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Financial Appraisal Of Railway Projects

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CHAPTER II

Financial Appraisal Of Railway Projects

201. General Principle -Indian Railways is part of infrastructure Ministry and hence substantial investments are to be made for augmentation of capacity and expansion of network which require large investment. Investment decisions are the most important decisions to be made. It is fundamental to railway system as a commercial undertaking that expenditure other than that wholly chargeable to Ordinary Revenue incurred on new assets or for improvement of existing assets should be financially justified and no expenditure should be incurred without sanction. Moreover these decisions are to be made by keeping long term perspective in mind and treating IR as a national asset.

202. As an exception to Para 201, while no financial justification as such need be given in the following cases, it should be seen that the scale of expenditure incurred is as economical as possible consistent with the extant orders, if any, on the subject:-

a) when the expenditure is incurred on a statutory obligation;
b) when the expenditure is unavoidable on considerations of safety;
c) when the expenditure is incurred on **passenger amenity*** works; and
d) when the expenditure is incurred on labour welfare works except residential buildings for which special rules are applicable.

*(Authority Board's letter no. 2023/F(X) II/10/1 dated 01/02/2023 ACS No1)

Note -

1) When expenditure on any of the above items forms part of a scheme and is not essential independently of the scheme, the total cost of the scheme, inclusive of the cost of the above works, should be financially justified.

2) In the case of savings in engine days or wagon days or both by avoidance of or reduction in detentions to stock, etc., the financial justification should be worked out on the basis of increased locomotive or wagon, etc., utilization and consequent postponement of the purchase of new engines or wagons, etc., if such saving can be definitely secured, and not on the basis of the earning capacity of the stock saved.

3) Savings on a particular railway should not be taken into account if they mean a loss on another railway. In such cases, the interest of railways as a whole should be considered.

4) No credit should be given to a proposed scheme for a saving which can be achieved regardless of whether the proposed scheme is or is not embarked upon.

5) If flag stations are included in the new scheme, the cost of operating them should be taken into account as an item of expense in working out the financial justification of the scheme.

6) Where a number of works required in connection with and/or increasing the line or transhipment capacity have to be carried out on different stations of a section as part of a scheme, the financial justification should be worked out for the section as a whole, as it might be difficult to allocate anticipated savings to individual stations.

7) Expenditure on works required for meeting statutory obligations or on consideration of safety should be subjected to proper scrutiny to see if the proposal is the result of a fresh development not already covered by the existing rules, or for implementation of a new recommendation of the Standing Safety Committee (accepted by the competent authority) or any Commission of Enquiry set up by Government, as the case may be.

203. Scrutiny by Finance & Accounts Officer -The **Finance &** Accounts Officer in his position as the Financial Adviser to the Administration, should carefully scrutinize the justification for proposed expenditure with reference to the principles enunciated in this Chapter and other orders on the subject. Even in cases where the return on the investment is not the determining factor, it will be incumbent on him to examine and offer his advice on the general merits of the proposal in the spirit of a prudent individual spending his own money.

204. Test of remunerativeness: The net financial gain expected to accrue from a project be either by way of savings in expenditure or increase in net earnings (i.e. gross earnings less working expenses),or a combination of both. Except in case residential buildings, assisted sidings and rolling stock to which special rules are applicable, no proposal for fresh investment will be considered as financially justified unless it can be shown that the net gain expected to be realized as a result of the proposed outgo would after meeting the working expenses or average annual cost of service(see para217) yield a return of not less than 10 percent under DCF method on the initial estimated cost.

(Authority:F(X)-II/2011/ROR/1 dated 05.10.2017)

Note-

1) Interest during construction should be added to the cost (excluding that chargeable to Revenue) of the projects, the construction of which is likely to last for more than one year.

2) Depreciation should be calculated on the total cost of the scheme and not only on the portion chargeable to Capital, unless the contrary procedure can be justified in any particular case. However, depreciation as an element of working expense is to be ignored for assessing annual cash flows under the DCF Method (see para 228).

3) In the case of construction of bridges, maintenance charges should include, besides the Maintenance charges on the bridges proper.

4) The element of interest charges, vide item (d) of para-215, should be ignored in determining the average annual cost of service in the case of a new project, though it should otherwise be included for the purpose of working out the comparative cost of two or more alternative schemes.

205. Following is an illustrative list of the various types of investment proposals which must pass the prescribed test of financial remunerativeness:

a) New Lines: -
   1) Project oriented or 'single purpose'.
   2) General purpose.

b) Line Capacity Works-
   1) Gauge conversions.
   2) Doublings.
   3) Major Signalling Schemes i.e. Tokenless Block Working, Automatic Block Signalling, CTC, Route Relay Interlocking, KAVACH etc.
   4) Lengthening of loops and/or provision of additional loops.
   5) Crossing stations.
   6) Strengthening of electric traction distribution system and/or major modifications to electric traction installations.

c) Yard Remodelling and Terminal Facilities-

1) Marshalling yards.
2) Goods and passenger terminals.
3) Transhipment points.

d) Telecommunication Works.

e) Electrification and provision of Loco Sheds herefore

f) Introduction of new services- Passenger trains, container services, etc.

g) Workshops-
1) Production Units.
2) Repair Units.

206. It may sometimes be necessary to reject a more economical alternative, because of considerations on which it is difficult to put a precise money value. If on the strength of any such factor a proposal is adopted that is less economical than its alternatives, the reasons determining such a choice should be recorded in the report of the estimate containing such proposals. In those cases in which the reasons as recorded are not accepted by the Finance & Accounts Officer, the latter should offer his remarks in his certificate of verification of the estimate concerned, so that these remarks may be taken into consideration by the authority sanctioning the proposal.

207. In regard to works proposals which are intended to increase line capacity, detailed traffic surveys should be conducted by a team consisting of officers of requisite status and experience from the Commercial/Operating Department and the Finance & Accounts Department. Where the traffic survey is conducted along with an engineering survey (Reconnaisance, Preliminary Engineering or Final location), the traffic survey report should be prepared under the general guidance of the Leader of the Team who will be an officer of appropriate status from the Civil Engineering Department.

208. Provision of Rolling Stock –Investment proposals for purchase/manufacture of additional rolling stock are to be justified on the basis of a general increase in the level of traffic which may or may not require line capacity works being taken up at the same time for the anticipated level of traffic. Where a line capacity work is justified due to anticipated increase in traffic, and also in the case of proposals for new line construction, the initial cost estimate should, for the purpose of Project appraisal, invariably include the cost of the rolling stock and the financial return on the project should be measured with reference to the overall initial cost of the project including the cost of rolling stock.

209. A very substantial part of the capital employed on the Railways is represented by the investment in rolling stock. The assessment of rolling stock required for moving additional traffic is directly related to the targets for movement of freight traffic, commodity-wise as projected by the Planning Directorate of the Railway Board. For additional passenger coaches, the Planning Directorate makes a forecast of the rate of growth of passenger traffic over a specified plan period. This detailed exercise should take into account the existing and projected operating parameters and efficiency indices such as wagon turn-round, provision for 'sickness', requirements for busy season, etc. In all cases where a distinctly new type of rolling stock is proposed to be acquired or manufactured, a detailed financial appraisal should be made of the proposed investment to see that it yields the requisite financial return.

210. Scheme for change of traction –Projects connected with the electrification are best formulated on a long term basis after considering the relative claims of the various high density sections of the Railways for better traction. A thorough techno-economic appraisal should be made in respect of each of the various sections proposed to be taken up for change of traction. Wherever possible, priorities for taking up the scheme for change of traction should be determined on the basis of the relative financial return expected from the various alternative schemes.

211. Revenue estimate –The revenues expected from additional traffic whether on the existing line or on a new line should be very carefully estimated in the traffic survey report. The estimate of revenues should be worked out for each commodity and for the lead from its origin up to the point of termination of the traffic. It should be ensured, however, that in case line capacity works are required to be undertaken in the contiguous section or Railway system over which the additional traffic is expected to be moved, the initial cost estimate for the scheme takes into account the cost of such additional line capacity works over the entire lead of the traffic.

212. In the case of a 'project-oriented' new line, i. e., when a new railway line is proposed to be built to serve the needs of a specific project or industrial complex, the estimated revenue from the traffic which will move on the line should be assessed realistically in consultation with the authorities concerned with that specific project. It is, however, essential that the Traffic Survey Team also makes its own independent assessment of the likely traffic which the project is expected to generate, instead of placing complete reliance on the data furnished by the Project Authorities or, in the case of a public sector undertaking, the concerned Department of the Government. The traffic survey officers must deeply probe into the various stages of scheduling of the project; e. g. what commitments have been entered into by the

Project Authorities and whether the progress in the execution of the project is adequate to justify any specific claim in respect of the anticipated traffic. While working out the additional revenue from the traffic expected to move on the new line over its entire lead, the Railway Administration should make a careful assessment of the line capacity works required or terminal or any other facilities to be developed on the contiguous section/Railway system to carry this traffic. As stated in Para- 211, if additional works are considered necessary, the scope and cost thereof should be defined and included in the main project estimate. In case it is considered that adequate line capacity exists in the contiguous section or Railway system so that the additional traffic on the new line can be carried throughout its lead on the Railway without any hindrance the Railway Administration should confirm that no additional works would be required to be undertaken anywhere on the system to carry this traffic.

213. This approach inevitably involves grouping of a number of works with a common (or complementary) objective, such as for movement of additional traffic by improving line capacity, or for avoidance of detention to trains through yards. 'Group Justification' in such cases should be worked out for the project as a whole in case the individual works cannot stand on their own and must necessarily be taken up as part of a single project. However, where each of the works is self-contained, selection of priorities after consideration of various alternatives should necessarily be done with a view to 'sub-optimization', i.e. to realise the optimum benefit for the project by substituting the less remunerative sub-works by those anticipated to improve the return further.

214. Before proposals are made out for new marshalling yards or major remodeling of existing marshalling yards or mechanisation of marshalling yards, goods terminals and transhipment yards, etc., a work study team should go into the actual working and suggest such improvements in operation as can be achieved even with the existing facilities. Additional facilities should be justified only after all the possibilities of improvement in working by optimum utilisation of the existing assets have been fully explored and evaluated. For line capacity works generally Master Charts should be prepared of the existing (optimum) capacity, the extent to which it is presently utilised, and the capacity expected to be available after the provision of the proposed facilities. The additional traffic beyond the optimum existing capacity of the section should only be reckoned for financial appraisal.

215. A. Assessment of Working expenses/Average Annual Cost of Service –
The average annual cost of service of an asset is the sum of:

a) The average annual cost of operation;
b) The average annual cost of maintenance and repairs of the assets;
c) The annual depreciation charges (but see para 228);and
d) Annual interest charges on the cost of the asset.

Note.–In computing working expenses in financial evaluation of any capital expenditure proposal under D.C. F. technique, only items (a) and (b) above should be reckoned.

