Impact Assessment of Technologies Developed and Commercialized by Defence Food Research Laboratory : A Case Study

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ABSTRACT

It is important for every Research and Development (R&D) organizations especially government funded organizations to assess their impact on the technologies developed and transfer of the same for commercialization and large scale adoption among the potential users in order to shape its R & D and to meet the global competition. Mostly, the impacts of government funded R&D organizations were measured in terms of cost of investment, products and technologies developed, human resources development, publications etc. Only very few number of attempts were made to study the impact of R&D organisations in terms of technology development and commercialization. With this brief a study was conducted to analyse the impact of Defence Food Research Laboratory (DFRL), Defence Research and Development Organisation (DRDO), Mysore in terms of technology development, commercialization, spread across the nation, resources generation and adoption among Indian food industries. The study on R & D impact revealed that a total of 467 products and technologies were developed by acquiring 118 projects during 1964-2013. A significant compound growth rate of 6.20 per cent and 3.80 per cent were achieved on products and technologies development and projects acquired. By transferring 438 technologies to 251 entrepreneurs, DFRL paved the way for development more number of food industries in India. The study on technology spread showed medium to high level spread across different region of India

Key words: *Compounded growth rate; Transfer of technology; Technology acquisition; Technology spread index;*

Research and Development (R&D) could be defined as the process of discovering new knowledge about products and services and application of such knowledge to create new and improved products/ processes to meet market requirements. Many countries and private multinational companies invest huge amount of money for R&D in order to develop new products and technologies, improve the existing processes, and reduce the cost of production and to find the new markets according to changing need of customers. In the modern economic scenario, the role of technological developments and adoption at industrial level plays a major role in growth and development of a country. As in many countries, research and development activities in India are undertaken by government, academia and private organisations. As a part of its initiatives to establish a robust science and technology infrastructure Government of India established many research and development organizations such as Council of Scientific & Industrial Research (CSIR), Defence Research and Development Organization (DRDO), Indian Council of Agricultural Research (ICAR) , Indian Council of Medical Research (ICMR) etc. (*Anonymous, 2011*)

Defence Food Research Laboratory (DFRL) is one such R&D institute established at Mysore in December 1961 under Defence Research Development Organization (DRDO), Ministry of Defence to meet the R&D need in the area of food science and technology for the armed forces of India. It is important for every R&D organization especially government funded organization to assess their impact in the technologies developed and transfer of same for commercialization and large scale adoption among the potential users in order to shape its R&D to meet global

competition. Every R&D organization needs to focus on continuous improvement in its performance which requires impact evaluation to track the exact position and get feedback in order to know the gaps for improvement. In this competitive era, success of R&D not only depends upon the amount of resources deployed but also depends upon the sharp vision, mission and strategy of an organization. (*Jyoti Benwet et al, 2006*).

Several methods were used for analysing the R&D impact in terms of return on cost of investment, human resource deployment and development, product and technology development, number of patents, number of publication etc. (*Ojanen and Vuola 2003, Chien et al 2009, Thorleuchter et al 2010 , Ragasa et al 2011 and Rupak* and *Paul 2012*). However it is very difficult to assess the impact using a common performance criteria as the vision, mission and mandate of organizations are diverge. The impact of Universities and other academic organizations can be evaluated by using the above indices however the R&D organization like Defence Food Research Laboratory with basic mandate on applied research can only be evaluated by technologies developed, spread technologies and resource generated through commercialization and adoption among the potential users. With above brief an attempt has been made to assess the impact of DFRL through above said parameters of evaluation over five decades (1963-2013).

METHODOLOGY

The primary and secondary data on the number of projects and assignments acquired, products and technology developed, and Technology commercialized and resource generated by DFRL over five decades (1963-2013) through various five year plans and other plans were collected from Planning and Coordination Division (P&C), Technology Transfer and Commercialization Division (TT) and Technical Information Centre (TIC) , DFRL, DRDO, Mysore. The data were classified into different categories and analysed with statistical techniques such as Compounded Growth rate (CGR), Correlation, Mean, Standard deviation and per centage by using SPSS and MS Excel. The compound growth rate on projects, products and technology development, technology commercialized and resource generation was analyzed by using following formula:

$$Y_t = ab^t$$

Yt = Number Projects / Number of Products and Technology Developed / Technology Commercialized / Resource generated for the year't'

t = Time variable (1, 2…n) for each period / year

a = Intercept

b = Regression co-efficient

The per cent compound growth rates (r) were computed using the relationship:

$$r = (b - 1) \times 100$$

The channels of technology transfer and the effectiveness of external agency in commercializing the technology also studied in order to understand the mode of technology transfer to the industries. The indices such as technology acquisition per centage and technology spread index were studied to analyse the performance of DFRL and the impact of DFRL on Indian Food Industry.

