Enterprise Infrastructure Management, IT Outsourcing and Value Creation

K. M. Mital[1]

ABSTRACT

Enterprise infrastructure management is an important function in any business firm that deals with a number of customers, vendors, and other trading partners who have to be in constant touch with the organization as part of supply chain or customer relationship management, Every organization besides its core operations needs to have several infrastructure support services such as information technology, communication, hospitality, etc. as no organization can function in isolation. An organization has several stakeholders including customers and vendors, who need to stay in touch with the organization through some communication aids like telephone, fax or IT-enabled technologies such as e-mail, and when visitors have to pay visit, organizations need to provide some minimum hospitality support in transit accommodation or company empanelled hotels. In the context of enterprise infrastructure management, an issue that often arises is whether the organization should have its own in-house IT and IT-enabled services (ITeS) or it should outsource them as a policy option. Outsourcing of services can be economically advantageous when volume of services is below a threshold or cut-off limit. On the other hand maintaining an in-house facility shall be economically more beneficial when volume of services to be handled is more than this limit. The present study reports comparative economics of in-house IT/ITeS of an organization vis-a-vis those charged by an external service provider after quatifying each and every cost involved, and based on comparison determining the cut-off limit. Economic analysis was carried out after quantifying each and every cost involved. This paper presents the case for comparative economic analysis for outsourcing IT/ITeS in healthcare area and comes out with a framework for determining cut-off limits for outsourcing based on comprehensive economic analysis.

Keyword: Enterprise infrastructure management, outsourcing economics, selective outsourcing, in-sourcing and value creation.

1. Introduction

This study relates to comparative economic evaluation of carrying out IT/ITeS internally by making significant investments on equipment and software, or simply outsourcing these services to outside service providers, who on account of providing such services to a large number of hospitals and clinics can provide them at much less cost and more professionally. The present paper reports three cases of economic

[1] IILM Institute for Higher Education, 3, Lodhi Institutional Area, New Delhi 110003, India (E-mail : krishna.mital@iilm.edu)

analysis of outsourcing IT/ITeS, in terms of costs of equipment and services, to external service providers in an healthcare organization evolved with reference to MRI (Magnetic Resonance Testing), CAT (Computerised Axial Tomography) scan, and ultrasonic testing, all of which essentially fall within the domain of IT and IT enabled services (ITeS). All the three services can be provided in-house in a hospital or can also be outsourced to professional service providers who are available in large numbers in every major town. Outsourcing of services is not economically beneficial when volume of services is more than a minimum threshold limit.

Name of the organization, equipment covered, model details, exact price, period of study, etc. are disguised due to proprietary reasons though data is real. This is because the objective is to come out with a practical methodology for analyzing economics of outsourcing IT/ITeS rather than focus on specific organization or equipment that forms part of the study. While MRI and CAT scan involve major capital investment, ultrasonic testing involves relatively much less capital investment, but all three essentially need effective and reliable IT application software that helps in interpretation and diagnosis of suspected ailments. In outsourcing IT/ITeS such as CAT scan, MRI or ultrasound services, there are several possibilities such as either outsource both testing and data generation including data processing and interpretation services, or outsource only testing, with interpretation and diagnosis to be done by the outsourcer.

These days most of the imaging equipments similar to 'consumer durable' items are available in reconditioned form also at much cheaper cost than original equipment but in usefulness as good as new. At the remanufacturing plant, the returned products are completely disassembled into parts and components. All the parts are thoroughly inspected, defective and worn out parts are repaired or replaced by new ones and then reassembled to build up the reconditioned product. Non-usable worn out parts are sold as scrap to the recyclers. Accordingly, cost price of reconditioned equipment is much lower than the cost of brand new equipment. In thus study, equipment in all the three cases is assumed to be bought in reconditioned form which is available at much less cost and as good as new. Thus, cost items of these products in reconditioned form are not comparable with the prevalent market rates of new products, and accordingly differences can be wide.

A computerized axial tomography scan is more commonly known by its abbreviated name CT scan or CAT scan. The Greek word tomography is derived from *tomos* (slice) and *graphein* (to write). It is IT- enabled X-ray procedure to generate cross-sectional views including three-dimensional images of the internal organs and structures of the body. Cross-sectional slices are similar to the slices of bread loaf and it amounts to examining body in terms of successive slices from the crust to the center. The body is seen on CT scan slices in a similar fashion from the skin to the central part of the body being examined. When these levels are reassembled by computer software, the result is a very detailed multidimensional view of the body's interior. The images can then be examined on a computer monitor or printed. CT scans of internal organs, bone, soft tissue and blood vessels provide much greater clarity than conventional x-ray examinations (MedicineNet.com. Accessed on December 7, 2007).