215 B. Average cost per unit of service -The average cost per unit of service is obtained by dividing the average annual cost of service by the total number of units of service rendered by the asset in a year. In comparing two assets on this basis, care must be taken to see that the number of units of service taken into account in both cases represent the actual number utilised or consumed. Units of service rendered by either of the assets in excess of the actual requirements should be ignored in computing the cost per unit of the asset.

216. For the purpose of assessment of the average annual cost of operation and maintenance, full use should be made of the traffic costing data relevant to the investment proposal under consideration. Correct application of the cost data and, in particular, assessment of the direct/variable and the indirect/fixed or semi-variable costs is very important in arriving at a realistic estimate of the working expenses in respect of the proposed scheme.

217. In applying the unit cost data for working out the cost of moving the additional anticipated traffic, it has to be considered whether it would be reasonable to adopt the 'incremental cost' approach or to take 'fully distributed costs' into account. Logically, it would be realistic to work on the basis of 'incremental costs' for any small increases in traffic and over the short run. In the long run, however, even the so-called fixed costs will vary, and the incremental or marginal costs may fail to cover such semi-variable expenses. On the other hand, it would be equally unreasonable to apply fully distributed costs in all cases while working out the financial implications of a line capacity work. A realistic (though somewhat conservative) approach would, therefore, be to adopt 'long term variable costs' (based on percentages given at the end of Annexure 'A' for each item of cost) which will ensure not only that projects are not thrown out because of the adoption of the 'fully distributed costs' but also that a project is considered as remunerative so long as it yields the requisite return after meeting the 'long term variable costs'.

218. **Provision for depreciation-** Depreciation provision in respect of an asset will be equal to the annual payment to a Sinking Fund which, together with the interest thereon at such rates as may be prescribed by the Railway Board, when compounded annually, will provide the amount required for the replacement of the asset at the end of the normal life. The duration of the Sinking Fund payment will be determined by the 'normal life' of the asset, and the amount of the annual Sinking Fund payment will be ascertained by referring to the table reproduced as Annexure 'B' to this Chapter, which shows the annual amount payable at different rates of interest ranging from 2% to 8% (over periods extending up to 100 years).

219. Normal lives of assets– For the purpose of the annual Sinking Fund payment referred to in para 218, the normal life of the various classes of railway assets should be taken as in the table below (However, instructions issued from time to time from Board's Office regarding Codal Life may also be referred to):-

(i) CIVIL ENGINEERING ASSETS:					
S.No.	**Class of Assets**	**Average life in years**			
		ROUTES			
		A & B	**C(Sub)**	**D**	**E***
1. **RAIL & FASTENTING etc.**					
1	**Rail & Fastenings**				
(a.1).	Rails (60kg)	25	19	38	38
(a.2)	Rails (52 kg)	20	15	30	30
(b).	Wooden Sleepers	10	10	10	10
(c.1)	Metal sleepers (Cast Iron & Steel)	20	20	20	20
(c.2)	Fittings steel trough	10	10	10	10
(d).	PSC Sleepers	35	35	40	40
(e).	**Elastic Fastenings**				
(i)	Elastic Rail clips	8	8	10	10
(ii).	Rubber Pads (GRSP)	4	4	4	4
(iii)	Rubber Pad (CGRSP)	8	8	8	8
(iv)	Metal Liners	8	8	8	8
(v)	GFN Liners	4	4	4	4
(f) Switches					
(f.1)	Switches (52 kg)	4-6	4-5	8-10	8-10

(f.2)	Switches (60 kg)	5-8	4-6	10-12	10-12
(f.3)	Thick Web Switches	14-18	13-16	20-24	20-24
(g).	Crossings	7-8	6-7	10-11	10-11
2 (A). MAJOR BRIDGES					
(a).	Bridges work- Steel work	60			
(b).	Bridge Masonry	100			
(c).	Structures Steel	60			
(d).	Structure- masonry and cement concrete	65			
(e).	RCC Bridge Works	60			
(f).	Pre-stressed concrete-Bridge work	40			
(B). MINOR BRIDGES					
(a).	Bridges work-Steel work	60			
(b).	Bridge Masonry	100			
(c).	Structures Steel	60			
(d).	Structure- masonry and cement concrete	65			
(e).	RCC Bridge Works	60			
(f).	Pre-stressed concrete-Bridge work	40			
3. FOOT OVER BRIDGES					
(a).	Bridges work-Steel work	60			
(b).	Bridge Masonry	100			
(c).	Structures Steel	60			
(d).	Structure- masonry and cement concrete,	65			
(e).	RCC Bridge Works	60			
(f).	Pre-stressed concrete-Bridge work	40			
4	TRACK MACHINE (All Categories)	15			

*Service life as indicated in the table is general life/service life for track components. However, renewal/replacement will be subject to various criteria laid down in IRPWM about its condition.

(ii) **COMPUTERS AND OTHER IT SYSTEMS:**		
S.No.	**Class of assets**	**Average life in years**
1(a)	Servers and storage devices (enterprise class)	8
1(b)	Network active devices (Routers, switches etc.)	6
1 (c)	Network passive devices (Patch panels, outlets, network cables)	10
1(d)	UPSs (>/= 50 KVA), cooling equipment (PACs, Chillers) Fire suppression systems for Data centers	8
2 (a)	UPSS< 1KVA	4
2(b)	UPS>1KVA, <50 KVA	8
3	PCs	4
4	Portable computers/Laptops, Tablets, Workstations	4
5	Thin clients / Dumb terminals (for PRS/UTS/ATVMs etc	4 years
6	Printers (All type) including MFD	5 years
7	Biometric Machines	4

Note *ATVM (composite unit) earlier at S.No.7 deleted

(iii) <u>ELECTRICAL ASSETS</u>

S.No.	Class of assets	**Average life in years**
1	Electric Locomotives	35
2	EMU/Metro Motor Coaches and EMU/Metro Trailor Coaches	25
3	Rail Bus	15
4	Over Head Power Lines	40
5	Over Head Traction Line excluding contact wire	60
6	Electric under ground Cables	30
7 (a)	Electric contact wire (Alm.)	25
(b)	Electric contact wire (Copper)	40
8	Electric Power plant excluded oil engine driven	25

9	Electric Plant above 25 HP		25
10	Electric power plant oil engine driven (diesel)		15
11	Overhead traction lines contact wire		40
12	Electric Machinery others		30
13	Electric Sub Station Building		50
14	Water Cooler, Refrigeration, Air Conditioner, hospital and domestic appliance		10
15	Internal wiring of building	Coastal area	15
		Non-coastal area	20
16	Switch Gear		25
17	Instruments		25
18	Electric Pumps		20
19	Electric Lifts & Hoist		20
20	Ceiling Fans		20
21	Electric Battery charging set		15
22	Flood Light Projection		10
23	Battery lead Acid		4
24	(a) Coach wiring (old)		12
	(b) Coach wiring (e beam)		18
25	Carriage Fans		10
26	Air conditioner Central unit – above 3 tons		10
27	Safe load Indicator		8
28	Pantry equipments		6
B) Equipments required for replacement through DRF/ Sinking Fund			
S.No.	**Class of assets**		**Average life in years**
1	**AC EQUIPMENT**		
(i)	25 KVA Inverter		15
(ii)	AC Control Panel		15
(iii)	Inverter Panel		15
2	**TL Power Equipment**		
(i)	4.5/25 KW Alternator		12

(ii)	800 A.H.L.A Battery	Delete
(ii)	1100 AH VRLA (SMF) Battery	4.5
(iii)	Diesel Engine for Power Cars	(i) 20 years for those assets which have completed less than 10 years (ii) 16 years for those assets which have completed over 10 years.
(iv)	Alternator for Power Car	
3	**Electric Locomotive Equipments**	
(i)	All Electric rotating machines up to 25 HP used on Electric Locomotives, EMU's Coaches and stationary items	12
(ii)	All Electric rotating machines above 25 HP and upto 750 HP used on Electric Locomotives, EMU's Coaches and for stationary items	12
(iii)	Traction Motor	18
(iv)	Traction Converters	18
(v)	Auxiliary Converters	18
(vi)	Control Electronics	18
(vii)	Tap-Changer	35
(viii)	Rectifier Block	18
(ix)	Traction Gears	12
(x)	Motor Suspension	12
(xi)	Bogies with Wheel	18
(xii)	Armature for Traction Motors	15
(xiii)	Stator for Traction Motor	18
(xiv)	Commutator for Traction Motor	15
(xv)	Locomotive re-cabling	18
4	Microprocessor based control and fault diagnostic system	12
5	Speedometer cum recorder and monitoring system	10
6	BA Panel	18

7	VCB		18
8	DBR (roof mounted)		9
9	DBR (vertical mounted)		9
10	Pantograph		12
11	**TRD Equipments**		
(i)	Current/Potential/transformer		30
(ii)	Earthling system in sub-station etc.		15
(iii)	Lightning arrestor (Gapless type)	(a) 42 KV)	15
		(b) 96 KV/120 KV/198 KV	20
(iv)	Lightning arrestor (Convertor type)		15
(v)	Buster & Terminal connection		30
(vi)	Battery charger		20
(vii)	Relay (Electromechanical)		15
(viii)	Relay (Electronic)		15
(ix)	Instruments (Electrical)		30
(x)	Instruments (Electronic)		30
(xi)	Relay testing kit & other testing equipment		15
(xii)	**OHE conductors & components - For Normal Zone**		
(a)	**OHE fixed structures**		
(i)	Mast / Structure / Guy Rod / foundation		80
(b)	**Other than fixed structures**		
(i)	a) Cantilevers assembly		45
(i)	b) All types of insulators	(a) Porcelain	40
		(c) Composite	25
	(ii) Isolators / ATD	(a) Isolators	30
		(b) ATD	32
(c)	**Wires**		
	(i) Catenary / feeder wire / return conductor	60	
	(ii) Contact wire	45	
(xiii)	**OHE conductors & components - For Polluted Zone ****		

**Definition of polluted zone for item xiii under OHE conductors & components (for Polluted Zone)- Zones having ESDD(Equivalent Salt Deposit Density) >0.3 should be considered as Polluted Zone.			
i)	Cantilever assembly &	Cantilever assembly	45
	Insulators:		
	All types of insulators	Composite	25
ii)	ATD		24
iii)	Contact Wire	(a) Silver Brazed/ERB W	40 years/on the basis of condemning dia. whichever is earlier
		(b)Continuous Cast(CC) type	45 years/ on the basis of condemning dia. whichever is earlier
(xiv)	**PSI Equipments**		
(a)	Substation's equipments		
	(i) Power Transformer / Auxiliary Transformers		40
	(ii) All types of cables		30
	(iii) Fixed capacitor bank		20
(b)	**Control equipments**		
	(i) Circuit Breaker, panels, all switchgear and protective circuits		25
	(ii) SCADA system		10
(xv)	**Transmission line equipments & components**		
	(i) 110KV/132 KV, ACSR conductors / Earth wire / insulators / Tower fittings		60
12	Tower Wagons (both 4 wheeler, 8 wheeler & all types)		40
C). Equipments required for replacement through Revenue			
S.No.	**Class of assets**		**Average life in years**
1	**Electric Loco Equipment**		
(i)	Armature for Traction Motor		15

