

**DEVELOPING TECHNOLOGICAL CAPABILITY
FOR A VIRILE ECONOMY:
A Way Forward for Nigeria**

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ABSTRACT

From about 1970, successive Nigerian governments have struggled to develop modern technological capabilities — the specific bodies of knowledge and skills needed for modern production. They have created several institutions for this purpose; the most important of which is the Ministry of Science and Technology. In 1986, the Ministry of Science and Technology formulated and published a 'Blueprint on Science and Technology' and has, over the years, sought to implement it. But the expected results have not been achieved.

Investigations show that the country's approach to technological development lacks elements necessary for success. Changes are needed in the country's technology programme and in its implementation. Above all, changes are needed in the attitudes and practices of the major agents of technological development: the state, local research centres, and local enterprises. This paper suggests some of the specific changes that need to be considered. The ideas envisage a more active, organized, systematic, and determined approach to technological development.

1. Introduction

SINCE independence in 1960, successive governments in the country have sought to build a virile economy. In pursuing this objective, most governments, particularly up to 1985, chose the 'planning' strategy. The belief was that by consciously charting the path of progress for the country, achievement of the desired economy would be more certain. Accordingly, each of the governments designed, published, and implemented its own programme. These were the 'development' programmes of the 1960s and the 1970s.

Each development programme spelt out the specific conditions the government would accept to achieve the desired development. They included:

- a. the diversification and indigenization of the economy (diversifying the predominantly agricultural economy into industrial production) in order to reduce external dependence
- b. a reduction in the level of unemployment
- c. a substantial increase in per capita income
- d. a more even distribution of income

Each programme also showed the specific steps the government intended to take to achieve its objectives.

Initially, and in line with thinking on development at the time, the emphasis was on 'industrialization'. The chosen strategy for this was import reproduction more commonly called 'import substitution', and efforts were made to induce import-reproducing activities in as many sub-sectors of the economy as possible. The setting up of a large number of import-reproducing industrial enterprises was expected to usher in a scale of industrialization that would bring about the desired economic transformation.

As part of development efforts, government began, in about 1970, to try to promote scientific and technological activities in the country. It set up a number of institutions for the purpose, and, gradually, introduced other measures, to stimulate the development of those technological capabilities needed for economic transformation and development. Unfortunately, expected results have not yet been achieved, and there are no signs that they will be achieved in the near future. This paper examines the country's approach to the crucial matter — of developing technological capability — with a view to identifying some of the changes that need to be introduced for greater effectiveness.

2. Theoretical Background

In order to minimize controversy, we shall begin by clarifying concepts: in particular, the concept of technology, its components, and its role in the development process.

2.1 The concept of technology

There are two ways in which the term 'technology' is used in the literature. One represents a broad view of the term, while the other represents a narrow view.

When viewed broadly, technology is defined as 'the cultural traditions' developed in a human community for meeting societal needs, or simply 'a social institution' (Dickson, 1974; Kranzberg and Davenport, 1972). These traditions include the practical arts involved in virtually every activity in the community, including hunting, agriculture, mining, manufacturing, construction, transportation

and communication, and the provision of energy and health care services. Viewed narrowly, technology is defined as 'know-how', that is, the knowledge of how to do something — information, skills, and procedures needed for performing particular activities in the society (see Stewart, 1977: 1; Green and Morphet, 1977: 1-3; Norris and Vaizey, 1973). In this sense, we talk of paper production technology, beer brewing technology, shoe making technology, gin or 'ogogoro' production technology, and so on. The 'cultural traditions' referred to involve specific bodies of knowledge, skills, and procedures for doing specific things: technology is essentially knowledge (Verschuur, 1984: 2). Technology is sometimes defined as a 'set of techniques' for carrying out an activity (Green and Morphet, 1977). A technique is 'a particular way of doing something', and each such way embodies knowledge. When technology is defined, therefore, as a set of techniques, it is still a specific body of knowledge that is being referred to.

2.2 Components of technology

The technology of any activity has two main components. One is process knowledge or process technology, that is, knowledge of the inputs, the input combinations, and the processing procedures necessary for completing the activity. The other is design and fabricating capability, that is, the knowledge of how to design and fabricate the necessary machines and tools, and to install and operate the production system. A country has to have adequate capabilities in both of these components before it can claim to have enabling capacity. The more of these capabilities a country has, the more technologically developed it is.