The main aim of calculating the technology acquisition per centage is to know the strength and competence of DFRL in terms attracting more entrepreneurs to choose maximum number of technology from the available basket. It is calculated by total number of technologies acquired by individual entrepreneur/firm to the total number of technologies adopted by all entrepreneurs during 1984-2013.

$$TA\% = \frac{\text{Technologies Adopted by individual entrepreneur}}{\text{Total no. of adopted technologies}} \times 100$$

TA%=Technology Acquisition percentage

The technology spread index which is the indicator of technology adoption across the region of India is calculated by adding number of technology adopted in each region (East, North, South and West) divided by maximum number of technology adopted in particular region and multiplied by 4 (Total number of region).

$$TSI = \frac{\text{TOT in (East + North + South + West)}}{\text{Max. technologies adopted in perticular region}} \times 4$$

TSI=Technology Spread Index

RESULTS AND DISCUSSION

Pattern of projects and Technology and Product Development in DFRL: Based on the requirement of armed forces, DFRL over a period of five decades from 1964-2013, developed 467 food products and technologies through a total number of 118 projects, sub projects, assignments and collaborative projects. This period was divided into 5 sub-periods as showed in Table 1 and each

period had 10 years based on the technology development: (i) Development of ready reconstitute products (1964-73); (ii) Development of ready to eat food (1974-83); (iii) Development of Instant Foods (1984-93);(iv) Advancement in Packaging Technologies (1993-2003) and (v) Development of Functional food & detection kit (2004-2013).

Table 1. Trend in projects acquired and products & technology developed from 1964 to 2013

Periods	No. of Projects	No of Products & Technologies
1964-1973	12	28
1974-1983	11	33
1984-1993	17	53
1994-2003	27	67
2004-2013	51	286
1964-2013	118	467

The study on the number of projects undertaken by DFRL over five decades as illustrated in Table.1 showed the fluctuated trend with slow and steady increased growth rate of projects undertaken during the entire period. It is also observed from the study that till 1990 only planned projects for five years were undertaken by DFRL and diversification of projects in terms of assignment , subprojects and collaborative nature were observed after the year 1990. A total of 23 assignments, 5 subprojects, and 11 collaborative and 9 sponsored projects were taken by during 1991-2013. The high competence of DFRL in food technologies may be the main reason for the more number of sponsored and collaborative projects during the period. The analysis of CGR on projects acquired as showed in the Table 2 revealed a positive and significant growth rate of 3.6 per cent for the entire study period. However, first two decades showed the non significant negative growth rate in projects acquired. Technological backwardness may be the reason for less number of projects. A significant high growth rate of 26.5 per cent was noticed on acquired projects during 2004-2013 due to more number of collaborative and sponsored projects undertaken by DFRL.

The study on the technology and products development revealed that a total of 467 products and technologies were developed during 1964-2013 by average staff strength of 185 per year (Table 1). A positive and increase trend on products and technology development was noticed during the entire study period. The period 2004-2013 showed highest number of products and technology development when compared to other period with 287 products and technologies. The introduction of modern processing technologies such as microwave processing, IR processing, high pressure processing and modern communication information system may be the reason for the more number of products and technologies developed during this period. The analysis compounded growth rate during the entire study period as illustrated in Table 2 showed positive and significant growth rate of 6.20 for products and technology development. The highest number of product and technologies (286) were developed during the period 2003-2014 with significant growth rate of 20.90 under 51 projects followed by 67 products technologies with non significant growth rate of 0.8 per cent under 27 projects. The first two decade of R & D work at DFRL showed negative and non significant growth rate in products and technology development as that of products acquired.