Using specialized equipment and expertise to create and interpret CT scans of the body, radiologists can more easily diagnose problems such as cancers, cardiovascular disease, infectious diseases, trauma and musculo-skeletal disorders. Physicians often use a CT scan to plan and properly administer radiation treatments for tumors, guide biopsies and other minimally invasive procedures, plan surgery, measure bone mineral density for the detection of osteoporosis; and quickly identify injuries to the liver, spleen, kidneys or other internal organs in cases of trauma.

CT scan in a way can be perceived as extended IT-enabled X-ray procedure. Unlike conventional X-rays, a CT scan provides very detailed images of many types of tissue as well as the lungs, bones and blood

vessels. An X-ray machine utilizes electromagnetic radiation to produce an image of an object, usually for visualizing something located below the objects surface. The machine is made up of X-ray source or X-ray tube, an X-ray detective system and positioning hardware to align these two components with the objects to be imaged. (Monarch Medical.com. Accessed on December 12, 2007).

Magnetic resonance imaging (MRI) formerly referred to as magnetic resonance tomography (MRT) is essentially a non-invasive method that uses nuclear magnetic resonance to study inside of an object. Unlike X-rays and CAT scans, which use radiation, MRI uses powerful magnets and radio waves. An MRI scanner contains a magnet that forces hydrogen atoms in the body to line up in a certain way. When radio waves are sent towards the lined up hydrogen atoms, they bounce, which with a special computer software are recorded as a specific signal as different types of tissues send back different signals. Thus, it may help in detecting an ailment like cancer as a healthy tissue sends back a slightly different signal than a cancerous tissue.

An MRA (magnetic resonance angiogram), which is an alternative form of magnetic resonance imaging that creates three dimensional pictures of blood vessels, is often used when traditional angiography cannot be done. It is primarily used in medical imaging to look into pathological or other physiological alterations of living tissues. Combining MRIs with other imaging methods can often help doctor make a more definitive diagnosis (MedlinePlus. Accessed on December 14, 2007).

Medical sonography (ultrasonography) is an ultra-sound based diagnostic medical imaging technique to visualize muscles, tendons and many internal organs, their size structure and any pathological lesions with real time topographic images. Ultrasound scans commonly known as *sonographs* are obtained by healthcare professionals using using ultrasound equipment and related IT accessories. Ultrasound imaging is one of the most widely used diagnostic techniques which poses no risks to the patients. Ultrasound equipment along with IT accessories is easily transportable from one place to another as compared to MRI and CAT Scan equipment. In terms of capital costs it involves much lower expenses than than MRI and CAT scan equipment. (Monarch Medical.com. Accessed on December 12, 2007).

2. Estimation of Different Cost Components Including Depreciation

In this study it has been attempted to determine minimum usage of IT/ITeS in terms of daily workload on per day basis above below which on economic considerations, it is beneficial to outsource these operation and it is only when it exceeds the minimum threshold limit, services can be done internally by making investments on hardware and software. This study enabled to find out find out minimum threshold limit of IT/ITeS in terms of hours of services utilized per day for deciding to run it in-house profitably or outsource depending on the volume of services the organization is handling (Annexure 1, Table 1 to 12).

For making analysis of this nature, costs were divided into two categories, namely, fixed costs independent of IT/ITeS usage, and variable costs dependent on computer usage. Fixed costs related to costs of building, manpower and other fixed expenses. Variable costs pertained to electric power expenses, stationery costs and other consumables costs which are usage dependent. Capital expenditure involved costs of hardware, software, furniture, fixtures, etc. Comparative economic gains of owned versus outsourced services were arrived at corresponding to varying number of shifts and varying degree of IT/ITeS utilization per day. The estimation of total expenses for MRI equipment, Estimation of Total Expenses CAT Scan Equipment, Estimation of Total Expenses for Ultrasound Equipment and IT Accessories are given in Annexure 1.

3. Outsourcing Economics and Value Creation

As long as volume of services is below the threshold limit, unless it is a matter of operational ease or professional expertise, services should normally be outsourced to external service providers. When services

volume increases beyond the threshold limit on permanent basis over a time period, organization may consider making capital investments on in-house services in place of outsourcing to external service provider. Reducing expenses on services but without compromising quality of services in any way should be seen as a ***value creation*** for the hospital in terms of less expensive services, and diverting services to other more ***value-adding activities*** in an organization. When IT and ITeS are not part of a hospital's area of core-competence and their volume is also below the cut-off limit, it is sensible to outsource these services. However, an organization while outsourcing can exercise all flexibilities from total outsourcing to total in-sourcing or selective outsourcing in varying magnitude.

