R&D, followed by production, are likely to occur owing to the changed requirements in the technical development phase and the add-ons required by the armed forces during the period of design and development. India is no exception to the global phenomenon. Given this situation, India needs to to analyse and amend the workings of its defence R&D.

India needs to build up its own defence industrial base that is competitive in price, product and punctuality of delivery.

Defence R&D: Indian Perspective

As mentioned earlier, defence R&D is known to be a mission oriented activity comprising both basic and applied research, which involves development and fabrication, as well as testing of new weapons and weapon systems. The need today at the world level is project-based intensive R&D, so as to come up with high quality items even if it means a slight compromise on quantity. India is also in the churning process of deciding what the priorities should be. In fact, major weapon systems have taken 10 to 20 years for development and have cost billions of dollars. Defence R&D also contributes to a technological arms race and, owing to the rising costs of defence equipment, exerts pressure for increased defence spending. But, whatever the challenge, indigenous development efforts are a must for India because of the technology denial regimes that India has been facing time and again and also due to undependable foreign suppliers who, at any time may renege because of political pressures.

All this boils down to one simple fact: with missionary zeal, India needs to build up its own defence industrial base that is competitive in price, product and punctuality of delivery. Defence planners and commentators have criticised R&D performance without suggesting any alternatives. Also, the private firms' commitment to, and performance on, projects they have been given have hardly been reassuring, given the fact that defence R&D has a long gestation period and, the longer it takes, the greater the profit for the companies. If this had not been the case, huge investments could have flowed into the infrastructure sector. This has not happened and, as of date, our power sector, for one, is still going a begging for funds. Even in the railways, which require huge investments, there has not been much private sector participation. The solution to this malaise lies in building the technological base and scientific infrastructure in the country. Scientific infrastructure helps the country to be up-to-date enough to develop even those technologies that are specific to resource endowments.

In this regard, the private sector can build consortiums with the government's help and this should include the higher centres of learning like Indian Institutes of Technology (IITs) and Indian Institute of Science (IISc), which could be given project-based funding to develop technical acumen among the budding engineers. The second step could be to start in-house research programmes by the private sector, which could go in for joint ventures with foreign firms. Recently, Singapore Technologies Engineering has signed a joint venture with Kalyani Group for manufacturing defence equipment in India with 26 per cent foreign direct investment (FDI) approved by the government.[16] This shows that there is scope even with the 26 per cent FDI, if companies are willing to invest in this field. Thirdly, the Defence Research and Development Organisation (DRDO), which has been lambasted for non-performance, has to shed its projects flab and orient itself to basic defence research. Few countries have allowed their defence R&D firms to even venture into the commercial market to make it more economically viable. Fourthly, India has no dearth of PhDs in basic sciences, but there is serious shortage of doctorates in applied and engineering sciences. Those who have an exposure in technical fields find greener pastures abroad rather than hunt for jobs in India. Even South Korea, whose population is about 4 per cent of India's, produces as many engineers as this country.[17] As compared to other countries, India has a very small a pool of Science and Technology (S&T) labour for a speedy development of leading edge weapons.

Table 2: Science & Technology: How India Compares

	Patents Granted (Per Million?)	R&D Outlays(% of GNP)	Researchers in R&D(per million people)	Tertiary Students in Science,Maths & Engineering(% of all tertiary students)
Finland	5	3.4	7110	37
United States	298	2.8	4999	-
Japan	884	3.1	5321	23
South Korea	490	3.0	2880	34
Britain	71	1.9	2666	29
Germany	205	2.5	3153	31
Malaysia	---	0.4	160	---
China	5	1.1	584	53
Brazil	0	1.1	323	23
India	0	0.7	157	25

Source: UN Human Development Report, 2004.