(ii)	Stator for Traction Motor	18
(iii)	Commutator for Traction Motor	15
(iv)	Auxiliary Motor	18
(v)	Arno Converter	18
(vi)	Blower Impeller/Casing	10
(vii)	Locomotive re-cabling	18
(viii)	Power Cables	18
(ix)	Control Cables	18
(x)	Compressor with exhausters complete recondition /replacement	`10/15
2	**AC Equipment**	
(i)	Compressor ACCEL/ CARRIER	Deleted
(ii)	Sealed Compressor KCL make	Deleted
(iii)	Sealed Compressor Maneurope make	Deleted
(iv)	Compressor Motor (DC)	Deleted
(v)	Compressor Motor (AC)	Deleted
(vi)	Condenser Fan Motor (DC)	Deleted
(vii)	Condenser Fan Motor (AC)	Deleted
(viii)	Condenser Fan Motor (RMPU)	12
(ix)	Evaporater Fan Motor (AC)	Deleted
(x)	Evaporater Fan Motor (DC)	Deleted
(xi)	Evaporater Fan Motor (RMPU)	12
(xii)	Compressor (Scroll)	12
(xiii)	Condenser fan	12
(xiv)	Condenser Unit	Deleted
(xv)	Condenser Unit (RMPU)	12
(xvi)	Evaporater unit	Deleted
(xvii)	Evaporater unit (RMPU)	12
(xviii)	Mercury in glass thermostat	Deleted
(xix)	Evaporator Blower Drum	12
(xx)	Microprocessor Controller	12
3	**TL/Power Equipment**	
(i)	4.5/25 KW alternator regulator	12
(ii)	Emergency 90 AH VRL (SMF)	4

	Battery	
(iii)	120 AH VRLA (SMF) Battery	4.5
(iv)	290 AH starting L.MLA Batteries for Power Car	4
(v)	70 AH VRLA Batteries	4.5
(vi)	Power Car power panel	15
(vii)	Power panel (AC coaches)	15
(viii)	Pre Cooling cum battery charging transformer rectifier unit	12
(ix)	50 KVA /60 KVA (750/415 V) transformer unit	15
(x)	3 KVA 415/190 V transformer	Deleted
(xi)	15 KVA, 9KVA, 5KVA, 3KVA coach transformer and control metering transformers (1KVA,500VA, 250VA, 200VA, 100VA)	15
(xii)	Water Raising Apparatus (WRA)	5
(xiii)	Water Boiler for Pantry	5
(xiv)	Hot Case for Pantry	5
(xv)	Bottle Cooler cum deep freezer	5
(xvi)	Ventilation Blower Motor for Power Car	12
(xvii)	Radiator for Power car	15
(xviii)	Radiator Motor for Power Car	15
(xix)	Pump controller	12
(xx)	I.V. Coupler 400A/500A	18
(IV)	**MECHANICAL ASSETS**	
S.No.	Class of assets	Average life in years
	Machinery & Plant	
1	Machine Tools like Lathes, Planners, Drilling, Boring and Milling machines etc.	20
2	High Precision and special purpose machines like wheels	20

	Lathes etc.	
3	Tool Room and Testing Laboratory equipment	15
4	Foundry and Forge Equipment	20
5	Heat Treatment Equipment	20
6	EOT Cranes	36
7	Power Generation Machinery & Switches	Deleted
8	General purpose light machinery e.g. band saw, floor grinder etc.	15
9	Air Compressors	20
10	Other miscellaneous machines eg. Light cleaning machines, test equipment in loco sheds , workshops, depot & sick lines	Deleted
11	(i) Construction Machinery equipment	Deleted
(ii). Track Maintenance equipment		
	(a)Tamping, Ballast cleaning and handling, DTS and relaying machines	20
	(b) Material handling machines	25
	(c) Rail Grinding Machines	15
12	Station machinery like weighing machines etc.	15
13	Miscellaneous machinery and equipment for hospital, offices etc.	10
14	Mechanical Weigh Bridges	Deleted
15	Electronic in motion Weigh Bridges	12
16	Wheel impact Load detector(WILD)	12
17	Diesel Pumps	15

18	Welding equipment	10
19	Diesel Refrigeration equipment	Deleted
20	Material handling equipment like FLT, Lister trucks etc.	10
21	Traversers	25
22	Fuel Station Dispensation Equipment	10
23	(i) Bulldozers and	20
	(ii) Other earth moving equipment	Deleted
24	Motor Boats	15
25	Hydraulic re-railing equipments	16
ROAD VEHICLES		
26	Staff Cars including Jeeps	7
27	Light Motor Vehicles	10 years for Diesel and 15 years for Petrol as per norms
28	Heavy Motor Vehicles	
29	Tractors	
(IV) MECHANICAL ASSET		
ROLLING STOCK		
30	Diesel Electric/ Hydraulic Locomotives	36
30	Diesel Engine	18
31	Shunting Locomotives	36
32	Steam Locomotives	40
33	Boiler and Tender	20
34	Steam Cranes	30
35	Diesel Hydraulic Cranes	25
36	Steel Body Coaches including DMUs / EMUs, Restaurant Cars etc.	25

37	Full Stainless Steel Body Coaches including DMUs/EMUs, Restaurant Cars etc.		30
38	Light utilisation categories of coaches (steel body) like inspection carriages etc.		40
39	IRS Coaches		30
40	Open Bogie wagons with air brakes and Casnub bogies		
(a)	BOXN, BOY, BOBRN, BOBSN		35 years (subject to outcome of structural and financial justification to be conducted for extension beyond 30 years)
(b)	BOBYN		38
(C)	Other open wagons		30
41	Bogie tank wagons with air brakes and Casnub bogies		
(a)	BTPN		45 years (subject to outcome of structural audit to be conducted for extension beyond 40 years)
(b)	Other tank wagons		40
42	All other types of Bogie wagons with air brakes and Casnub bogies		
(a)	BCN		40 years(subject to outcome of structural audit and financial justification to be conducted for extension beyond 35 years)
(b)	All other wagons		35

43	Open Wagons with vacuum brakes and UIC bogies	Deleted
44	Other Wagons with vacuum brakes and UIC bogies	Deleted
45	4- wheeler wagons (open and covered)	Deleted
46	4 – wheeler tank wagons (with plain bearings)	Deleted
47	4- wheeler tank wagons (with roller bearings)	Deleted
	Equipment/Sub assemblies of Diesel locos	
48	Engine Block	18
49	Crank Shaft	18
50	Turbo Super Charger	12
51	Governor	18
52	ECC assembly with RA Gear Box	18
53	Radiator Fan	16
54	Heat Exchangers including radiator	10
55	Expressor/Compressor	16
56	Bogies with wheels	18
57	Traction Motor	18
58	Traction Generator/Alternator	18
59	All electrical rotating machines above 5 HP on Diesel locos	18
60	Rectifiers	18
61	Traction Gear	18
62	Loco Batteries	4
63	Power Cables	18
64	Control Cables	18
65	Blowers	10
66	Armature for Traction Motor	18
67	Stator for Traction Motor	20

68	Control Equipments	18
	Equipment/Sub assemblies of DMUs	
69	Power Pack	16
70	Bogies with wheels	18
71	Traction Motor	18
72	Traction Generator/Alternator	18
73	All electrical rotating machines above 5 HP on DMUs/Rail bus/Railcar	18
74	Rectifiers	18
75	Heat Exchangers	10
76	Batteries	4
77	Power Cables	18
78	Control Cables	18
79	Control Equipments	18
80	Hydraulic Transmission Rehabilitation/Replacement	16

(V) SIGNAL & TELECOMMUNICATION ASSETS			
(A) SIGNALLING SYSTEM			
S.No.	Class of assets	**Routes**	**Average life in years**
1	Electrical/ Mechanical Signalling System	Route-' A'	25
		Route-'C'/Sub Urban section	
		Big Yard (more than or equal to 200 routes) on all Routes	
2	Electronic interlocking	For all routes	20 years or based on obsolescence
3 (i)	Electronic Signalling system like Axle Counter, ATP, AFTC, IPS etc		20 years or based on obsolescence
3(ii)	Kavach (Automatic Train Protection- ATP)		15

(A) SIGNALLING EQUIPMENT

S.No	Class of assets	Life in terms of operations	Average life in years				
			Routes				
			A	B	C/ Suburban	D & D-Spl	E & E-Spl
1	Cranks and Compensators	50,000	2	2	1	4	4
2	Lock Bar Clips	1,00,000	3	3	3	5	7
3	Facing Point Lock with bolt detection	3,00,000	8	8	8	15	15
4	Mechanical Detectors	5,00,000	-	15	—	20	25
5	Circuit breakers	5,00,000	15	15	15	25	30
	Lever locks	-	7	7	7	12	15
6	EK Transmitter	-	10	10	10	15	15
7	SM's Slide Frame	-	30	30	30	30	30
8	Electric Point Detector & Reversors	-	15	15	15	20	20
9	Signal Machines	1,50,000	-	10	-	20	20
10	Signal Wire Transmission	-	3	3	3	3	3
11	Point Machine	3,00,000	12	12	7	15	15
12(i)	Plug-in relay (metal to metal)	15,00,000	25	28	25	28	30
12(ii)	Plug in relays (metal to carbon)	10,00,000	25	28	25	28	30
12(iii)	Track Relay, QL1 and QBCA1 relay		10	10	10	10	10
13	Track Feed battery chargers	-	10	10	10	10	10
14(i)	Transformers		30	30	30	30	30
14(ii)	Battery chargers, DG Sets, inverters, ELD		10	10	10	10	10
15 (i)	Batteries (VRLA)		4	4	4	4	4

15(ii)	Batteries (LMLA)		5	5	5	5	5
16	Block Instruments		25	25	25	25	25
17	Cable		25	25 to 28	25	**30**	**30**
18	Block Instrument Electro Mechanical/Electronics		20	20	20	20	20
19	Electric Lifting Barrier		10	10	10	10	10
20	LED Signals (all aspect types) of specification prior to version 2011		6	6	6	6	6
21	LED Signals (all aspect types) of specification version 2011 or later		8	8	8	8	8

(B) Telecommunication Equipments		
S.No.	Class of Assets	Average life in years
1	Microwave Equipments	12-15 years
2	MTRC Equipments/LTE	15 years
3	(i) Exchange and accessories including telephone equipment	12-15 years
	(ii)Telephone instruments IP/Non IP, Push button telephone, Magneto phones & FCT	8 years
4	Server based IP Exchanges	12 years
5	Underground cables	
	(a) Quad PIJF	25 years
	(b) OFC	25 years
6	Overhead alignment	25 years
7	All other electronic/wireless items including OFC equipment	(i) 10 years for items with RDSO approved specification (ii) 5 years for COTS items
8	OFC measuring equipment	8 years
9	Cell phones	3 years
10	Video Phone & WLL phone	8 years