2.3 The role of technology in economic development

There is little point in belaboring the obvious importance of technology: the use of tools, together with the development of moral sensibility, has enabled man to advance from an apelike creature through the Stone and Bronze Ages eventually into an industrial society whose objects we see all around us and which conditions our daily lives. Furthermore, our hopes and fears for the future of mankind are largely bound up with technology.

(Kranzberg and Davenport, 1972: 11)

This passage sums up the role of technology in the development process. Technology creates the goods and services needed for survival and growth, and promotes efficiency in their provision. In today's world, it is technological capability that distinguishes a strong economy from a weak economy, and a

strong country from a weak country. It is because of technology's crucial importance that countries have sought to acquire it.

3. Developing Technological Capability

From history, three main ways by which countries have sought to develop technological capabilities can be identified. These are:

- a. by discovering relevant knowledge consciously or unconsciously, and inventing the necessary tools and machines, i.e., by research and development (R & D) and/or chance events
- b. by learning from countries that already possess the relevant knowledge, i.e., by transfer of technology
- c. by both (a) and (b), combining local R & D efforts and technology transfer (Baranson, 1981; Kunio, 1980; Lilley, 1980; Akpakpan 1986; Lewis, 1979; Rosenberg, 1976).

Unconscious or 'chance discoveries' brought about the first technological revolution in the world. Examples of such discoveries are the tool-making and fire-using activities which started the human story. From such events, craftsmen emerged to produce tools and machines which facilitated the performance of tasks. The skills of such craftsmen were 'handed down from generation to generation'. Improvements were usually slow, and depended on 'chance discoveries', and the scientific principles behind the skills were not known.

After the first technological revolution, subsequent revolutions resulted, not from chance events, but from deliberate efforts at improvement. It became necessary to carry out systematic studies of nature and its laws — what came to be called 'science' — and to apply the scientific knowledge gained from such studies to production. Such applications, started during the industrial revolution in England, and were the major factor in the spread of an industrial culture in that country. Thus, England developed technological capabilities mostly by discovering the relevant knowledge and inventing the relevant machines and tools (Cipolla, 1980).

Virtually all other technically developed countries achieved their capabilities through a combination of technology transfer and R & D. European countries learnt from the British and supplemented and improved upon their acquired knowledge through local R & D efforts. The United States of America, the Soviet Union, Japan, and recently, India and Brazil, also achieved production technology through this approach (Landes, 1969; Rosenberg, 1976; Smith, 1986; UNIDO, 1978; Baranson, 1981). Even England, which because of its early lead in modern industrial matters was the main source of modern technology for other countries,

had to also learn some aspects of industrial technologies from others after its technological development was overtaken by some of these countries.¹

Many of the less-developed countries (LDCs) in Africa, Asia and Latin America have also tried to develop technological capabilities by the two-pronged approach of technology transfer and local R & D efforts. India, Brazil, Mexico, Kenya and Nigeria are examples of LDCs that have adopted this approach (Baranson, 1981; UNIDO 1981; Thomas, 1976; Adikibi and Akpakpan, 1991). With the notable exception of India, Brazil, and, to some extent, Mexico, most of these countries have failed in their efforts to develop the desired capabilities. It is necessary, therefore, to examine what these countries have been doing in their efforts to develop technological capabilities, to assist in guiding future policies and programmes

4. Approaches to Technological Development in Nigeria

4.1 Technology policy

As indicated in section 1, conscious efforts to develop Nigeria's technological capability started about 1970. The first major step was the establishment of the Nigerian Council for Science and Technology (NCST) whose main function was 'to coordinate research and development activities in the country'

In 1975, the government showed a desire to use the activities of the foreign-owned modern industrial enterprises in the country to speed up the process of technological development. Thus, during the Third National Development Plan period, 1975-1980, the government planned to adopt:

... a system which, while liberalising the expatriate quota allocation system, will at the same time ensure that Nigerians are exposed to advanced technology and will be in a position to take over the operations within a reasonable time period. (Third National Plan, p. 152)

It was not indicated how the intention was to be pursued, and, therefore, there was little sign of progress.