In the rapidly changing dynamics of the contemporary world, technology is also developing very fast. The demarcation between civilian and defence technology has blurred with more and more of the former providing major inputs to defence capabilities. In India, the contribution of the private sector to defence R&D has been miniscule. The war China waged against India in early 1962 jolted India into realising the dire need for a strong defence R&D base to meet the needs of the armed forces in the eventuality of a conflict. The result of this indigenisation effort was the birth of DRDO, which has over the last five odd decades, grown to become a well developed organisation with 49 laboratories and other establishments. The Department of Defence Production and Supplies has 39 Ordnance Factories (OF) and eight Defence Public Sector Undertakings (DPSUs). As noted by former DRDO scientists and the armed forces officers, the organisation has its fingers in too many technical pies.[18] This has led to non-completion or long delays in the completion of the set tasks and, in some cases, the product of a completed project fails to meet the precise requirements of the armed forces at that point of time. Another problem is the result of globalisation. Many retired decision-makers have chosen to serve new multinational masters. This is a bad precedence, for it lowers the morale of the forces as well as the scientists of the country.

There are shortcomings in defence research anywhere in the world and programme delays dog the developed West too. Being the brunt of criticism has hardly helped the defence research establishment and it is high time that it went in for serious introspection to find down to earth solutions to the many ills of the organisation. As a first step, items that are easily available in the market should either be outsourced or directly purchased off the shelf. At the same time, the initial planning and feasibility study for any project should be carried out with objective and result oriented pragmatism.

India is working on an ambitious missile defence programme of far-reaching importance to national security. Such a programme must perforce be tenaciously sustained and brought to its fruition, as it is the sole known counter to weapons of mass destruction (WMD) threats from nations that are fast reaching a state of parity with the world's most militarily developed nations. The success of such projects makes India a power to contend with. The importance of R &D to this task cannot be overstressed.

To shut down projects merely because of cost delays is indeed unwise and impractical. The solution would be to first divide and grade projects according to priority and drop only the least important ones and those that are technically unsound. The nation's economic compulsion, by itself, would be good enough a reason to shelve certain projects, but only if defence collaborations and supplies were freed of political pressures. The pattern of industrial R&D (defence sector), shown in Table 3 reveals that in the post-liberalisation and pre-Kargil conflict phase, the magic word was indigenisation.

Table 3: Patterns of Industrial R&D under Liberalisation

(Figures are represented in Rs. 10 million and the data in brackets connote its percentage of sales turnover.)

Industry Group	1994-95	1995-96	1996-97	1997-98	1998-99
Electricals &Electronics	128.86(0.6)	136.10(0.6)	185.60(0.28)	204.06(0.30)	200.03(0.29)
Defence Industries	79.48(1.9)	79.85(1.7)	144.79(4.44)	180.23(5.22)	218(6.11)
Metallurgical Industries	51.79(0.2)	51.75(0.2)	123.95(0.48)	123.16(0.57)	142.56(0.78)
Drugs and Pharmaceuticals	165.81(0.4)	198.73(0.4)	266.34(0.63)	287.49(0.63)	377.50(0.76)
Transportation	170.42(0.9)	226.88(1.0)	133.11(0.47)	201.15(0.79)	152.83(0.60)
Fuels	81.33(0.1)	106.02(0.1)	110.66(0.11)	99.20(0.09)	156.68(0.13)
Chemicals (other than fertilisers)	243.46(0.8)	309.16(0.8)	180.49(0.51)	174.67(0.47)	195.14(0.51)

Source: Department of Science and Technology, Government of India, and presentation by Dinesh Abrol, NISTADS, at IDSA, October 5, 2006.

The share of R&D in the sales of military equipment started increasing after 1995-96 and the percentage has been growing. This can be attributed to the long range missile programmes and also the development of a few indigenous projects. Sanctions that followed the nuclear tests forced the government to increase the allocation for R&D. The India's experience in defence R&D has not been a very smooth one. Time and again, India has had to face export control regimes and sanctions on high technology transfer. With such experience to make one wiser, one needs to examine India's options.