11	Portable VSAT, Satellite phone	6 years
12	Walkie-Talkie sets/VHF	(i) 6 years – WT
		(ii) 8 years – 25 W VHF
		(iii) 1year-Battery of WT for Drivers/Guards
		(iv) 2 years- Battery of WT for others
13	Datacom Equipments, Router, Modem, Switch (including Core/Aggregation/L-2 switch), Media converter, Active system (viz. MIS systems including external storage systems and their connects) & Passive systems (viz. Networking equipments and cabling), Remote Diagnostics and Predictive maintenance system (NMS), Servers, Network video recorder &Video Conferencing System.	8 years
14	LED display Boards for passenger information system, true colour video cum train information display system and Public Address System (including IP based)	(i) 8 years for items with RDSO approved specification (ii) 5 years for COTS items.
15	GPS based Digital Clocks	(i) 8 years for items with RDSO approved specification (ii) 5 years for COTS items.
16	VOIP based Train Control Communication systems	10 years
17	Voice Logger for Control, auto phones, BSNL phones & LC gate telephone	(i) 8 years for items with RDSO approved specification (ii) 6 years for COTS items.
18	Control Communication & Gate comm..Equipment	8
19	Telecom Battery Charges /SMPS Based power Supply Equipment/Inverters	15
20	CCTV Camera (Fixed dome, PTZ and other type) and associated	8

	equipment, video camera	
21	Large format display monitor/ Video wall & LED/ LCD TV	8
22	Fax	Earlier appearing as item 7 in RBA 25/2006. Shall not be replaced after its normal life.
Note 1.: PCs and Secondary System may be deleted from list of Telecom assets and their life will be as indicated under (ii) Computer and Other IT systems		
Note 2. Para 219 ibid includes all correction slips circulated vide RBA circulars issued upto 12.8.2022		
Note 3: The average life of the assets is detailed above however the actual replacement of all assets shall be based on the condition of the asset.		

220. Technique of financial appraisal of projects- The following methods of appraisal of capital expenditure proposals are commonly used in industrial and commercial undertakings:

a) Accounting rate of return,
b) Pay back period, and
c) Discounted Cash Flow.

Of these, methods, (a) *&* (b) are employed without considering the time value of money. These are also known as the 'Financial statement' methods since the calculation involves data taken from and used essentially in the same form as in financial statements. When time is considered, the method employed for financial appraisal is the Discounted Cash Flow method, also called the 'Present value method', since the time value of money is an explicit consideration.

220 A. DPR for Technical and financial appraisal of projects- Detailed Project Report (DPR) for projects are to be prepared as per Board's guidelines. Proforma for submission of Detailed Project Report is given in Annexure – 'J'.

221. Accounting rate of return method - Under this method, the rate of return is worked out by arriving at a percentage ratio of the net gain (i. e., revenue less working expenses) over the initial anticipated investment of the project. Simply illustrated, it is proposed to construct a masonry building at a cost of Rs.1 lakh to accommodate an

office which is now housed in a building at a rental of Rs.15,000 per annum. It will be necessary to ascertain (a) the average annual cost of maintenance and repairs of the proposed building and (b) its scrap value at the end of its normal life. If these are taken to be (say) Rs. 5,000 and Rs. 10,000 respectively, then the average annual cost of the proposed new building will be (a) Rs.5,000 plus (b) Rs. 801 being the annual sinking fund payments (at 3 per cent for 50 years which is equal to 0.0089 multiplied by Rs.1 lakh minus Rs.10,000), or Rs.5,801 in all. This will result in a saving of Rs. 9,199 (Rs.15,000 minus Rs. 5,801) in the annual rental charges that are presently being paid, or a net return of 9.2 percent on the investment of Rs.1 lakh.

222. A minor variant of the above illustration would be to take the average investment over the life of the asset at half the initial cost, viz., Rs.50,000 on the assumption that depreciation is written off in equal instalments over the life of the asset and the amount invested on the asset will decrease each year as funds are released through the effect of the depreciation charge. In that case the return on the average investment will work out to 18.4%.

223. **Pay back period method -**Since recoupment of the original capital invested in a project is an important consideration in appraising a capital investment, the method of working out the pay back period lays emphasis on the calculation of the time it takes to recoup the expenditure incurred on the project. In the table given below, the pay back period is 5 years, as the accumulation of the net cash flow, year by year equals the initial investment at the end of 5 years:

Original Investment-Rs. 1,00,000
Net Cash Flows (i. e., net earnings or reduction in expenditure) : -

Year	Annual	Cumulative
	Rs.	Rs.
1	10,000	10,000
2	12,000	22,000
3	20,000	42,000
4	30,000	72,000
5	28,000	1,00,000

Under this method no attempt is made to assess the return on the capital invested. It only shows the length of time required to recoup the amount invested on the project, the assumption being that projects with short pay back period are better investment

propositions than those with long pay back periods. Bare recoupment of the amount invested under the pay back period method would yield no return unless a suitable rate of interest return on the capital outstanding in each of the years involved is built into the calculation of the net cash flow.

224. The method of ranking projects, or project grading, on the basis of pay back period is of limited application as it can be employed only in situations where there is a strict time limit to the investment before the expiry of the useful life of the project. An example would be of a proposed investment in a project in a foreign country where the political stability can be foreseen only for a limited number of years, or in plant and machinery involving processes or products that are likely to be replaced by technological changes within a few years or a 'single purpose' new line where the known reserves of coal, iron ore, etc., are expected to be depleted/exhausted after a specific number of years. Though presently not in vogue on the Indian Railways, there is no bar to the application of the Pay Back Period method to evaluation of Railway Projects in consultation with the Financial Adviser and Chief Accounts Officer in the special circumstances illustrated in this Para.

225. Discounted Cash Flow -The accounting 'Rate of Return' (R.O.R.) Method commonly in use on the Railways does not take into account the time value of money. Also, the return on investment is worked out as at the time of completion of the project or at a single point of time (6^{th} year or 11^{th} year) and not through the entire useful life of the project. The R.O.R. method may, therefore, yield an incorrect result depending on the point of time selected for the purpose of project appraisal. A factor of fundamental importance to investment decisions and one which the R.O.R. method does not take into account is the timing of profits and cash flows that result from an investment and this factor is crucial to the Discounted Cash Flow Method of project appraisal.

226. **Net Present Value (NPV) or Net Present Worth (NPW) -**The concept of the time value of money which is basic to the Discounted Cash Flow Method is illustrated thus **:**

Rs.100 receivable today is more than Rs.100 receivable a year hence, as Rs. 100 received today will earn interest or profits and shall accumulate to more than Rs. 100 in a year's time. Alternatively, Rs. 100 received today can be used to reduce borrowing thereby avoiding interest payments as well as reducing debts by Rs.100. Assuming that the Railways' cost of finance is its current dividend rate (say 10% per annum), Rs. 110 received a year hence should be worth Rs.100 today and Rs.100 which may be

received in a year's time is worth about Rs. 91 today (actually it is worth Rs.90.91). Likewise, the present value of Rs.100 receivable 2 years hence is about Rs.82.64, and so on. In this way the cash flow for the project in any future year can be discounted to obtain the present value.

227. The NPV/NPW of a project is sum of the present values of the net cash flows for all the years of the project's economic life. The net cash flow in each year will be the expected net reduction in expenditure or increase in net earnings. The net cash flows are discounted to arrive at the NPV of a project by applying a pre-determined discount rate. For example, consider the following excerpts:

TABLE - A From Col.2 under 'Single payment'			
Present value of Re. 1			
Year	12%	15%	20%
1	0.893	0.870	0.833
2	0.797	0.756	0.694
3	0.712	0.657	0.579
4	0.635	0.572	0.482
5	0.567	0.498	0.402

TABLE-B From Col. 4 under 'Uniform series'			
Year	Present Value of Re.1 received annually		
	12%	15%	20%
1	0.893	0.870	0.833
2	1.690	1.626	1.528
3	2.402	2.283	2.106
4	3.037	2.855	2.589
5	3.605	3.352	2.991

TABLE -B is derived by adding the data in TABLE -A**.** At 20% the 0.833 in TABLE-B is the same as the 0.833 in TABLE-A since the time involved is only one year. The 0.833 and the 0.694 for years 1 and 2 under 20% represent the 1.528 under TABLE-B at 20% in year 2. The 0.833, 0.694 and 0.579 in TABLE-A are added to form the 2.106 in TABLE-B. Thus, it can be seen that TABLE-B is essentially a summation of TABLE-A. With TABLE-B, present value calculations can be made more quickly if the cash inflows

or out flows are constant. Instead of multiplying the same cash flows by the individual items of TABLE-A, one can multiply the annual cash flow only once by the sum of the data in TABLE-A which is conveniently arranged in TABLE-B.

228. **Annual Cash Flows-** It is important that the annual cash flows should be estimated on a realistic basis. By definition, the cash flow will take into account only the realisable revenue and cash expenditure or, in the case of expenditure reducing projects, the net reduction in cash expenditure. Purely accounting adjustments such as depreciation and other provisions are to be completely ignored. The reason is that cash flow is the foundation of the NPV and depreciation is an expense item not involving a flow of cash. It is implicit in the basic arithmetic of the D.C.F. Method of project appraisal that so long as the cash flows are adequate from year to year and the NPV computed at the requisite discount rate equals or exceeds the investment, the capital invested in the Project will remain intact. This is shown by a solved example below :

Basic data-
Initial investment- Rs. 4,00,000
Annual Cash Flow- Rs. 1,00,000
Life of the Project- 10 years
DCF rate of return (say)- 21.4%(See Para 230)

Year	Capital in the beginning of the year	Net surplus the year	Payment of interest @ 21.41 %	Recovery of Capital	Capital at the end of the Year
(1)	(2)	(3)	(4)	(5)	(6)
1	4,00,000	1,00,000	85,652	14,348	3,85,652
2	3,85,652	1,00,000	82,580	17,420	3,68,232
3	3,68,232	1,00,000	78,919	21,081	3,47,151
4	3,47,151	1,00,000	74,335	25,665	3,21,486
5	3,21,486	1,00,000	68,840	31,160	2,90,326
6	2,90,326	1,00,000	62,168	37,832	2,52,494
7	2,52,494	1,00,000	54,067	45,933	2,06,561
8	2,06,561	1,00,000	44,231	55,769	1,50,792
9	1,50,792	1,00,000	32,289	67,711	83,081
10	83,081	1,00,000	17,790	82,210	871
				3,99,129	

The small margin of difference (Rs.871) is accounted by the error in interpolation of the rate of return. It will be seen that at the discount rate of 21.41%, the project has recovered the original cost in full (Col. 5), apart from paying off interest at the same rate.