To improve things, in 1977 the government dissolved NCST and set up in its place the National Science and Technology Development Agency (NSTDA). It sought to raise the status of science and technology in the country by creating in NSTDA the post of an Executive Secretary and putting the agency under the

¹ The illuminating story of the loss of position is told in Lilley (1980).

chairmanship of the next in command to the Head of State at the time, the Chief of Staff, Supreme Headquarters.

In 1980, the government took the most significant step in the country's search for technological development. It created a ministry for technological matters, the Ministry of Science and Technology. It dissolved NSTDA and transferred its functions to the new ministry. Specifically, the government mandated the Ministry of Science and Technology to:

- a. formulate and monitor a national policy on Science and Technology
- b. promote and administer technology transfer programmes
- c. promote and coordinate scientific and technological research and development activities in some specific fields
- d. promote and coordinate scientific and technological innovation, development, adaptation and production
- e. establish relations with the national research institutes (24 in number at the time), and with relevant international scientific and technological research bodies²

In addition to creating the Ministry of Science and Technology, the government introduced changes in the educational system in an attempt to provide crucial technological infrastructure. It began to emphasize science education, and introduced some technical courses in the school system.

4.2 The technology programme of the Ministry of Science and Technology

The Ministry of Science and Technology sought to develop modern technological capabilities in the country by using a two-pronged approach programme to the problem: providing for local R & D efforts, and the transfer of technology. It created several professional departments and assigned each of them specific functions (see table 1).

Technology transfer matters are handled by a specific unit of the Ministry. This is the National Office for Technology Acquisition Promotion which is supervised by the Department of Industrial Technology. The specific functions of the unit are to vet, register, and monitor technology transfer agreements.

² See Ministry of Science and Technology, Fact Sheet (1990) pp. 3-4.

Table 1. Summary of Science and Technology Programme

The Professional Departments	Major Functions
Science and Technology Promotion	Formulation of science and technology policy Promotion of science culture Promotion of indigenous scientific and technological activities Publication and dissemination of scientific and technological information
Agricultural Sciences	Formulation of agricultural research policies Identification of problems in agric. science research and determining the resources for solution Promotion of the development of special services in support of agric. production Monitoring, evaluation and coordination of agric. extension, and training to develop intermediate level manpower for agriculture
Industrial Technology	Formulation of policies for industrial research Development of priorities in industrial research Promotion, monitoring, direction and coordination of activities of industry-based research institutes, including the National Office for Technology Acquisition Promotion Promotion of local inventions and innovations as well as indigenous technology in the industrial sector Monitoring, evaluation and encouragement of industrial research in the private sector
Medical and Pharmaceutical Sciences	Formulation of policies for medical and pharmaceutical sciences research Promotion of medical and pharmaceutical science research in the public and private sectors Promotion of the development of traditional medicine, with a view to giving it a scientific basis Promotion of local drugs and their production Monitoring and evaluation of research in the medical and pharmaceutical sciences
Energy Research and the Natural Sciences	Formulation of policies for energy research and the natural sciences Promotion of research in all forms of energy and areas of the natural sciences Coordination of research in energy and the natural sciences Supervision of research establishments in energy and natural sciences under the Ministry Promotion of the development of indigenous expertise in the application of new and renewable energy technologies

Source: Ministry of Science and Technology (1990).

In 1986, the Ministry of Science and Technology formulated and published the National Policy on Science and Technology which it described as:

. . . a guideline designed to create harmony in the quest for knowledge about the environment through research, and the use of that knowledge to assure a better quality of life.

The specific objectives of the policy were to:

- a. increase public awareness of science and technology (S & T) and their vital role in national development and well-being
 - b. direct S & T efforts along identified national goals
 - c. promote the translation of S & T results into actual goods and services
 - d. create, increase and maintain an endogenous S & T base through R & D
 - e. motivate creative output in S & T
 - f. increase and strengthen the theoretical and practical scientific base in the society
 - g. increase and strengthen the technological base of the nation
- (Ministry of Science and Technology, 1986: 12)

With these arrangements, it was believed that the country had finally taken the necessary steps for the pursuit of technological development. When the government launched the celebrated Structural Adjustment Programme (SAP) in 1986, one of its main policy measures was the liberalization of the economy so that private investors could respond to market forces better than before. It was expected that the economy would begin to function well; that it would begin to produce more of the goods and services needed by the people and that the country's dependence on external markets would be reduced.