One such option would be to outsource a few areas of defence R&D to private players, so as to get an estimate of their competence. There is every likelihood of a private company resorting to technology transfer from its foreign partners so as to cut the costs of in-house research. This means the company gets what it wants, but India does not acquire the technological knowledge it seeks. S&T establishments in India are centralised, which is a good thing as far as economy goes, but decentralisation would prove more advantageous as it would help integrate system development with a community of users. There is lack of coordination between research in the industry and defence establishments. As scientists do not have direct links with commercial and defence sectors, transfer of technical knowhow through personnel is minimal. Then, there is the problem originating from supplier nations. However, hard Indian industries may try to acquire the required technology, what they get would always be slightly outdated and weighed down with numerous riders. The possible option is an effective coordination between the private firms' R&D and government institutions.

Time and again, India has had to face export control regimes and sanctions on high technology transfer.

DRDO, which has been unduly criticised for project delays, has found itself bogged down with shortage of engineers, as was noted in the report of the comptroller and auditor general of India. Firm initiatives need to be taken in resolving these issues. What is really surprising is that that Indian defence establishment has to learn from other countries the lessons of modernisation and self-sufficiency. A Ministry of Defence (MoD) review, "Self-Reliance: A Defence Requirement" 1994, showed that only about 30 per cent of the defence requirement was being provided from indigenous sources and 70 per cent were imported. Although a determined policy decision was taken by the MoD to reverse this situation within 10 years from 1995, much remains to be done even today to infuse self-reliance in, and modernise, the defence forces. The weakness in the overall system could be traced to various factors such as lack of an integrated modernisation plan for the three armed forces, the dearth of research institutions to provide time-bound defence technology innovations and the failure on the part of the production units to provide competitive and cost-effective equipment and stores. This does not mean that everything should be privatised, because private industry, profit-oriented as it is, has a cost driven research agenda and cannot sustain long gestation periods. Even carefully selecting a few private concerns will not serve to expand the technology and knowledge base of the country.

The problem can be solved by identifying the factors and responses. Firstly, with the costs of getting research work done rising because of – among other things – the high wages being paid to researchers, India is fast becoming the hub of R&D outsourcing. As it is, our country's competence in the field is well established. In late 2002, the US secretary of defence notified the US Congress of his intention to designate India as a country eligible for cooperating with in defence programmes, adding that one of the criteria for this privilege was that the country concerned should "possess the industrial or technological means to cooperate meaningfully with the United States in defence research, development, test, evaluation or joint production programmes."[19]

Conclusion

The international trend today favours joint defence ventures between business groups rather than those between governments. Governments, however, have been inclined to tacitly promoting and creating a lobby to facilitate the export of their defence products. On the other hand, the active participation of the private sector the world over in the development and manufacture of defence products has given the DRDO the economically advantageous alternative to assign design and fabrication tasks to competing companies. This is despite past experience having shown that in fabrication and designing projects, even in a joint R&D programme, the funding increases with the progress in the work on the product. This means that as the product nears the completion phase and enters the phase of manufacturing, the countries concerned start joining the programme with an eye on a share of the benefits.

A good example is the joint fighter development programme. What steps should the Indian defence R&D establishment take to stay abreast of such international trends? The answers are manifold. First, it should abandon projects for low-technology items, as it would be far more economical in time and money to buy the items from the world market. On the other hand, for medium technology products, the better option would be joint technical collaborations with friendly and strategically like-minded countries, along with an end user agreement. Also, private units should be invited for the competitive design process, so that the project is time-based and cost-effective. In the high technology field, the focus and insistence should be on transfer of technology, so that India moves rapidly towards its goal of becoming a major technology power. India needs to learn from the sanctions it suffered post-nuclear tests. If external support is unavailable, it must have the courage to go ahead with an indigenous time-bound programme to develop high-tech defence products, involving the best of the talents available in the country. India, no doubt, has financial constraints that negatively effect the funding of defence research. But this problem should never be allowed to come in the way of an important and well-planned project. There is also the reluctant attitude of the private sector to be taken into account. And, there have hardly been any credible R&D project plans that could be sustained with the help of the government for a long period of time.