Table 2. Compound growth rate of no of projects acquired & no of products & technologies developed from 1964 to 2013 (10 Year)

Periods	No. of Projects	No of Products & Technologies
1964-1973	-0.80^{NS}	-9.30^{NS}
1974-1983	-5.30^{NS}	-14.30^{NS}
1984-1993	3.70^{NS}	23.8^{NS}
1994-2003	20.00*	0.80^{NS}
2004-2013	26.50**	20.90**
1964-2013	3.80**	6.20**

**Significant at 1 per cent, *Significant at 5 per cent level of probability; NS = Not significant.

With the meagre manpower of 185 (including 48 scientist, 74 technical officer and Technical Assistant and 63 Admin and allied staff) DFRL was able develop more than 450 products and technologies which are highly used by Indian Armed forces and Indian food Industries. The analysis on relationship between projects acquired and product & technology development showed highly positive and significant relationship with correlation coefficient 0.817 (Table. 3)

Table 3. Correlation Analysis between projects acquired and Products & Technology Developed

Details		Project	Products
Project	Pearson Correlation	1	0.817**
	Sig. (2-tailed)		000
	N	47	47
Products	Pearson Correlation	.817**	1
	Sig. (2-tailed)	.000	
	N	47	47

**Correlation is significant at the 0.01 level (2-tailed).

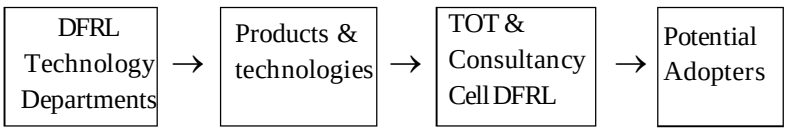
Pattern of Technology transfer process in Defence Food Research Laboratory: The economic progress of any nation depends upon the successful adoption of cutting edge technologies and products developed by research and development organization by progressive industrial partners for the mass production with appropriate use of natural resources. The importance of Transfer of Technology (ToT) for the well being of national economy, national and international competitiveness, corporate profitability and growth has been well established and documented. In spite of the several pro-active policy initiatives, many of the technologies developed in Indian publicly funded R&D institutions have either remained unexploited or the desired impact has not been made by the transferred technologies (*Kumar and Jain, 2003*). Technology transfer is a lengthy, complex and dynamic process, which involves transfer of license agreement in which the R&D organization retains ownership of the intellectual property while the industrial partner obtains conditional right to use and develop a technology for commercial purpose. Transfer of technology need a dynamic initiative that combines engaging researchers, promoting the technology and encouraging potential industrial partners to use the technology. The R&D organizations obtain recognition for its achievements and also generate revenues for transfer of technology which can be used in future research programmes. Industry partners can also reduce the costs incurred during their research and development stage by licensing the technology obtained from a R&D organization. In this study, an attempt was made to understand process of technology transfer from DFRL, the channels of technology transfer, number of technology transfers and revenue generated during 1984-2013 and its spread across the nation and its commercial adoption.

Successful scaling up of developed technologies and setting up of pilot scale production unit at DFRL helped to carry out a more than 400 number of technology transfer over a period of time. It is observed from the study that there was no organized system of TOT until 1983. The clearance from Ministry of Defence during 1980's regarding the use of defence technologies for civilian use resulted in establishment of a separate division for TOT and transfer of technologies developed was carried out through technology transfer and consultancy division of DFRL till 2011. The creation of exclusive technology transfer wing named Directorate of Industry Interface and Technology Management at DRDO HQ Delhi resulted in the in the establishment of DRDO –FICCI (Federation of Indian Chambers of Commerce & Industry) - ATAC programme (Accelerated Technology assessment and Commercialisation) for the technology transfer. . The costing pricing committee of DFRL chaired by Director, DFRL, with members from technology transfer division, technology and product development division and Central Defence Accounts fix the basic price for the technology developed. Based on the current market scenario DIITM (Department of Industry Interface and Technology Management), DRDO, with assistance of FICCI fixes the price for the technology transfer with royalty amount. The potential entrepreneurs who are interested in the technologies can approach either DFRL or FICCI for the ToT. Thus the perusal of ToT modes clearly indicated two types of Technology transfer channels as depicted in the figure 1.