The objective of the country's efforts at technology development, however, have not been achieved. Expected technological capabilities have not emerged, and local enterprises have remained dependent on external sources for technological inputs to their processes. As a consequence of persistent technological dependence, the range of modern industrial activities in the country has remained narrow, and the productive capacity of the economy has remained low. The Structural Adjustment Programme, therefore, had no basis for success; the technological capabilities needed for modern productive activities did not exist. Given the crucial role of technological capabilities in modern production, no programme of economic development will succeed in Nigeria under the present circumstances.

5. The Problem with the Current Approach to Technological Development

There are several problems associated with the current approach to technological development. Some are institutional; others concern the content of our technology programme, programme implementation, and funding.

5.1 Institutional problems

One institutional problem is the chequered history of the Ministry of Science and Technology. In 1984, about four years after its creation, the Ministry of Science and Technology was merged with the Ministry of Education to form the Ministry of Education, Science and Technology. It was restored to a full, separate ministry in 1985, downgraded again later to the status of an agency, and restored to its current status. An institution with the kind of responsibility the Ministry of Science and Technology has cannot function effectively when treated in this way.

Another institutional problem has to do with the relationship between the Ministry of Science and Technology and the research institutes in the country. Many institutes are outside the control of the Ministry, which could hinder the coordination of research and development efforts.

5.2 Content of technology programme

The main problem here is the overwhelming emphasis on R & D. The Ministry itself makes this clear in explaining its functions. It points out that at its inception

... the national science and technology problems included the urgent need to establish a national science and technology policy for achieving self-reliance, and self-sustaining science and technology capability for socio-economic development, based mainly on local research and development (R & D) effort. (Ministry of Science and Technology, 1990: 3-4)

Certainly local R & D efforts are necessary in the struggle for technological development. But it is a mistake to think that these efforts alone will bring about the capabilities we need. The overwhelming emphasis on R & D is based on two assumptions. These are:

- a. that the ideas generated by the research centres will be easily passed on to local enterprises
- b. that local enterprises will readily use the ideas passed on to them

These assumptions are unrealistic, and the experiences of advanced countries confirm this.³

The first factor which explains the unrealistic nature of these assumptions is that research centres usually do not produce 'operational technology packages'; their ideas usually need to be turned into 'prototypes' before they become the goods and services people want, and this requires facilities — development facilities — which most centres do not have.

The second factor is the weak link between the research centres and local enterprises. Research ideas are more readily used where there is a strong link between these two agents of technological development. In Nigeria, this link is, to say the least, weak, and not readily used by enterprises.⁴

The consequence of overwhelming emphasis on R & D is inadequate attention to the other component of the programme, the transfer of technology. Apparently the Ministry does not expect much from this component of its programme, perhaps because of past experiences. This is a mistake. We have failed in the past mainly because of the ideas we have had about technology and technological development, and the approach that those ideas led us to adopt. We can successfully acquire some existing foreign technology, but we will require more than a 'national office' for 'vetting, registering, and monitoring of technology transfer agreements'.

5.3 Funding of programme

There have been complaints about inadequate funding of projects with obvious crippling effects. Results cannot be expected if the necessary facilities are not provided.

6. Towards a More Effective Approach to Technological Development

6.1 Key factors in an effective approach

Two sets of factors determine the results achieved by a programme of technological development: they are the content of the programme, and the implementation of the programme. Both factors in a technology programme must be correct to achieve objectives.

³ See Lewis (1979) for the experiences of the UK and the Soviet Union.

⁴ At the NES/AERC Policy Workshop at the Central Bank of Nigeria, Lagos, in March 1996, a representative of the Manufacturers' Association of Nigeria (MAN) complained about the way Nigerian researchers communicate as a factor in the organization's attitude to research findings.

- a. *The Technology Programme:* As seen in Section 4.2, this refers to the package of activities and actions designed to bring about desired capabilities in the country. Such a programme, in virtually all successful countries, has considered two main sets of activities, as noted in Section 4 — local R & D efforts and the transfer of technology from other countries. Investigations have shown significant differences in each set of activities, and it is these differences that account for the differing results achieved by various countries.

To be successful, a technology programme has to be specific about what is to be pursued in each area, and it has to be realistic about the ways in which the specific objectives are to be pursued.