229. **Rate of return under D. C. F.-**Two alternative methods can be used for assessing the viability of a project under the D. C. F. technique. For example, assuming an even cash flow of Rs.4,000 per annum over a period of 10 years in respect of a project where the original investment is estimated to be Rs.18,000, it will be observed from the following table that the discount factor of 4.5 (18,000 ÷ 4,000) occurs against the 10th year under the discount rate of 18%:

	Present value of the Re. 1 received annually		
Year	16%	18%	20%
8	4.344	4.078	3.837
9	4.607	4.303	4.031
10	4.833	4.494	4.192
11	5.029	4.656	4.327

In this case the rate of return under the D.C.F method for an even cash flow of Rs.4,000 per annum for an investment of Rs.18,000 will be about 18%. Since the D.C.F. return of 18% is more than the minimum acceptable rate of return (say 10%) , the project would be considered desirable from the financial point of' view. Under an alternative method, the minimum acceptable rate of return (say 10%) would be applied to calculate the NPV of the project. If the NPV is (zero or) positive, it would be financially acceptable, and if the NPV is negative, the project will not be financially acceptable. In judging the ranking of competing projects, under the first method, the D. C. F. rate of return would be used and whichever project gives the higher rate of return would be preferred. Under the second method, the competing projects will be ranked according to their NPV and whichever project gives a higher NPV at the minimum acceptable rate of return would be the preferred project.

230. Another illustration may be given of a case where the initial outgo of (say) Rs. 4,00,000 is incurred in one year and the project starts giving a net cash flow of Rs.1,00,000 per annum over 10 years thereafter. Discounted cash flow at various rates of interest would be as shown below where the cash flows are uniform throughout the project life:

	10%	20%	25%
Factor for 10th year	6.145	4.192	3.571
NPV for even cash flow of Re. 1 lakh per annum	6,14, 500	4,19,200	3,57,100
	R.O.R. will be about 21.41%		

231. The simple illustrations given above presume that the investment is completed in one year and the project starts yielding a return immediately thereafter. Where the investment is spread over a number of years, it is necessary to work out the value of the investment, by applying the relevant rate of interest, from the inception up to the point when the project is expected to be ready for operation, the rate of interest being the minimum acceptable rate of return of (say) 10%. In the illustration given in the preceding para, if the investment of Rs. 4,00,000 is assumed to have been spread over a period of three years including the year in which the project was completed, the total investment, inclusive of interest, up to the year of completion would be as shown below :-

	0%	10%
Year	Interest Rs.	Interest Rs.
-2	1,00,000	1,21,000
-1	1,50,000	1,65,000
0	1,50,000	1,50,000
Total investment	4,00,000	4,36,000

In this case, if the net return over the life of the project of ten years assumed in the earlier illustration is constant amount of Rs.100,000, the return would be about 18% instead of 21.41 % worked out in Para 230.

232. A short write-up on the technique of working out the rate of return under the Discounted Cash Flow Method is at Annexure 'D'. Detailed examples of railway projects showing application of the D. C. F. technique are given in Annexure 'E'.

233. **Residual Value -**Each project will have an estimated life span at the end of which the various assets will be disposed of or put to other uses. The flow of funds created by the sale or disposal of the assets at the end of the life of the project should

be estimated so that appropriate credit can be given to the project in the year in which the flow of funds is expected to occur by the sale or disposal of the assets. Since all the assets may not be discarded or sold at the same time, the cash flows resulting from residual values should be allocated to the years in which they are likely to be received. If some of the assets are to be taken out of service and disposed of before the termination of the project, the resultant cash flows must be included in the appropriate years.

234. **Alternative Schemes -** Equivalent Annual Cost **-** The criterion of choice between alternative schemes, each of which is capable of rendering the required service, is the principle of least cost in the long run. This approach is particularly applicable when the cash outflows under each competing project have sharply different time patterns. To obtain the annual cost, the outlays of the project are summarised into a single present worth amount and then spread over the years of the project life as an equal amount per year, which includes interest at a standard rate. By the same summarization and spreading for an alternate project, the two projects can be compared by reference to the per year figure for each. The comparison is usually of cost only, revenues being assumed as the same under either project. An illustration appears below :

	Year	0	1	2	3	4	Total.
Project A :							
cash inflows		(the same as for Project B)					
cash outflows		(104)	(5)	(1 0)	(1 5)	(20)	(154)
Project B :							
cash inflows		(the same as for Project A)					
cash outflows 10%		(45)	(30)	(30)	(30)	(30)	(165)
Worth Factors		1.00	.91	.83	.75	.68	....
Present Worth : Project							
A		(104)	(5)	(8)	(11)	(14)	(142)
Project B		(45)	(27)	(25)	(22)	(20)	(139)
***Equivalent Annual Cost** :							
Project A		....	(45)	(45)	(45)	(45)	...
Project B		...	(44)	(44)	(44)	(44)	...

*These annual amounts are determined by dividing the project present worth by the present worth of a four-year Re.1/ - per year annuity. This is the sum of the individual present worth factors .91, .83, .75, .68 which totals Rs 3.17.

The above analysis shows that Project 'B' has the lower uniform annual cost, by a small margin, even though it shows a larger total outlay. The reason for this is that the project outlays take place later under Project 'B', which reduces its present worth and lowers its annual cost including interest, relative to Project 'A'.

235. **Economic Evaluation.** -As a commercial undertaking, it is incumbent on the Railways to ensure that a proper financial return is earned from every investment subject to the exceptions given in Para 202. At the same time it has to be borne in mind that the Railways are an important instrument of economic and industrial development of backward areas not connected by a reliable transport network. In the case of major projects such as new line constructions, or change of traction from diesel to electric, the benefits likely to be realised by the economy as a whole are assessed by the Economic Adviser to the Railway Board. The principles on which economic evaluation of Railway investments should be carried out as distinct from working out a financial return to the Railways, are indicated in the note (together with an illustration) at Annexure 'F'.

235A. A detailed economic appraisal framework is given in Annexure- 'I'.

236. **Replacements and Renewals -**The proposal for replacement of an existing asset (whether involving improvement or otherwise) should be examined critically with a view to seeing whether it would not be possible to avoid, or, at least, postpone such replacement by suitable repairing or reconditioning the asset at a cost that could be comparatively justified financially. In all cases in which it is considered necessary to replace an asset, instead of reconditioning it, it should be examined whether the estimated average annual cost of service (i. e. cost of operation and maintenance, sinking fund payment to the depreciation fund, and the interest on the cost of the asset), or the estimated average cost per unit of service of the new asset is likely to be less than that of the old asset after reconditioning. Except when renewals or replacements are inevitable, the expenditure chargeable to the Depreciation Reserve Fund, should be financially justified in the same manner as any other expenditure of capital nature.

237. Where a replacement is proposed on grounds of economy in operation and maintenance costs, the estimate therefore should justify the outgo on the proposed replacement by showing that the average annual cost of service or the average cost per unit of service, that will be rendered by the new asset, is less than that of the existing asset.

Note -The above two paragraphs will not apply to cases of casual or programme renewals, not involving any improvement.

238. **Reconditioning** – When an as asset is repaired at a comparatively high cost in preference to its being replaced, it is referred to as being 'reconditioned'. The cost of such reconditioning is chargeable to Ordinary Repairs and Maintenance. It may be noted that reconditioning is different from routine repair. For all reconditioning works, detailed estimates should be prepared.

239. **Scrapping, condemning and abandoning assets -** An asset may be scrapped, condemned or abandoned without replacement, when the service rendered by it is no longer required. If the service rendered by it is still necessary and if it is proposed to make other arrangements for such service, it should be definitely established that it is more economical to scrap, condemn or abandon the existing asset and obtain the required service from the new arrangement than to continue to obtain the required service from the existing asset. Here also the relative economics of the two proposals should be assessed on the basis of the average annual cost of service or the average cost per unit of service, as the case may be.

Note -The preparation of financial justification as contemplated in this paragraph is not necessary for condemning rolling stock in the following cases:-

i) Overaged stock due to be replaced by virtue of their age but condemned before replacement.
ii) Under or overage stock involved in accidents and certified to be irrepairable (not included under the category of "beyond economical repairs").
iii) Non I.R.S. type coaches and wagons of inherently weak design proposed to be condemned on condition basis whether under or overage.

240. Examples are given in Annexure 'G' illustrating the method of financial justification to be adopted in the case of replacement, reconditioning or abandonment of existing assets. The data used in the illustrations are hypothetical and the methods adopted are not to be regarded as exhaustive or as precluding the use of other methods that may be found to be more appropriate. The D.C.F. method can be conveniently used in some cases as has been shown in Example (1) of Annexure 'G'.

241. Second-hand Value- The second-hand value of an asset is what it is presently

worth and has often to be distinguished from its scrap value. For purposes of financial justification of transfer, purchase or sales, the second-hand value of assets may, except in certain cases (e.g. rails, locomotives, boilers, etc.) where separate rules have been prescribed for the determination of the second-hand value, be determined as provided below :-

i) The first cost of an asset (based on which its second-hand value has to be computed) should be taken as the value of a similar asset at present day prices and not the value actually paid for the asset when it was originally purchased.
ii) The second-hand value of an asset that does not depreciate is the same as the first cost.
iii) The second-hand value of a depreciating asset should be so appraised that the average annual cost of service or the average cost per unit of service, as the case may be, of the second-hand asset is equal to that of the same or similar asset while new.

242. Examples illustrating the application of the principles enunciated in the preceding paragraph are given in Annexure 'H'.

243. **Post project appraisal -** It is important that an investment proposal is subjected to proper financial appraisal not only before it is a sanctioned but also a certain period of time after the project has been in operation. Whether the financial return anticipated from a project at the estimate stage is actually realised in due course or not should be determined by conducting a 'Productivity test' in respect of all major works. For any such comparison to be meaningful and realistic, it is important that the computation of the actual additional earnings and working expenses is done on the same lines as at the project estimate stage. As commercial profitability is liable to be affected by escalation in prices or any other extraneous development, in order to have a more reliable and accurate evaluation wherever relevant, a comparison in terms of physical units of throughput may be carried out. Such a comparison should preferably be done class-wise in the case of passenger traffic and commodity-wise in the case of goods traffic. The post project appraisal should be conducted by the user department in consultation with Engineering and Finance.

Further, all projects sanctioned on the basis of ROR, should be subjected to mid term review at the time of every revision of estimated cost. Such review shall consist of review of both existing projection in current scenario, revised estimated cost and consequential change in ROR. Financial feasibility of project need be assessed and

commented by General Managers of Zonal Railway.