The government should take the initiative to fathom the research potential of the private sector by allocating medium level research projects. This may help them reach global standards, thereby winning orders from other countries in case the government is unable to absorb the entire bulk of the product. Defence R&D is a long, ongoing process, and it is not a good practice to scrutinise it year after year. Few things have a longer gestation period and the academic and defence community just have to learn to be patient and wait for the results. Channelising the defence products to the civilian domain is another economically sound option and would help towards closer civil-military cooperation in R&D, besides swelling the funds through public–private partnership. Privatisation, in itself, will do no good to the defence establishment, especially when there is ambivalence about the capacity of the private sector to meet the demands of the defence R&D. Transfer of technology, while it has its good points, can never be a match for transfer of technical knowledge for it would only superficially increase the technical competence of a nation but does not add to the technical knowledge base, the top priority for a country like India, which has suffered more sanctions than international cooperation in the recent past.

In the high technology field, the focus and insistence should be on transfer of technology, so that India moves rapidly towards its goal of becoming a major technology power.

Notes

1. Keith Hartley and Todd Sandler (eds.), Handbook of Defence Economics,Vol.1 (Amsterdam: Elsevier, 1995), p. 8.
2. For futher details, see J Spanier, Games Nations Play (New York: Holt, Rinehart and Winston, 1984), pp. 97-100.
3. B Latour, Science in Action (Cambridge: Harvard University Press, 1987), p. 174.
4. J Garnett, “Technology and Strategy,” in J Baylis, K Booth, J Garnett and P Williams, Contemporary Strategy (New York: Holmes and Meier, 1987), vol.1: Theories and Concepts, p. 92.
5. Richard Coopey, Matthew R.H Uttley and Graham Spinardi (eds.), Defence Science

and Technology: Adjusting to Change (Berkshire: Harward Academic Publishers, 1993), pp. 2-3.
6. Ibid.
7. US Department of Defence, Lessons of the Gulf War: Interim Report, September 1991.
8. M Thee, "Science-Based Military Technology as a Driving Force Behind the Arms Race," in NP Gleditsch and O Njolstad (eds.), Arms Races: Technological and Political Dynamics (London: Sage Publications, 1990).
9. Oren Setter and Asher Tishler, "Introduction: Defence Research and Development in the 21st Century," Defence and Peace Economics,Vol. 17(3) June 2006, pp. 165.
10. National Audit Office (NAO), Classification of Defence Research and Development Expenditure, London, 1991.
11. Keith Hartley, "Defence R&D: Data Issues," Defence and Peace Economics, Vol. 17 (3), June 2006, pp. 165-167.
12. Ibid., pp. 165-167.
13. Keith Hartley, NATO Arms Cooperation: A Study in Economics and Politics (London: George Allen and Unwin, 1983).
14. A Latham and N Hooper (eds.), The Future of the Defence Firm: New Challenges, New Directions (The Netherlands: Kluwer Academic Publishers, 1995), pp. 122-124.
15. Richard Ball, "UK Defence Projects go 2.6 bn Over Budget", at http:www.electronicsweekly.com/Articles/Article.aspx?liArticleID=40233.htm (Accessed 30 November 2006).
16. "Kalyani Group Enters into Joint Venture Agreement with Singapore Technologies Kinetics" at http://www.bharatforge.com/investers/JV_with_Kalyani_Final.pdf (Accessed 14 December 2006).
17. Ravinder Pal Singh, "An Assessment of Indian Science and Technology and Implications for Military Research and Development," Economic and Political Weekly, 29 July 2000, p. 2764.
18. Amitav Malik, "Whither Defence R&D," paper presented at the National Seminar on Public-Private Partnership in Defence, New Delhi, 2006, Observer Research Foundation.
19. G Balachandran, "Planning for the Future of a Viable Indian Defence Industry," Agni, Journal of Forum for Strategic and Security Studies, Vol. 8(4), October-December 2005, p. 31.