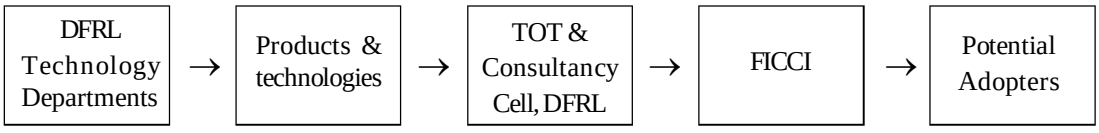
The study on the technology transfer channel revealed that till 2011 channel No. 1 only used by entrepreneurs for technology adoption and from 2012

Figure 1. Technology Transfer channels used by Industries

Technology Transfer Channel 1:



Technology Transfer Channel 2:



both channels were used by entrepreneurs and industries. The analysis of ToT during 2012-2013 revealed that a total of 26 ToT occurred during this period. Among these ToT, more than 80 percent of entrepreneurs and industries adopted TOT channel 1 followed by Channel 2. The proximity and personal relationship of Industries with DFRL and confidence of Industrial partners may be the reason for choosing channel 1 rather 2. Our study is in confirmation with the finding of Purushotham et al 2013, who reported that effective communication and personal relationship between R & D organisation and Industries plays a major role in technology transfer.

The compilation of data on the technology transfer carried out during 1984-2013 revealed that, DFRL over a period of 30 years successfully carried out 438 of number of technology transfer and generated a revenue of 17.70 million Indian rupees. Many Industries and entrepreneurs across India adopted DFRL Technologies which resulted in the development of many food processing industries in different regions of India.

Trend of technology Transfer and revenue generation : As it is difficult to list out 438 TOT, the data on TOT broadly grouped into 13 categories viz, Ready to eat & cook chapattis, Retort Processed ready to eat Foods, Instantised Foods and Mixes, Ready to Eat Bars Biscuits and snacks, Quick Cooking Dehydrated Foods, Ready to drink Juices, Ready to reconstitute beverages, Tender Coconut Water Preservation, Design Food Additives, Freeze Dried products, Fruits and Vegetable Preservation, Process Technologies.. The list of technology transfer happened in each group and the contribution each category in terms of revenue generation is listed in the Table 4. The perusal of the table showed that quick cooking food, ready to eat & cook Chapathies. Retort processed ready to eat food and Instant foods were contributed more than 72 percent for the technology transfer. The Convenience of these food products which facilitate easy cooking with short period of time and preference of consumer may be the reason for large scale adoption of these technologies. The analysis on revenue generation showed that retort processed ready to eat food and tender coconut water preservation technology together contributed about 62 percent of revenue generation followed by ready to eat & cook chapathies and instantised foods and mixes (22.6%). The large scale procurement of ready to eat products by armed forces as well as high export potential of processed tender coconut water together with high technology transfer cost may be the reason for large scale contribution of these technologies on revenue generation.

Table 4. Technology wise grouping of TOT carried out during 1984-2013

Product and Tech. Group	No.	%	Resource Generated	
			Rs.	(%)
Ready to eat & Cook chapathies	84	19.18	2566000	14.49
Retort Processed Ready to eat Foods,	77	17.58	6581500	37.17
Instantised Foods and Mixes	70	15.98	1440250	8.13
Ready to Eat Bars Biscuits and snacks	39	8.90	475750	2.69
Quick Cooking Dehydrated Foods	86	19.63	482515	2.73
Ready to drink Juices	7	1.60	110000	0.62
Ready to reconstitute beverages	7	1.60	171500	0.97
Tender Coconut Water Preservation,	27	6.16	4475000	25.27
Design	7	1.60	208000	1.17
Food Additives	12	2.74	298000	1.68
Freeze Dried products	3	0.68	379500	2.14
Fruits and Vegetable Preservation	12	2.74	351000	1.98
Process Technologies	7	1.60	167500	0.95
Total	438	100	17706515	100

It is also observed that ready to eat & cook chapattis alone contribute nearly 15 percent of revenue generation with more number of technology adopters (84 No). The low investment and high market potential of chapattis technology and preference of chapattis over rice based products due to health consciousness in India may be reason for large number adoption among entrepreneurs.