244. **New Lines -** In respect of each new line opened for traffic, the railway administration should submit to the Railway Board a statement, showing the financial results of its working in Form No. 244 shown below. The statement should reach the Railway Board not later than the 31st December following the financial year to which it refers and should be accompanied by a covering memorandum in which brief explanations should be given of important variations between the actual realisation and the estimated revenue, together with a Note by the General Manager indicating how the actual net cash flow compares with what was estimated at the project stage. The Note should also bring out the probable traffic prospects of the line in the sixth and the eleventh year of opening.

Statement showing Financial Results of working of New Branch Lines. Form No.F.244	
Railway **----------**	Name of branch **----------**
Length in Kilometers----------	Gauge ----------Opened on----------

Year	Cost on 31st March plus calculated interest during construction.		Earnings of Branch line proper		Actual expenditure of branch assessed on the basis of costing/financial data applied to the traffic over the branch line		Net earning of branch proper (Col.3-4)	
					Working expenses (excluding depreciation & interest)			
	As originally Estimated	Actuals	As originally Estimated	Actuals	As originally Estimated	Actuals	As originally Estimated	Actuals
(1)	(2)		(3)		(4)		(5)	

Actuals afteropening -- 1st year 2nd year 3rd year 4th year 5th year 6th year 7th year 8th year 9th year 10th yr and so on upto 30 years				

Main line				Additional net earnings (Col.6-7).		Total net earnings (Col.5+8)		Return on Total cost Col.9 x 100	Remarks
Additional revenue minus any loss due to short circuiting or diversion of traffic.		Additional expenses calculated on the basis of costing/ financial data applied to traffic from the existing line to branch line and vice-versa							
		Working expenses (excluding Depreciation & interest)						Col.2	
As originally estimated	Actuals	As originally estimated	Actuals	As originally estimated	Actuals	As originally estimated	Actuals		
6		7		8		9		9A	10

Foot notes to Form No. F. 244.-

i) Actuals will be actuals to end of the year for which accounts have been closed, and fresh estimatesfor the years thereafter.

ii) Special steps taken in the course of the year -

(a) To develop the traffic revenue-

(i)
(ii)
(iii)
(iv)

(b) To reduce the expenses

(i)
(ii)
(iii)
(iv)

iii) Probable future development of traffic and possibility of the line paying its way (short note)—

Head of Traffic Department Head of Account Deportment

Note- The traffic data required to be maintained vide Para 245 should be used for costing purposes so as to arrive at the expenditure of the Branch proper and of traffic moving from the existing line to the Branch line and vice versa.

245. The following statistics should be maintained from year to year in respect of all new lines opened for traffic and submitted to the Railway Board by l st August of each year :-

i) a) Passenger revenue from traffic local to the branch line.
   b) Other coaching revenue from traffic local to the branch line.
ii) a) Passenger revenue from traffic from the new line to the existing lines and vice versa.
   b) Other coaching revenue from traffic from the new line to the existing lines and vice versa.
iii) a) Tonnage of goods traffic local to the branch line.
   b) Tonnage of goods traffic inter-changed with the existing lines
iv) a) Revenue from goods traffic local to the branch line.
   b) Revenue from goods traffic interchanged with the existing lines.

246. The following instructions should be followed in preparing the statement F-244 :-

i) Column 3 should indicate the revenue of the branch from all traffic originating therein, whether local or foreign (Proportion due to the branch) and all traffic received from the main line.
ii) Columns 4 & 5 should be worked out on the basis of the costing/financial data under Group 'C' (see Annexure 'A') in respect of the traffic referred to in (i) above.
iii) The additional or new traffic interchanged to be shown in column 6 should include only that portion of the traffic received by the main line from the new branch and of the traffic from the main line to the branch, which arises solely from the construction of the new branch line. In the absence of actual figures of additional traffic interchanged with the existing lines, a reasonably approximate figure may be adopted. In the case of chord line short-circuiting

a previously existing route, figures relating to cross traffic which would have been carried by the previously existing route, if the chord line had not been constructed, may be omitted from this statement and a proportionate reduction in the working expenses on the branch line made. Column 7 should be worked out on the basis of costing financial data under group 'C' (See Annexure 'A' and para 217).

247. The statements vide Paras 244 & 245 should be submitted for every completed financial year after the date of opening of the new line for a period of 11 years. The actuals for the years to end of which accounts have been closed and the cash flows for the remaining years of the assumed project life should be arrived at on the basis of the best possible estimation. The entire series of net cash flows should then be discounted to arrive at the rate of return compared to the originally expected return. In case the actual cash flows shown in statement F.244 indicate a fair degree of proximity to the original estimates, it may be assumed that the cash flows for the remaining years of the project life will also follow the same trend unless definite foreknowledge is available to the contrary. If a review of the annual cash flows for a sufficiently long period (say 5 to 7 years) indicates that the cash flows have settled down, within limits, to a 'uniform' series, the Railway Board may decide that submission of the Statements F. 244 & F. 245 for future years in the case of a particular new line be discontinued.

248. **Open Line Works –** For the purpose of applying the productivity tests to open line works, i.e. works undertaken with the definite object of increasing revenue or reducing expenditure and to which such tests can be applied within five to seven years of their completion, selection will be made out of these works sanctioned (and/or charged to Capital) on grounds of remunerativeness. All such works costing over Rs. 1 crore will invariably be subjected to this test. The result of the test should be reported by the General Managers to the Railway Board. As stated earlier in the preceding para in the case of New Lines, the actual net cash inflow for each year, to end of the $5^{th}/7^{th}$ year from the date of commissioning should be recorded for each open line work to be subjected to the productivity test, and the cash flows for the rest of the project life assessed on the basis of the latest estimate. The whole series of net cash flow should then be discounted to arrive at the rate of return compared to the return originally expected.

249. In addition to productivity test to be conducted as provided in paragraph 248 above, a productivity review should also be undertaken in respect of selected works costing over Rs. 50 lakhs which are estimated to fetch some return, even though not the return prescribed for a work being classified as remunerative. The methodology to

be followed will be the same as prescribed in the preceding para in respect of works costing over Rs.1 crore each.

Note-Justification for works or part of a scheme should show the probable period ,that will elapse between the completion of the works and the time when the productivity review can be made. This note equally applies to paragraph 248.

250. The fact that productivity tests are to be applied to a particular work should be intimated to the authorities entrusted with its execution as also to the Finance and Audit officers. In respect of all such selected works, the Financial Adviser and Chief Accounts Officer should also keep such statistics as would be necessary for the verification of the tests conducted by executive, in addition to those usually available.

251. In order to ensure that a work selected either by the Railway Board or by the General Manager for the application of productivity tests or review is not lost sight of, Executive Officers and Finance Officers should maintain a register containing a list showing the following particulars :-

i) Reference to sanction of the estimate.
ii) Brief particulars of work selected for the application of productivity tests or review.
iii) Total estimated expenditure.
iv) Nature and extent of "productivity" claimed in the estimate.
v) When the test or review is to be applied.
vi) Brief remarks about the results of the test or review.

This list should be reviewed half-yearly and timely action taken to apply the test or review to all works due for examination during each half-year.

252. When, in due course, the tests or reviews are actually applied or carried out, the Financial Adviser and Chief Accounts Officer after verifying should submit a report embodying the results of the test or review to the General Manager. In case of works sanctioned by the Railway Board, the General Manager will submit the Financial Adviser and Chief Accounts Officer's report to the Railway Board with his own comments. The object of these reports is not only to furnish information about results actually achieved to the authority who sanctioned the expenditure but also to serve as a lesson for the future.

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ANNEXURE -A

(Please refer to Annexure I & J also)
(Ref. paras 216 *and* 217)

Check List With Detailed Notes For Guidance Of Zonal Railways And Concerned Branches In Railway Board's Office, In The Preparation Of Project Estimates

The procedures and methodology to be adopted for a proper financial appraisal of projects are laid down in the Engineering Code and in the Report of the Committee on Technique of Financial Appraisal of Railway Projects as well as the circulars issued by the Railway Board from time to time.

2. Some of the survey reports submitted by the Zonal Railways were scrutinised by the Cost Analysis Cell of the Board's office. It was found that the estimates of working expenses have been substantially understated owing to many important elements such as empty haulage, number of marshallings, tare tonne kilometres, etc., not having been taken into account by the Zonal Railways. In some cases, instead of applying the unit costs the Railways have adopted the operating ratio to estimate the working expenses. The operating ratio is only an end figure and should not, therefore, be used for estimating working expenses. Further, the revenues depend on the product mix, i. e., the proportion of the high-rated, low-rated commodities or short lead or long-lead traffic and the estimate made thereof should be reasonably correct.

3. In order to ensure that no item of cost is excluded and no item of cost is over stated / understated, a check list, together with detailed notes, has been prepared for the guidance of the Zonal Railways and the concerned staff of the Railway Board's office (E.A. Branch F (X) Branch and Planning Branch). The more common mistakes and deficiencies noted in the calculations at present can be avoided if the check list is adhered to.

4. Unit costs are worked out for the broad and metre gauge systems of each of the Zonal Railways under 3 main groups-

Group 'A' – Gives the unit costs applicable for all- traction movement. These unit costs include the direct costs as well as the element of overheads.

Group 'B' - Gives unit costs for particular facets, as cost per shunting engine

hour, train engine hour, engine hour etc., for each traction. The unit costs in this group include the element of overheads.

Group 'C'- Gives unit costs traction-wise. The wagon provision costs which include the element of repairs and maintenance, interest and depreciation, are separately shown. The overheads and the central charges are separately indicated.

Unit costs of line haul are worked out separately for through trains and van and shunting trains under both groups 'A' and 'C'.

All the unit costs are furnished separately under 3 heads - Working Expenses, Depreciation and Interest, so that the rate of return can be worked out both under the conventional method or D.C.F. technique.

Group 'A' and Group 'C' costs are more widely used for assessing the costs of specific flows or streams of traffic. If the traction is known, the Group 'C' costs are adopted. If the traction of line haul is not defined or specific, then all-traction figures in Group 'A' are adopted. Group 'C' costs are much more refined and specific and, therefore, by taking note of special characteristics of operation the costs may be estimated with a higher degree of accuracy. Group 'B' costs are generally used for estimating the savings in monetary terms of engine hours, wagon hours and shunting engine hours.

5. Study has been made to estimate broadly the variability of different items of expenditure with appropriate units of performance. The results of the study are summarised at the end of this Annexure.

6. In estimating the expenditure in respect of additional traffic the variability factors mentioned above should be adopted to arrive at the long- term variable costs. In estimating the expenditure in respect of existing traffic, however, the fully distributed cost should be used.

7. **Check list -**The check list and procedures/steps for estimating the costs are detailed below :-

	Existing line		Project line	
	Existing traffic	Additional traffic	Existing traffic	Additional traffic
Freight Traffic-				

a) b) c) d) e) f) g) h) i) j) k) 1) m) n) o) p)	Tonnage loaded under specific commodities Tonnage unloaded under specific commodities Tonnage transhipped Tonnage repacked Tonnage of cross traffic Load of specific traffic Net tonne kilometres Loaded wagon kms. Empty wagon kms. Tare tonne Kilometres Gross tonne Kilometres Engine Kilometres Train Kilometres No. and name of marshalling yards. No. and name of Repacking points. No. and name of Transhipment points				
	Coaching/Passenger traffic- a) No. of Passengers- (i) Originating (ii) incoming b) Train Kilometres c) Engine Kilometres d) Vehicle Kilometres.				