Based on this study, it was found that hospitals can have their own MRI and CAT scan facility and run them on profit center lines, when the facility is made to be utilized minimum for more than 3.61 and 4.1 hours/day. Similarly for determining limits for outsourcing ultrasound services, unit services rates are determined for each incremental rise in services volume, which on comparison with prevalent market rates charged by service provider, can help find out such limits (Table 13 to 15).

4. CAT Scan Services

Total capital costs of reconditioned CAT scan services involved an expenditure of Rs. 28, 19,963 including the cost of hardware, software, furniture, fixtures, electric works, air-conditioning, civil works, etc. (Table 13). Power expenses were estimated as Rs. 21, 240 per annum on per shift basis. Annual building rentals for seven year period were estimated as Rs. 13,104, Rs. 14,676; Rs. 16,438; Rs.18,410 and Rs, 20,619. Based on service contract and past experience, annual maintenance charges for CAT Scan Services were estimated as Rs.1.17, 1.19, 1.21, 1.23 and 1.25 lakh, respectively. Annual expenses of the operating staff were taken as 3.58 laks per annum. Costs of

consumption of computer stationery were taken as Rs. 11.84 per hour. (However, rates have gone up considerably since when the study was carried out).

Let x be the break-even point (hours of hardware/ITeS per day) above which in-house computer operations are more economical and below which in-house services are more economical.

Fixed costs + variable costs = total costs

610907 + 488164 + 21240 + 3433x = (25x12x925) x

Whence,

x = 4.1 hours/day

5. MRI Services

Total capital costs of the reconditioned MRI services involved an expenditure of Rs. !7, 11,977 inclusive of the costs of hardware, software, furniture, fixtures, electric works, air-conditioning, civil works, etc. (Table 14). Total estimated costs on power were to the tune of Rs. 39,672 per shift inclusive of the costs of fans, light, air-conditioners. Annual building rentals for seven year periods were estimated as Rs. 15,846; Rs. 17,748; Rs. 19,978; Rs. 22,263; Rs.24,935; Rs.27,927 and Rs. 31,278. Based on service contract and past experience, annual maintenance charges for MRI services for seven year period were estimated as Rs.1.42, 1.44, 1.46, 1.48, 1.50, 1.52 and 1.54 lakh, respectively. Annual expenses of the operating staff were taken as 3.6 lakhs per annum. Costs of computer stationery items were taken as Rs. 11.84 per hour. However, costs have gone up considerably since then.

Let x be the break-even point (hours of hardware/ITeS per day) above which in-house computer operations are more economical and below which in-house services are more economical.

Table 13 Economics of Working of Reconditioned CAT Scan Equipment along with IT Accessories during Single Shift Working for Varying Facility Utilization
(All cost figures in rupees)

No. of Shifts	Facility Utilization in Hours	Capital Recovery taking into Account Interest on Capital and Depreciation	Total Annual Fixed Operating Costs (Shift Dependent)	Total Annual Variable Power Costs (Shift Dependent)	Total Annual Variable Costs of Consumables (Usage Dependent)	Total Annual Costs (Fixed+Variable)	Operating Costs per Hour	Costs Chargeable as per the Prevalent Market Rates	Relative Gains from In-house Facility
1	2	6,10,907	4,88,164	21,240	6,866	11,27,177	1878.60	5,55,000	(-) 5,72,177
	3	6,10,907	4,88,164	21,240	10,299	11,30,610	1256.20	8,32,500	(-) 2,98,110
	4	6,10,907	4,88,164	21,240	13,732	11,34,043	945.00	11,10,000	(-) 24,043
	5	6,10,907	4,88,164	21,240	17,165	11,37,476	758.30	13,87,500	2,50,029
	6	6,10,907	4,88,164	21,240	20,598	11,40,909	634.00	16,65,000	5,25,091
2	6	6,10,907	4,88,164	42,480	20,598	11,62,149	645,60	16,65.000	5,02,851
	9	6,10,907	4,88,164	42,480	30,897	11,72,448	434.00	24,97,500	13,25,052
	12	6,10,907	4,88,164	42,480	41,196	11,82,747	328.50	33,30,000	21,47,253
3	12	6,10,907	8,46,224	63,720	41,196	15,62,047	434.00	33,30,000	17,67,953
	15	6,10,907	8,46,224	63,720	51,495	15,72,346	349.40	41,62,500	25,90,154
	18	6,10,907	8,46,224	63,720	61,794	15,82,645	293.00	49,95,000	34,12,355
4	18	6,10,907	8,46,224	84,960	61,794	16,03,885	297.00	49,95,000	33,91,115
	21	6,10,907	8,46,224	84,960	72,093	16,14,184	256.00	58,27,500	42,13,316
	24	6,10,907	8,46,224	84,960	82,396	16,24,483	225.60	66,60,000	50,35,517