- b. *Programme Implementation:* The success of any programme depends critically on implementation. The significant aspect in the implementation of a technology programme is the behaviour of the agents. These are the state itself, local enterprises, proprietors of the desired modern technologies, and local research centres, i.e., the universities and research institutes.

- i. *The state.* The state has a crucial, perhaps the most critical, part to play in the development of technological capabilities.⁵ The main reason for this is that the development of technology is a complex, very expensive activity often not attractive to short-term profit-seeking private investors, especially where they have an alternative.

For the LDCs of Africa, with nascent and technologically weak modern enterprises, the role of the state is even more crucial, to put in place policies that will induce other key players to play their parts. Its resources are needed to bolster the bargaining power of local enterprises in international technology transactions, shown to have played the major part in the dramatic achievements of some of the more successful LDCs.⁶

⁵ The state was instrumental to the great technological achievements of England which brought about the industrial revolution of the 18th and the 19th centuries, and it continued to play a 'dominant role in scientific and technological activities' in that country throughout the period for which we have data. See Norris and Vaizey (1973), p. 104. The role of the state was also crucial in the technological development of Germany (Landes, 1969), the US (Rosenberg, 1976), Japan (Kunio, 1980), the Soviet Union (Lewis, 1979), the UK (Supple, 1980), and Brazil (Baranson, 1981).

⁶ See the interesting story of the acquisition of Light Aircraft Manufacturing Technology by the Brazilian state-owned firm, EMBRAER, from the American firm, Piper, in Baranson (1981).

Most importantly, perhaps, the state is needed to provide the technological infrastructure without which success cannot be achieved. We are referring here to education, the kind of education that will equip the citizens with the 'know-why' necessary for absorbing modern 'know-how' technology.

- ii. *Local enterprises.* Local enterprises use the knowledge and skills we have been discussing, and it is the quantity and quality of the relevant knowledge and skills they have at their command that define the technological capability of the country. But the desire and ability of enterprises to acquire the relevant knowledge and skills depend critically on the policies of government. The policies work through their effects on the business environment. They may create an environment that induces enterprises to strive to acquire the knowledge and skills they need, or they may create an environment that induces enterprises to rely on rented knowledge and skills.
- iii. *Proprietors of desired technologies.* The role of the proprietors of desired modern technologies lies in their attitude to technology transfer arrangements. A proprietor of a technology has to be willing to let a second party use his secrets before a transfer can take place. Several factors contribute to such willingness. One of them is the nature of the technology, that is, whether it is simple or sophisticated. Another is the relationship between the proprietor of the technology or the potential transferor, and the enterprises wishing to acquire it or the potential transferees. But the most important of them all is the bargaining power of the potential transferee. For young LDC enterprises, the authority of government is visibly essential to boost bargaining power and thus secure favourable deals.
- iv. *Local research centres.* Local research centres have a duty to generate and disseminate relevant new knowledge. For these activities, centres need relevant skills, appropriate facilities, adequate funds and appropriate guides. These requirements are normally provided by the state, because of the cost involved and the nature of the expected output.

6.2 The changes we need to consider

Important changes are needed in both our technology programme and the arrangements and practices by which we seek to implement it. Some of the changes which could help produce better results are indicated below.

6.2.1 *Our technology programme*

- a. *Local R & D efforts.* The following should be considered for this component:
- i. Improving the link between research centres and local enterprises. One way of doing this is to include representatives of local industries on the boards of directors of relevant research centres. Another way is to encourage the research centres to emphasize work relevant to the needs of the local industries. Also, cooperation in the determination of research agenda could help
 - ii. Increasing the flow of information from research centres to local industries. This could be achieved through regular technical conferences, and the supply of bulletins on local research works to local industries
 - iii. Providing development facilities (pilot plants) at the research centres where necessary
 - iv. Providing local research to upgrade indigenous technologies.
- b. *Transfer of technology.* What is needed here is to provide for the acquisition, through appropriate means, of existing foreign technologies, especially those already being exploited in the country by their proprietors. For this, among other things, it will be necessary to:
- i. expand and strengthen that division of the Ministry of Science and Technology dealing with technology transfer matters, that is, the National Office for Technology Acquisition Promotion, whose functions should include the demystification of technologies and technological transactions.⁷
 - ii. specifically negotiate for, and use specific-purpose state enterprises to implant strategic foreign technologies
 - iii. negotiate with the proprietors of the many foreign technologies being exploited in the country today for the implantation of the skills involved.