8. The Traffic Survey Report should give in detail the quantum of existing freight traffic (originating, terminating, transhipped, cross, etc.) under important commodity groups, the pattern of movement (origin and destination of the important flows), the quantum assessed, both in terms of tonnes and in terms of B.G. or M.G.4-wheeler wagons. The additional traffic should also be assessed in a similar fashion. In case any difficulty is experienced in converting the tonnes into wagons, the figures of average starting loads (separately for originating and transhipped traffic) shown in the monthly wagon loading statements may be adopted. Otherwise, the minimum weight condition as per goods tariff may be taken into account.

9. Empty haulage should be carefully calculated taking into account the outward and inward traffic commodity-wise and equipment-wise. The source of empties should also be indicated so that the empty haulage may be reasonably assessed. Otherwise, following norms may be adopted :-

BFRs, Oil tanks, BOBs , BOI and Special types, etc. (B.G. and M.G.)	100%
POL Traffic, iron ore traffic, industrial raw material to steel plants, etc.(B.G. & M.G.)	100%
Coal--Average B. G.	80 %
Other commodities -B.G.	23 %
M. G. (including coal)	33 %

The correct estimate of empty haulage is very essential as this element appears in the calculation of –

i) Wagon kilometres,
ii) Gross tonne kilometres,
iii) Engine kilometres,
iv) Train kilometres,
v) Wagon days,
vi) Engine days, and
vii) Number of marshalling yards.

10. Marshalling yards. --The survey report should specify the Inward, outward and cross traffic dealt with at different marshalling yards on the project line and the existing main line. This should be separately assessed for the existing traffic and the additional traffic. We should take into account not only the loaded journeys but also the empty journeys of wagons. In case traffic bypasses the marshalling yard, detention to stock for carriage and wagons/train examination for engine changing and crew changing should be taken into account.

There are at least 2 marshalling yards for any movement irrespective of distance. The study reveals frequency of marshalling as indicated below:

	Broad Gauge	Metre Gauge
1-40 Kms.	2.00	2.00
41-120 Kms.	3.00	3.00
121-240 Kms.	3.50	3.50
241-500 Kms.	4.00	4.00
501-800 Kms.	4.50	5.00
801-1300 Kms.	5.00	6.50
1301 and above	5.50	7.50

The above is only for wagons moving in piece-meal. Where the wagons

are moving in a specific stream of Traffic, the actual marshalling requirements should be assessed on the concerned route.

11. Terminal:- Documentation charges are calculated on the basis of one invoice per 4-wheeler wagon in the case of wagon load traffic and one invoice for 0.54 tonne of smalls traffic.

In the case of train load movement, one invoice may be adopted for 10 four-wheeler wagons.

There are cases under which one-end terminal documentation is performed by the staff employed by the consignee or the consignor. In those cases, this element of cost for one end may be omitted.
Two terminal costs should be taken, one for the originating end and the other for the destination end.

12. A special study has been made in the case of coal traffic. The coal terminal costs at the originating end for 1970-71 are given below :-

Cost Per Wagon

Rail way	Terminal Cost	Trip haul between base yard and collieries	Other costs	Total originating Terminal costs
	Rs.	Rs.	Rs.	Rs.
Central	15.485	8.046	24.649	48.180
Eastern	17.436	8.307	19.870	45.613
South Central	8.605	4.918	17.210	30.733
South Eastern	19.118	11.101	19.514	49.733
Total Indian Railways (B.G.)	17.202	8.803	19.917	45.922

At the destination end, the average unit costs would apply even in the case of coal traffic.

13. Wagon days - It is not correct to adopt wagon kilometres per wagon day for assessing the wagon requirements. To illustrate this point, the example of a short distance traffic of lead of 40 kilometres with an empty return ratio of 100% may be considered. The wagon requirement on the basis of wagon kilometres per wagon day would work out to only one wagon day. It is common knowledge that it would take at least 3 days for the wagon to be loaded, unloaded and brought back to the loading point for the subsequent loading, if the detention to stock at the

originating end, terminating end, transit time and contiguous marshalling yards were properly taken into account. In the case of fairly long-lead traffic, the wagon user index may be adopted.

14. Engine kilometres - After calculating the train kilometres on the basis of the permissible load (in terms of BOX or 4-wheelers and the gross load) on various sections, the engine kilometres should be assessed on the basis of -

i) Single engine operation or multiple engine operation,
ii) Banking engines over gradient sections; and
iii) Light engines.

Figures of engine kilometres per engine day used for goods traffic are readily available in the Annual Reports and Statistical Pamphlets for each traction. It should be possible to work out engine days required on this basis after giving due allowance for the element of repairs and spares.

For example, 4 million tonnes of iron ore are to be moved over a section 100 kms. in length. The movement will be in BOX wagons with load of 55 tonnes each. The section is heavily graded and the trains will run triple headed (diesel traction) with a load of 40 BOX's plus an additional banking engine over a section of 8 kms. Estimates of engine km/engine days will be as follows :-

1)	No. of trains each way	1,818
2)	Train kms. both ways with 100% empty return (1818 x 2 x 100)	3,63,600
3)	Assisting required and Assisting not required Engine km.	7,27,200
4)	Banking engine kms. (1818 x 2 x 8)	29,088
5)	Light engine kms. (say 6% of train kms.)	21,816
		1,41,704
6)	Bare-engine days required @ say 360 km. per engine day in use (goods).	3172
7)	Total engine days required (add 16% for POH, spares, etc.)	3680 or 10 engines

The nature of movement should also be taken into account, i. e., whether the traffic is carried by shunting and van train or by through trains. The cost characteristics are different and separate unit costs are available.

15. Fuel and lubrication costs are calculated on the basis of GTKms. Other

operating costs (line haul) are calculated on the basis of train kilometres/engine kilometres.

16. Track and signalling line haul -This is calculated on the basis of GTKms. The average unit costs are not adopted for estimating the cost under track and signalling. A slight refinement is made taking into account the variability of this item of expenditure with reference to GTKms. The variability studies reveal that 50% of this expenditure is variable with GTKms. The average unit costs applicable to B.G. or M. G. systems of an individual Railway are adjusted by taking into account the specific density of traffic on the route or sections involved and the average density of the Zonal Railway system. As an illustration, a section with an average density of 18,000 tonnes per day as against the average density of 12,000 tonnes per day on the gauge may be considered. If the average unit cost for the gauge is Rs. 6.00 per 1000 GTKms., then the average unit cost for the section will be

$$= \text{Rs.3} + \left[\frac{\text{Rs.3} \times 12000}{18000} \right] \text{ or Rs.5 per 1000G.T.Kms.}$$

Particulars of Service for which unit costs of freight services are worked out on Indian Railways (See para 4 of Annexure A).

Line No.	Particulars
	GROUP A
1.	Terminal Cost per Tonne-Smalls.
2.	Terminal Cost per Tonne-Full Loads.
3.	Total Terminal Cost per Wagon-Full Loads.
4.	Repacking Cost of smalls per tonne per handling.
5.	Transhipment Cost at Break of Gauge per tonne per
6.	transhipment.Marshalling Cost per Wagon per yard handled.
7.	Line Haul Cost -per train kilometre.
8.	Line Haul Cost-per Wagon kilometre (Rev.)
9.	Line Haul Cost-per net tonne kilometre (Pay Load).
10.	Line Haul Cost-per Wagon kilometre (Carrying Unit).
	(i) Through Goods Trains.
11.	Line haul Cost per train Km.
12.	Line haul Cost per Wagon Km. (Rev.)
13.	Line haul Cost per NTKm (Pay Load).
14.	Line haul Cost per Wagon Km. (Carrying units).
	(ii) Van and Shunting Goods.

15. 16. 17. 18.	Line haul Cost per train Km. Line haul Cost per Wagon Km. (Rev.) Line hau1 Cost per NTKm. (pay load). Line haul Cost per Wagon Km. (Carrying Units).	
GROUP B		
19.	Cost of Documentation per Invoice.	
20	Cost of Traction per Engine Hour (Other than shunting and siding)	Diesel (Total).
21.	,, ,, ,, ,, ,, ,,	Electric (Total).
22.	,, ,, ,, ,, ,,	Diesel (Fuel and stores)
23.	,, ,, ,, ,, ,,	Electric (Electric current consumed)
24. 25.	Cost of Traction per Train Engine Hour. ,, ,,	Diesel (Total) Electric (Total).
26 27	,, ,, ,, ,,	Diesel (Fuel and Stores). Electric (Electric current consumed).
28. 29	Cost of Traction per 1000 G.T.Kms.. ,, ,,	Diesel (Total) Electric (Total).
30. 31.	Cost of Traction per 1000 G.T.Kms.. ,, ,,	Diesel (Fuel and Stores). Electric (Electric current consumed).
32 33.	Cost of Traction per Shunting Hour (Shunting Engines). ,, ,,	Diesel (Total) Electric (Total).
34 35.	Cost of Traction per Shunting Hour (Shunting Engines). ,, ,,	Diesel (Fuel and Stores). Electric (Electric current consumed).
36. 37	Track and Signalling ,, ,,	Provision and Maintenance Cost per train Kilometre Provision and Maintenance Cost per.1000 G.T Kms.

Group C
38. Terminal Services-Cost of Documentation per Invoice. 39. Terminal Services-Cost of Handling per tonne. 40. Terminal Services-Cost of other Terminal Services per tonne-Smalls. 41. Terminal Services-Cost of other Terminal Services per tonne-Full Loads. 42. Terminal Services-Cost of other Terminal Services per wagon (Full Loads). 43. Cost of Repacking of Smalls per tonne per handling. 44. Cost of Transhipment at Break. of Gauge per tonne per Transhipment. 45 Cost of Marshalling per Wagon per yard handled. 46 Carrying Units-Provision and Maintenance per wagon day. 47. Line Haul (Movement) service Traction Cost – Steam per 1000 GTKMS Diesel. 48. Line Haul (Movement) service Traction Cost – Steam per 1000 GTKMS Electric.
49. Line Haul (Movement) Service-Other Transportation expenses including Train Passing Staffper Train kilometre. 50. Line Haul (Movement) Service-Other Transportation Expenses including Train Passing Staffper 1000 G. T. Kms. 51. Line Haul (Movement) Service-Cost of Track and Signalling per train kilometre. 52. Line Haul (Movement) Service-Cost of Track and signalling per 1000 G. T. Kms. 53. General Overhead Charges-Percentage of Direct Costs.
54. Central Charges (Cost of Railway Board, Audit etc.)- Percentage of the total expenses. (i) Through Goods Trains.
55. Cost of traction per 1000 G. T. Km. (Diesel). 56. Cost of Traction per 1000 G. T. Km. (Electric). 57. Other Transportation Expenses per 1000 G. T. Km. (ii) Van and Shunting Goods.
58. Cost of Traction per 1000 G. T. Km. (Diesel). 59. Cost of Traction per 1000 G. T. Km. (Electric). 60 Other Transportation Expenses per 1000 G.T.Km.