Table 14 Economics of Working of Reconditioned MRI Equipment along with IT Accessories during Single Shift Working for Varying Facility Utilization
(All cost figures in rupees)

No. of Shifts	Facility Utilization in Hours	Capital Recovery taking into Account Interest on Capital and Depreciation	Total Annual Fixed Operating Costs (Shift Dependent)	Total Annual Variable Power Costs (Shift Dependent)	Total Annual Variable Costs of Consumables (Usage Dependent)	Total Annual Costs (Fixed+Variable)	Operating Costs per Hour	Costs Chargeable as per the Prevalent Market Rates	Relative Gains from In-house Facility
1	2	4,51,307	5,18,618	19,836	6,866	9,96,627	1661.0	5,55,000	(-) 4,41,627
	3	4,51,307	5,18,618	19,836	10,299	10,00,060	1112.0	8,32,500	(-) 1,67,560
	4	4,51,307	5,18,618	19,836	13,732	10,03,493	836.0	11,10,000	1,06,507
	5	4,51,307	5,15,618	19,836	17,165	10,07,376	671.6	13,87,500	3,80,124
	6	4,51,307	5,18,618	19,836	20,598	10,10,359	561.3	16,65,000	6,54,641
2	6	4,51,307	5,18,518	39,672	20,598	10,30,134	572.3	16,65,000	6,34,866
	9	4,59,307	5,18,618	39,672	30,897	10,40,494	385.4	24,97,500	14,57,006
	12	4,51,307	5,18,618	39,672	41,196	10,50,793	292.0	33,30,000	22,79,207
3	12	4,51,307	8,79,390	59,508	41,196	14,31,401	397.6	33,30,000	18,98,599
	15	4,51,307	8,79,390	59,390	51,495	14,41,700	320.4	42,62,500	27,20,800
	18	4,51,307	8,79,390	59,508	61,794	14,59,999	269.0	49,95,000	35,43,001
4	18	4,51,307	8,79,390	79,344	61,794	14,71,835	272.6	49,95,000	35,23,165
	21	4,51,307	8,79,390	79,344	73,093	14,82,134	235.3	58,27,500	43,45,366
	24	4,51,307	8,79,390	79,344	82,396	14,92,433	207.3	66,60,000	51,87,567

Fixed costs + variable costs = total costs

FC + VC (x) = (25x12x925) x

451307 + 51618 + 19836 + 3433x = (300x925) x

Whence,

x = 3.61 hours/day

6. Ultrasound Testing Services

Total capital cost of pre-owned and re-conditioned ultrasound equipment including was taken as Rs. 1,08,725. Power consumption was estimated as Rs. 2400 per annum on per shift basis. Annual building rentals for housing the facility for seven year period were estimated as Rs. 12,000, Rs. 13,000, Rs. 15,000; Rs. 18,000 and Rs. 20,000, respectively. Annual expenses on operating staff were estimated as Rs. 1,22,268. Cost of consumption of computer stationery was estimated as Rs. 5.48 per hour on single shift basis (Table 15).

Table 15: Economics of Working of Reconditioned Ultrasound Equipment along with IT Accessories During Single Shift Working for Varying Facility Utilization
(All cost figures in rupees)

Equipment Utilization in Hours	Capital Recovery Based on Interest on Capital and Depreciation	Total Annual Fixed Operating Costs (Shift Dependent)	Total Annual Variable Power Costs (Usage Dependent)	Total Annual Variable Costs of Consumables (Usage Dependent)	Total Annual Costs (Fixed and Variable)	Operating Costs per Hour
1	29374	57904	942	2058	90278	301.0
2	29374	57904	1884	4116	93278	155.5
3	29374	57904	2826	6174	96278	107.0
4	29374	57904	3768	8232	99278	83.0
5	29374	57904	4710	10290	102278	68.2
6	29374	57904	5652	12348	105278	58.5
7	29374	57904	6594	14406	108278	51.5
8	29374	57904	7536	16364	111278	46.4
9	29374	57904	8478	18522	114278	42.3
10	29374	57904	9420	20580	117278	39.0

Note: Costs have gone up considerably since when the study was carried out.