The analysis of technology transfer trend revealed the fluctuation during the study period (Table 5). Maximum number of technology transfers (181 Nos.) happened during 1984-1993 followed by 148 numbers during 2004-2013. The availability of maximum number of quick cooking and instant foods technologies for civilian use which reduce the drudgery of housewives and the clearance from of Ministry of Defence may be

the reason for the large scale adoption by industries during 1984-1993. It is also observed that less number of technology transfers happened during the years 1994 and 2003. The commitment of entire staff of DFRL on production and supply of ready to eat food to the armed forces during Kargil war period (1999-2000) possibly the reason for low level of technology transfer during 1994-2003. The analysis on number of TOT in individual period showed a static state equilibrium in technology adoption during 2009-2013 with an average of 12-14 technology transfers per year. The perusal of CGR on number of ToT showed a negative and non significant growth rate of -0.6 percent. Development of high investment and high end technologies which may not suitable for small entrepreneurs for adoption and production of more food products rather development of new technologies may be reason for non significant negative growth on number of technology transfer during 2004-2013 . The analysis on CGR during individual period also showed non significant growth in number of ToT. The highly fluctuating level of adoption in individual years may possibly reason for non significant growth.

The pattern of revenue generation over period of 30 years through technology transfer as presented in table 5 showed a positive and increased trend. A significant compound growth rate of 16.1 percent during 1984-2013 showed the strength of technology transfer over three decades. A highest amount of revenue has been generated in the year 2004-2013 due to adoption of high cost retorts a processed food technology by many food industries and Tender Coconut water processing technologies. The advantage of Retort food processing technology over other technologies in terms of shelf life extension food products over 12 months without using any chemical paved the way for technological revolution in the food industries of India.

Table 5. Trend & Compound Growth rate of ToT carried out and resource generation from 1984 to 2013

Periods	ToT carried out	CGR of ToT carried out	Resource generation through ToT	CGR of resource generation
1984-1993	181	-9 ^{NS}	667515	17.2*
1994-2003	109	11.2 ^{NS}	5854000	31.1*
2004-2013	148	-1.5 ^{NS}	11185000	4.5 ^{NS}
1984-2013	438	-0.6 ^{NS}	17706515	16.1**

**Statistically significant at 1 per cent level of probability;
*Statistically significant at 5 per cent level of Mprobability;

Technology acquisition percentage: The main objective of measuring the technology acquisition percentage is to know the strength and competence of DFRL in terms attracting more entrepreneurs for adoption. It is inferred from the Table 6 that about 67.7 percent of entrepreneurs (170 No's) acquired single technology from DFRL followed by 19.1 percent (48 No's) acquired two technologies with low level of acquisition. About 15 enterprises acquired 3 to 8 technologies and showed medium level of acquisition percentage. Four enterprises had high level acquisition with 11 to 14 technologies. The Enterprise TGL Groundnut corporation, Adoni, Andhra Pradesh acquired highest number of technologies (14 No's) followed by Real Contract Private Limited, New Delhi (13 No's) and Great value food, New Delhi (11 No's). The highest number of acquisition by these enterprises showed the strength of DFRL in meeting the industrial requirement. In the medium level of technologies acquisition categories, the prominent adopters is ITC, Kolkata which acquired about 10 technologies followed by Biseleri Beverages limited , Mumbai with acquisition of 8 technologies. It is also observed that these technologies were acquired by above firms over different period of time which showed the competence of DFRL in meeting the end user requirement.

Table 6. Technology Acquisition by Industries

No. of Tech.	Acquisition By Industries	No. of Tech. adopted	Acquisition Category
1.00	170	170 (67.7)	Low
2.00	48	96 (19.1)	low
3.00	14	42 (5.6)	Medium
4.00	4	16 (1.6)	Medium
5.00	5	25 (2.0)	Medium
6.00	3	18 (1.2)	Medium
7.00	2	14 (0.8)	Medium
8.00	1	08 (0.4)	Medium
11.00	2	22 (0.8)	High
13.00	1	13 (0.4)	High
14.00	1	14 (0.4)	High
Total	251	438 (100.0)	

Technology Spread pattern across the zone of India: It is important that technologies developed any R & D organization should reach different parts of country to bring industrial growth at uniform pattern. An effort have been made to analyse the technology spread pattern across the east, north, south and west zone of