The provisions for the development of a 'science culture' need also to be reviewed. Arrangements for the development of scientific manpower, the teaching of science in our institutions, and the teaching of 'introductory technology' in our

⁷ The way to demystify a technology is to spell out its components and what the potential buyer is required to pay for, e.g., the plans and diagrams, operating manuals, training of personnel, content of the training, detailed engineering and specific technical assistance.

secondary schools need to be improved to provide the infrastructure for technological development.

6.2.2 *Implementation of our technology programme*

What is needed here is a change of attitude by all agencies involved, starting with government itself.

- a. The government needs to be more organized and more determined in its efforts to implement the technology programme. This will require that:
 - i. it creates, through appropriate incentive packages, the environment to induce other agents to play their parts
 - ii. it insists on things being done as planned, and promptly
 - iii. it insists, through effective monitoring arrangements, that expected results of each activity are achieved

Also, government needs to create opportunities for local technical personnel to test and consolidate their skills by involving them in the design and execution of projects, allowing them to make mistakes and to learn from such mistakes. This is a crucial step; it is only the government that can do it. Political will and commitment are required.

- b. Local research centres need to focus on the technical problems of local industries and the local economy. In addition, they need to improve their interaction and communication with local industries, and to be more concerned than before about the utilization of their ideas.
- c. Local industries need to change their attitude to technological matters. In particular, they will need to begin to strive to acquire the capabilities necessary for their operations rather than continuing to rent them. In addition, they need to re-examine the implications of reliance on rented technologies for costs, profit ability, and growth in the long-run, and to look inward for potentially cheaper sources of technological inputs. They will need, in their own long-term interests, to cooperate with the government and local research centres efforts to improve local capabilities in modern production.

6.2.3 *Other changes required*

The other main area in which we need changes is the attitude to products of local technologies. Local technologies will be encouraged if the products of such technologies are readily bought. This requires us to cherish rather than despise local products; no longer to consider 'Aba made' as representing an inferior product. We have to realize that each time we buy a product of local technology

we are supporting the development of the relevant knowledge and skills needed to build the strong economy we desire.

The key requirements for success in technological development, therefore, are changes of attitude on the part of everyone, that is, a change of attitude on the part of every policy maker, every worker, both in the public and in the private sectors, every producer of goods and services, and every consumer of goods and services.

6.3 The emerging new perception

It would be unfair to end this paper without acknowledging a new perception of technological development on the part of the current economic managers, the Government. We are referring here to the refreshing view of technology and the way to pursue it that are expressed in the Federal Government Budget, 1996. The definition of technology is appropriate, and the indicated approach to it is pragmatic. We should, therefore, expect better results this time.

We are dealing here with proposals. Details have to be worked out, and concrete actions taken to implement them, before the aims can be achieved.

7. Conclusion

The major conclusion of this paper is that a more organized, more systematic, and more determined approach must be used in the search for technological development. This requires all Nigerians to treat the matter of technological development seriously. Policy-makers, teachers, researchers, administrators, engineers, technicians, entrepreneurs, factory and construction workers, and consumers of goods and services should begin to act in ways that will enhance, rather than retard, the technological development of Nigeria. Above all, government should be more actively involved in technology transactions and technology-related activities in the country, with a determination to succeed.

The economic and the political power of the government must be used, in a way not done before, to overcome the odds against our technological development. Nigerians will have to make sacrifices never made before, realizing that no sacrifice is too much for the development of the capacity to do things for ourselves:

- a. to grow our foodstuffs and to extend cultivation when necessary
- b. to produce chalk, pens, paper, books and materials needed for the education and training of our children
- c. to search for, mine and process for use the many mineral resources
- d. to design, construct and maintain buildings, roads, and bridges

- e. to manufacture the modern goods we have become used to, including spare parts

We have to realize, as Vernon (1986) says, that:

Technology is an asset created by sweat and by treasure, an asset whose continued generation will require considerable expenditure and careful policy in both the private and public sectors; and that it is also an area in which reliance on the invisible hand and the forces of the market would be, . . . a reckless position for any nation to take. (p. 48)

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