7. Concluding Remarks

A hospital's all IT/ITeS should as far as possible be run on profit centre basis as scattered services in various departments may not make much economic sense. When doing in-house, hospitals should preferably carry out their MRI, CAT scan and other ITeS such as ultrasonic testing services on profit centre basis by bringing out all-round awareness among medical and computer professionals in this regard. Each profit centre for distinct IT/ITeS in hospitals should be managed by a systems manager as in-charge of system development, system audit and the one who interacts with system users.

Systems managers in organizations can play important role in hardware and software procurement and periodic system up-gradation of jobs. In fact, it should not be understood that hospitals should always procure application softwares developed by others, but they should also develop their own software tailor-made to their specific needs wherever they can, in case they possess necessary IT expertise. Systems

managers need to accord priorities to software development projects in keeping with the emerging hospital needs. While developing internally, as far as possible software should be developed by joint project teams covering both computer professionals and user representatives or domain experts.

Systems managers of different profit centers of IT/ITeS should be in constant touch with one another, with a view to sort out matters related to software compatibility and uniformity, and software transfer from one center to another. System manager apart from software procurement and software development are also responsible for system operation and advising on matters like outsourcing of IT/ITeS to outside service providers wherever it is economically and professionally beneficial. As hospitals that outsource some of their services become more efficient, they can serve patients at lower costs, which in turn can boost demand for their services and bring all round system improvement.

About the Author

K. M. Mital is presently working as Professor of Strategic Management at the IILM Institute for Higher Education, Lodhi Road, New Delhi. He has earlier worked in three major public enterprises in energy sector, namely, BHEL for sixteen years, ONGC for nine years and EIL for twelve years. During 2003-04 for one year he taught as Professor at the Department of Management Studies, IIT, Roorkee on deputation from the Engineers India, where he joined back in May 2004 and worked till December 31, 2004 as General Manager (HR). Dr. Mital holds a B.E.(Mech.) and M.E.(Prod.) degrees from the erstwhile University of Roorkee and Ph. D in Industrial Engineering from the IIT Delhi. Dr. Mital is author of over one hundred and fifty papers and five books in the field of management and energy. Dr. Mital is having considerable editorial experience and is currently the editor of the IILM Journal 'Management & Change'.

Annexure 1

1. Estimation of Total Expenses for MRI Equipment and IT Accessories

1.1 Five Year Replacement Policy

C = 17, 11,877 S = 1, 50,000

n = 5 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\, s_{\overline{n}|i} = C(1+i)^n - S$

$= 1711977\,(1+0.12)^5 - 150000$

$= 2867088$

$s_{\overline{n}|i} = \frac{(1+i) - 1}{i} = \frac{(1+0.12)^5 - 1}{0.12}$

$= 6.535285$

Hence,

$R = \frac{2867088}{6.35285} = 451307$

Table 1: Depreciation Schedule of Reconditioned MRI Equipment and Related IT Accessories as per Sinking Fund Method
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	30,17,088
1	4,51,307	0	4,51,307	4,51,307	25,65,781
2	4,51,307	54,157	5,05,464	9,56,771	20,60,317
3	4,51,307	1,14,813	5,66,120	15,22,892	14,94,196
4	4,51,307	1,82,747	6,34,054	21,56,946	8,60,142
5	4,51,307	2,58,834	7,10,141	28,67,088	1,50,000

1.2 Six Year Replacement Policy

C = 17, 11,877 S = 1,00,000

n = 6, i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\, s_{\overline{n}|} = C(1+i)^n - S$

$R\ s\overline{n}|_i = 1711977\ (1+0.12)^6 - 100000$

$= 3279139$

$s\overline{n}|_i = \frac{(1+i)^n - 1}{i} = \frac{(1+0.12)^6 - 1}{0.12}$

$= 8.1152$

Hence, $R = \frac{3279139}{8.1152} = 404074$

Table 2: Depreciation Schedule of Reconditioned MRI Equipment and Related IT Accessories as per Sinking Fund Method
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	33,79,139
1	4,04,074	0	4,04,074	4,04,074	29,75,065
2	4,04,074	48,489	4,52,563	8,56,637	25,22,502
3	4,04,074	1,02,796	5,06,870	13,63,507	20,15,632
4	4,04,074	1,63,621	5,67,695	19,31,202	14,47,937
5	4,04,074	2,31,744	6,35,818	25,67,020	8,12,119
6	4,04,074	3,08,042	7,12,116	32,79,136	1,00,000

1.3 Seven Year Replacement Policy

C = 17, 11,877 S = 70,000

n = 7, i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\ s\overline{n}|_i = C\ (1+i)^n - S$