Table 7. Spread of TOT carried out across the Zone of India

No. of TOT in the Zone (No. & %)	State wise ToT	TOT No.	%
East zone	Bihar	1	5.56
18 (4.110)	Megalaya	1	5.56
	Meghalay	1	5.56
	Orissa	2	11.11
	West Bengal	13	72.22
North zone	New Delhi	64	35.16
182 (41.553)	Chandigarh	3	1.65
	Haryana	2	1.10
	Himachal pradesh	1	0.55
	Madhya Pradesh	1	0.55
	Maharashtra	102	56.04
	Punjab	7	3.85
	Uttar Pradesh	1	0.55
	Uttarakhand	1	0.55
South zone	Andhra Pradesh	58	26.73
217 (49.543)	Karnataka	84	38.71
	Kerala	29	13.36
	Tamil Nadu	45	20.74
	Puthucherry	1	0.46
West zone	Goa	1	4.76
21 (4.795)	Gujarat	16	76.19
	Rajasthan	4	19.05
	Total	438	(100)

India. The pattern spread as illustrated in Table 7 revealed that nearly half (49.5%) percent of technologies adopted by industries belong to Southern states of India followed by Northern States (41.5%) and East & Western States Industries (9%). Among the Southern States, Karnataka ranked first for adoption (38.71 %) followed by Andhra Pradesh and Tamil Nadu. The close of Proximity of these state's near to the location of DFRL at Mysore, possibly reason for more number of technology adoption. In Northern states Maharashtra ranked first for Technology adoption followed by New Delhi. High Industrial Development & readiness of industries in Maharashtra and New Delhi for adoption of modern technologies possibly the reasons for more number of technologies spread.

The spread index analysis of individual technology categories as presented in table 8 revealed that Quick cooking dehydrated food high technology spread index of 8 followed by retort processed ready to eat food and ready to eat & cook chapattis with spread index of 7.33 and 7.30 respectively. These three categories, when compared to other had uniform spread across the different region of India. The suitability of the above three category food technologies in terms meeting the taste and preferences of different consumers with recipe modification may be reason for high level spread. Food additives, Designs, Instantised food products and tender coconut water preservation technologies showed medium level spread as against ready to drink juices and ready to reconstitute beverages which showed low level spread (Table 8).

CONCLUSION

The study on Impact of Defence food Research Laboratory (DFRL) which has the basic mandate to serve the armed forces as India revealed that DFRL over period of 50 years developed 468 products & Technologies for armed forces as spin off these

Table 8. Technology wise spread of TOT carried out during 1984-2013

Technology Category	East	North	South	West	Total	Index	Category
Ready to eat & Cook chapathies	1	46	31	6	84	7.30	High
Retort Processed Ready to eat Foods	4	42	23	8	77	7.33	High
Instantised Foods and Mixes	2	35	33	0	70	6	Medium
Ready to Eat Bars Biscuits and snacks	0	9	29	1	39	5.38	Medium
Quick Cooking Dehydrated Foods	3	37	43	3	86	8	High
Ready to drink Juices	0	0	7	0	7	1	Low
Ready to reconstitute beverages	0	1	6	0	7	2.33	Low
Tender Coconut Water Preservation,	2	3	20	2	27	5.4	Medium
Design	1	0	6	0	7	2.33	Low
Food Additives	1	5	6	0	12	6	Medium
Freeze Dried products	1	0	0	1	3	6	Medium
Fruits and Vegetable Preservation	2	2	8	0	12	4.5	Medium

technologies made remarkable impact in the Indian food Industries in terms of ready to eat and quick cooking food development. It is observed that the number of technology transfer showed the negative growth rate when compared to revenue generation. Development of more products rather than technologies may be the possible cause for the sluggish growth. So, reshaping the R & D activities of DFRL towards development of low input and high output technologies is necessary in order meet the stiff competition from other R & D organization. Development advanced technologies rather than relying on old technologies for production of new products should be given at most importance. The study on technologies acquisition by entrepreneurs showed nearly 20 percent of entrepreneurs only acquired more than 2 technologies. So, dissemination of information about recent technological development to the industries, supporting industrial partners as and when required and regular survey on the need of industries should be carried out periodically to gain confidence of Industries. The technologies of DFRL reached different part of India and paved the way for uniform development food industries. However the spread was high among southern and northern states of India when compared to west and Eastern states. Establishment of technology dissemination and consultancy centre at different region with the help of other DRDO Laboratories will helpful in large scale adoption of DFRL technologies

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