$= 1711977\ (1+0.12)^7 - 70000$

$= 3714635$

$s\overline{n}|_i = \frac{(1+i)^n - 1}{i} = \frac{(1+0.12)^7 - 1}{0.12}$

$= 10.09$

Hence,

$R = \frac{3714635}{10.09} = 368186$

Table 3: Depreciation Schedule of Reconditioned MRI Equipment and Related IT Accessories as per Sinking Fund Method
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	37,84,635
1	3,68,186	0	3,68,186	3,68,186	34,16,449
2	3,68,186	44,182	4,12,368	7,80,554	30,04,081
3	3,68,186	93,667	4,61,853	12,42,407	25,42,228
4	3,68,186	1,49,089	5,17,275	17,59,682	20,24,953
5	3,68,186	2,11,162	5,79,348	23,39,030	14,45,605
6	3,68,186	2,80,684	6,48,870	29,87,900	7,96,735
7	3,68,186	3,58,548	7,26,734	37,14,634	70,000

Table 4 Estimates of Annual Fixed and Variable Operating Expenses and Capital Recovery on Account of Depreciation and Interest on Capital for a Reconditioned MRI Equipment Along With IT Accessories

Item	Year 1 (Rs.)	Year 2 (Rs.)	Year 3 (Rs.)	Year 4 (Rs.)	Year 5 (Rs.)	Year 6 (Rs.)	Year 7 (Rs.)
Maintenance Costs							
1. Annual maintenance charges	1,42,000	1,44,000	1,46,000	1,48,000	1,50,000	1,52,000	1,50,000
Fixed Operating Costs							
2. Annual building rentals assumed as 12% interest of building cost and rising annually @ 12%	15,846	17,748	19,878	22,263	24,935	27,927	31,278
3. Annual manpower wage-bill	3,60,772	3,67,972	3,75,172	3,82,372	3,89,572	3,96,772	4,03,972
(a) Two shift working	7,21,544	7,35,944	7,50,344	7,64,744	7,79,144	7,93,544	8,07,972
(b) Four shift working							
4. Total fixed operating costs	5,18,618	5,29,120	5,50,635	5,52,635	5,64,502	5,76,699	5,85,250
(a) Two shift working	8,79,390	8,79,390	8,97,692	9,25,807	9,35,079	9,73,471	9,89,222
(b) Four shift working							
Variable Operating Costs	19,836	19,386	19,836	19,386	19,836	19,386	19,386
	39,672	39,672	39,672	39,672	39,672	39,672	39,672
5. Annual power consumption	59,508	59,508	59,508	59,508	59,508	59,508	59,508
(a) One shift working	79,344	79,344	79,344	79,344	79,344	79,344	79,344
(b) Two shift working							
(c) Three shift working	3,433	3,433	3,433	3,433	3,433	3,433	3,433
(d) Four shift working							
6. Annual consumable charges based on minimum 1-hour/day working.							

Capital Recovery on Account of Depreciation and Interest on Capital	
7. Capital recovery for -	
(a) 5-year replacement	4,51,307 4,51,307 4,51,307 4,51,307 4,51,307 4,51,307 4,51,307
(b) 6-year replacement	4,04,074 4,04,074 4,04,074 4,04,074 4,04,074 4,04,074 4,04,074
(c) 7-year replacement	3,68,186 3,68,186 3,68,186 3,68,186 3,68,186 3,68,186 3,68,186

Note: Costs have gone up considerably since when the study was carried out.

2. Estimation of Total Expenses CAT Scan Equipment and IT Accessories

Five Year Replacement Policy

C = 28,19,968 S = 1,70,000

n = 5, i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$$R\, s\overline{n}|_i = C(1+i)^n - S$$

$$= 2819968\,(1+0.12)^5 - 170000$$

$$= 4799747$$

$$s\overline{n}|_i = \frac{(1+i)-1}{i} = \frac{(1+0.12)^5 - 1}{0.12}$$

$$s\overline{5}|_{0.12} = 6.35285$$

Hence,

$$R = \frac{4799747}{6.3528} = 755526$$

Table 5: Depreciation Schedule for CAT Scan Equipment as per Sinking Fund Method
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	45,69,747
1	7,55,526	0	7,55,526	7,55,526	42,14,211
2	7,55,526	90,663	8,64,189	16,01,715	33,68,032
3	7,55,526	1,92,206	9,47,732	25,49,447	24,20,300
4	7,55,526	3,05,934	10,61,460	36,10,907	13,58,840
5	7,55,526	4,33,309	11,88,835	47,99,742	1,70,000

2.1 Six Year Replacement Policy

C = 28,19,968 S = 1,00,000

n = 6 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\, s\urcorner_{n\,i} = C\,(1+i)^n - S$

$= 2819968\,(1+0.12)^6 - 100000$

$= 5466117$

$s\urcorner_{n\,i} = \frac{(1+i)^n - 1}{i} = \frac{(1+0.12)^6 - 1}{0.12}$

$s\urcorner_{6}\,0.12 = 8.1152$

Hence,

$R = \frac{5466117}{8.1152} = 673565$

Table 6: Depreciation Schedule as per Sinking Fund Method for Reconditioned CAT Scan Equipment along with IT Accessories (All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	35,66,117
1	6,73,565	0	6,73,565	6,73,565	48,92,552
2	6,73,565	80,828	7,54,393	14,27,958	41,38,159
3	6,73,565	1,71,355	8,44,920	22,72,878	32,93,239
4	6,73,565	2,72,745	9,46,310	32,19,188	23,46,929
5	6,73,565	3,86,303	10,59,868	42,79,056	12,87,061
6	6,73,565	5,13,487	11,87,052	54,66,108	1,00,000

2.2 Seven Year Replacement Policy

C = 28,19,968 S = 70,000

n = 7 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\, s\urcorner_{n\,i} = C\,(1+i)^n - S$

$= 2819968\,(1+0.12)^7 - 70,000$

$= 6164051$

$$s\overline{n}|_i = \frac{(1+i) - 1}{i} = \frac{(1+0.12)^7 - 1}{0.12}$$

$$s\overline{n}|_i 0.12 = 10.09$$

$$\text{Hence, } R = \frac{6164051}{10.09} = 6,10,907$$

Table 7: Depreciation Schedule as per Sinking Fund Method for Reconditioned CAT Scan Equipment along with IT Accessories
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	62,34,051
1	6,10,907	0	6,10,907	6,10,907	56,23,144
2	6,10,907	73,309	6,84,216	12,95,123	49,38,928
3	6,10,907	5,34,585	7,66,322	20,61,445	41,72,606
4	6,10,907	2,47,272	8,58,280	29,19,725	33,14,326
5	6,10,907	3,50,367	9,61,274	38,80,999	23,53,052
6	6,10,907	4,65,720	10,76,627	49,57,626	12,76,425
7	6,10,907	5,94,915	12,05,822	61,63,448	70,000

Table 8: Estimates of Annual Fixed and Variable Operating Expenses and Capital Recovery on Account of Depreciation and Interest on Capital for Reconditioned CAT Scan Equipment along with IT Accessories

Item	Year 1 (Rs.)	Year 2 (Rs.)	Year 3 (Rs.)	Year 4 (Rs.)	Year 5 (Rs.)	Year 6 (Rs.)	Year 7 (Rs.)
Maintenance Costs							
A. Annual maintenance charges	NA	NA	1,17,000	1,19,000	1,21,000	1,23,000	1,25,000
Fixed Operating Costs							
B. Annual building rentals assumed as 12% interest of building cost and rising annually @ 12%.	NA	NA	13,104	14,676	16,438	18,410	20,619
C. Annual manpower wage bill	NA	NA	3,58,060	3,65,260	3,79,660	3,79,660	3,86,860
(a) Two shift working	NA	NA	7,16,120	7,30,520	7,44,920	7,59,320	7,73,720
(b) Four shift working							
D. Total fixed operating costs	NA	NA	4,88,164	4,98,936	5,09,898	5,21,070	5,32,479
(a) Two shift working	NA	NA	8,46,224	8,64,196	8,82,358	9,00,730	9,19,339
(b) Four shift working							
Variable Operating Costs	NA	NA	21,240	21,240	21,240	21,240	21,240

5. Annual power consumption	NA	NA	42,480	42,480	42,480	42,480	42,480
(a) One shift working	NA	NA	63,720	63,720	63,720	63,720	63,720
(b) Two shift working	NA	NA	84,960	84,960	84,960	84,960	84,960
(c) Three shift working							
(d) Four shift working							
	NA	NA	3,433	3,433	3,433	3,433	3,433
6. Annual consumable charges based on minimum 1-hour/day working.							
Capital Recovery on Account of Depreciation and Interest on Capital							
	7,55,526	7,55,526	7,55,526	7,55,526	7,55,526	-	-
7. Capital recovery for –	6,73,565	6,73,565	6,73,565	6,73,565	6,73,565	6,73,565	-
(a) 5-year replacement	6,10,907	6,10,907	6,10,907	6,10,907	6,10,907	6,10,907	6,10,907
(b) 6-year replacement							
(c) 7-year replacement							

Note: Costs have gone up considerably when the study was carried out.

3. Estimation of Total Expenses for Ultrasound Equipment and IT Accessories

3.1 Three Year Replacement Policy

C = 1, 08,726 S = 15,000

n = 3 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$$R\, s\overline{\rceil}_{n\,i} = C(1+i)^n - S$$

$$= 108726\,(1+0.12)^3 - 15000$$

$$= 137752$$

$$s\overline{\rceil}_{n\,i} = \frac{(1+i)-1}{i} = \frac{(1+0.12)^3 - 1}{0.12}$$

$$s\overline{\rceil}_{3}\,0.23 = 3.374$$

Hence,

$$R = \frac{137752}{3.374} = 40827$$

Table 9: Depreciation Schedule as per Sinking Fund Method for Reconditioned Ultrasound Equipment along with IT Accessories
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	1,52,752
1	40,827	0	40,827	40,837	1,11,925
2	40,827	4,900	45,727	86,554	66,198
3	40,827	10,387	51,214	1,37,768	15,000

3.2 Four Year Replacement Policy

C = 1, 08,726 S = 10,000

N = 4 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$$R\, s_{\overline{n}|i} = C(1+i)^n - S$$

$$= 108726\,(1+0.12)^4 - 10000$$

$$= 161082$$

$$s_{\overline{n}|i} = \frac{(1+i) - 1}{i} = \frac{(1+0.12)^4 - 1}{0.12}$$

$$s_{\overline{4}|0.23} = 4.779$$

Hence,

$$R = \frac{161082}{4.779} = 33706$$

Table 10: Depreciation Schedule as per Sinking Fund Method for Reconditioned Ultrasound Equipment along with IT Accessories
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	1,71,082
1	33,706	0	33,706	33,706	1,37,376
2	33,706	4,046	37,751	7,457	99,625
3	33,706	8,575	42,281	1,13,738	57,344
4	33,706	13,649	47,355	1,61,093	10,000

3.3 Five Year Replacement Policy

C = 1, 08,726 S = 5,000

n = 5 i = 0.12

If i is the interest earned by the depreciation fund, then the annual deposit R in the fund is given by

$R\, s\urcorner_{n\,i} = C\,(1+i)^n - S$

$= 108726\,(1+0.12)^5 - 5{,}000$

$= 186612$

$s\urcorner_{n\,i} = \frac{(1+i)\ -\ 1}{i} = \frac{(1+0.12)^5 - 1}{0.12}$

$s\urcorner_{5}\,0.23 = 6.353$

Hence,

$R = \frac{186612}{6.353} = 29374$

Table 11: Depreciation Schedule as per Sinking Fund Method for Reconditioned Ultrasound Equipment along with IT Accessories
(All cost figures in rupees)

Age	Depreciation Charge	Interest on Fund	Increase in Fund	Amount in Fund	Book Value
0	0	0	0	0	1,91,612
1	29,374	0	29,374	29,374	1,62,238
2	29,374	3,525	32,899	62,272	1,29,340
3	29,374	7,472	36,846	99,118	92,494
4	29,374	11,894	41,294	1,40,386	51,226
5	29,374	16,846	46,220	1,86,606	50,000

Table 12: Estimates of Annual Fixed and Variable Operating Expenses and Capital Recovery on Account of Depreciation and Interest on Capital for Reconditioned Ultrasound Equipment

Item	Year 1 (Rs.)	Year 2 (Rs.)	Year 3 (Rs.)	Year 4 (Rs.)	Year5 (Rs.)
Maintenance Costs					
A. Annual maintenance charges	12,000	13,000	15,000	18,000	20,000
Fixed Operating Costs					
B. Annual building rentals assumed as					

12% interest of building cost and rising annually @ 12%.	5,148	5,766	6,458	7,233	8,100
C. Annual manpower wage bill					
D. Total fixed operating costs	40,756	41,476	42,196	42,916	43,636
Variable Operating Costs					
E. Annual power consumption	942	942	942	942	942
F. Annual consumables charges based on minimum 1 hour/day working.	2,058	2,058	2,058	2,058	2,058
Capital Recovery on Account of Depreciation and Interest on Capital					
G. Capital recovery for					
	10,827	40,827	40,827	-	-
(a) 5-year replacement	33,706	33,827	33,706	33,706	-
(b) 6-year replacement	29,374	29,374	29,374	29,374	29,374
© 7-year replacement					

Note: Costs have gone up considerably since when the study was carried out.