Percentage of 'variable costs' to total costs average- all Railways.									
S. No.	Facets of operation	BROAD GUAGE				METER GAUGE			
		Working exp.	DRF	Interest	Overall	Working exp.	DRF	Inter-est	Over-all
	(i) For cost in group A -								

1. 2.	Terminal Marshalling	76 74	75 83	77 85	76 78	75 74	70 80	70 80	74 77
3.	Transhipment at break-of-gauge point	80	70	74	79	80	70	74	79
4.	Repacking of Smalls	84	70	74	82	79	70	70	78
5.	Line Haul- (a) Pay load (b) Carrying Unit	 74 72	 46 70	 50 72	 67 72	 73 61	 45 65	 45 70	 67 62
	(ii) For costs in Group 'C -@								
1. 2 3. 4.	Terminal Marshalling Transhipment at break of gauge point Repacking of small	87 88 91 91	50 55 55 54	50 55 57 60	80 80 86 87	85 85 91 90	50 50 55 50	50 60 57 55	80 80 86 85
5.	Line Haul--- (i) Traction :								
	a) Steam b) Diesel c) Electric*	100 100 100	100 100 100	100 100 100	100 100 100	100 100 100	100 100 100	100 100 100	100 100 100
	(ii) Other Transportation	85	45	45	70	85	45	45	77
	(iii) Tracks Signalling	90	45	45	47	48	45	45	47

@ -	1) Variability factors indicated for different facets of operation in Group Care exclusive of costs of provision and maintenance of wagons. The variability for provision and maintenance of wagons is 100% for D.R.F. and interest charge for both B.G. & M. G.
	2) Variability factors for overhead expenses will be in the ratio of constant and variable expenses asworked out about to the total expenses under these heads.
	3) For a quick and broad analysis, a variability of 78.5% may be taken as representing working expenses.
*	The variability factor relates to total cost including cost on overhead equipment.

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ANNEXURE-B

SINKING FUND PAYMENT TABLE

N-Normal life of assets in years

N	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.4975	0.4950	0.4926	0.4902	0.4878	0.4854	0.4831	0.4808	0.4785	0.4762
3	0.3300	0.3268	0.3235	0.3203	0.3172	0.3141	0.3111	0.3080	0.3051	0.3021
4	0.2463	0.2426	0.2390	0.2355	0.2320	0.2286	0.2252	0.2219	0.2187	0.2155
5	0.1960	0.1922	0.1884	0.1846	0.1810	0.1774	0.1739	0.1705	0.1671	0.1638
6	0.1625	0.1585	0.1546	0.1508	0.1470	0.1434	0.1398	0.1363	0.1329	0.1296
7	0.1386	0.1345	0.1305	0.1266	0.1228	0.1191	0.1156	0.1121	0.1087	0.1054
8	0.1207	0.1165	0.1125	0.1085	0.1047	0.1010	0.0975	0.0940	0.0907	0.0874
9	0.1067	0.1025	0.0984	0.0945	0.0907	0.0870	0.0835	0.0801	0.0768	0.0736
10	0.0956	0.0913	0.0872	0.0833	0.0795	0.0759	0.0724	0.0690	0.0658	0.0627
11	0.0865	0.0822	0.0781	0.0741	0.0704	0.0668	0.0634	0.0601	0.0569	0.0540
12	0.0788	0.0746	0.0705	0.0666	0.0628	0.0593	0.0559	0.0527	0.0497	0.0468
13	0.0724	0.0681	0.0640	0.0601	0.0565	0.0530	0.0497	0.0465	0.0436	0.0408
14	0.0669	0.0626	0.0585	0.0547	0.0510	0.0476	0.0443	0.0413	0.0384	0.0357
15	0.0621	0.0578	0.0538	0.0499	0.0463	0.0430	0.0398	0.0368	0.0341	0.0315
16	0.0579	0.0537	0.0496	0.0458	0.0423	0.0390	0.0359	0.0330	0.0303	0.0278
17	0.0543	0.0500	0.0460	0.0422	0.0387	0.0354	0.0324	0.0296	0.0270	0.0247
18	0.0510	0.0467	0.0427	0.0390	0.0355	0.0324	0.0294	0.0267	0.0242	0.0219
19	0.0481	0.0438	0.0398	0.0361	0.0327	0.0296	0.0268	0.0241	0.0217	0.0195
20	0.0454	0.0412	0.0372	0.0336	0.0302	0.0272	0.0244	0.0219	0.0195	0.0175
21	0.0430	0.0388	0.0349	0.0313	0.0280	0.0250	0.0223	0.0198	0.0176	0.0156
22	0.0409	0.0366	0.0327	0.0292	0.0260	0.0230	0.0204	0.0180	0.0159	0.0140
23	0.0389	0.0347	0.0308	0.0273	0.0241	0.0213	0.0187	0.0164	0.0144	0.0126
24	0.0371	0.0329	0.0290	0.0256	0.0225	0.0197	0.0172	0.0150	0.0130	0.0113
25	0.0354	0.0312	0.0274	0.0240	0.0210	0.0182	0.0158	0.0137	0.0118	0.0102
26	0.0339	0.0297	0.0259	0.0226	0.0196	0.0169	0.0146	0.0125	0.0107	0.0092
27	0.0324	0.0283	0.0246	0.0212	0.0183	0.0157	0.0134	0.0114	0.0097	0.0083
28	0.0311	0.0270	0.0233	0.0200	0.0171	0.0146	0.0124	0.0105	0.0089	0.0075
29	0.0299	0.0258	0.0221	0.0189	0.0160	0.0136	0.0114	0.0096	0.0081	0.0067
30	0.0287	0.0246	0.0210	0.0178	0.0151	0.0126	0.0106	0.0088	0.0073	0.0061
31	0.0277	0.0236	0.0200	0.0169	0.0141	0.0118	0.0098	0.0081	0.0067	0.0055
32	0.0267	0.0226	0.0190	0.0159	0.0133	0.0110	0.0091	0.0075	0.0061	0.0050
33	0.0257	0.0217	0.0182	0.0151	0.0125	0.0103	0.0084	0.0069	0.0056	0.0045
34	0.0248	0.0208	0.0173	0.0143	0.0118	0.0096	0.0078	0.0063	0.0051	0.0041
35	0.0240	0.0200	0.0165	0.0136	0.0111	0.0090	0.0072	0.0058	0.0046	0.0037

36	0.0232	0.0192	0.0158	0.0129	0.0104	0.0084	0.0067	0.0053	0.0042	0.0033
37	0.0225	0.0185	0.0151	0.0122	0.0098	0.0079	0.0062	0.0049	0.0039	0.0030
38	0.0218	0.0178	0.0145	0.0116	0.0093	0.0074	0.0058	0.0045	0.0035	0.0027
39	0.0211	0.0172	0.0138	0.0111	0.0088	0.0069	0.0054	0.0042	0.0032	0.0025
40	0.0205	0.0166	0.0133	0.0105	0.0083	0.0065	0.0050	0.0039	0.0030	0.0023
41	0.0199	0.0160	0.0127	0.0100	0.0078	0.0061	0.0047	0.0036	0.0027	0.0020
42	0.0193	0.0154	0.0122	0.0095	0.0074	0.0057	0.0043	0.0033	0.0025	0.0019
43	0.0187	0.0149	0.0117	0.0091	0.0070	0.0053	0.0040	0.0030	0.0023	0.0017
44	0.0182	0.0144	0.0112	0.0087	0.0066	0.0050	0.0038	0.0028	0.0021	0.0015
45	0.0177	0.0139	0.0108	0.0083	0.0063	0.0047	0.0035	0.0026	0.0019	0.0014
46	0.0172	0.0135	0.0104	0.0079	0.0059	0.0044	0.0033	0.0024	0.0017	0.0013
47	0.0168	0.0130	0.0100	0.0075	0.0056	0.0041	0.0030	0.0022	0.0016	0.0011
48	0.0163	0.0126	0.0096	0.0072	0.0053	0.0039	0.0028	0.0020	0.0015	0.0010
49	0.0159	0.0122	0.0092	0.0069	0.0050	0.0037	0.0026	0.0019	0.0013	0.0009
50	0.0155	0.0118	0.0089	0.0066	0.0048	0.0034	0.0025	0.0017	0.0012	0.0009

The use of the Table – What sum must be paid at the end of each year to Sinking Fund so that the annual payments together with interest therein at 4 per cent compound annually, will at the end of 18 years amount to Rs.2,000/-

Opposite 18 under 4 per cent we find 0.0390 which is the annual payment required for Re.1/- so for Rs. 2,000 the annual payment is 2,000 x 0.0390 i.e. Rs. 78/-

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ANNEXURE -C

(See Para 227)

Interest Formulas And Tables For Discounted Cash Flow Techniques

Interest Formulas

The interest formula and tables that follow may be found of considerable use in evaluating thefinancial aspects of Engineering projects.

Symbols:- The symbols used in these formulas and Tables are:

i represent rate of interest per interest period.

n represent number of interest periods

p represent sum of money

S - do - sum of money that is equivalent to p with interest i, at the end of n

R - do - the end of period payments/receipt in a uniform series continuing for the coming n periods, the entire series equivalent to p at interest rate i.

Formulas :- The interest formulas expressing the relationship between P, S and R

in terms of i and n are :-Given P, to find S

$$S = P\left[(1+i)^n\right] \quad (1)$$

Given S, to find P . $$P = S\left[\frac{1}{(1+i)^n}\right] \quad (2)$$

Given S, to find R , $$R = S\,\frac{1}{(1+i)^{n-1}} \quad (3)$$

Given P, to find R , $$R = P\left[\frac{i(1+i)^n}{(1+i)^{n-1}}\right] \quad (4)$$

Given R, to find S , $$S = R\left[\frac{(1+i)^{n-1}}{i}\right] \quad (5)$$

Given R, to find P , $$P = R\left[\frac{(1+i)^{n-1}}{i(1+i)^n}\right] \quad (6)$$

In the following explanations of these formulas the interest period is taken as one year; theexplanations can be made general by substituting "Period" for "year".

Development of Formulas for Single Payment- If P is invested at interest rate l, the interest for thefirst year is iP and the total amount at the end of the first year is P(l+i).

The second year the interest on this is ip(l+i), and the amount at the end of this year is $P(l+i)+iP(l+i) = P(l+i)^2$. Similarly at the end of the third year the amount is $P(l+i)^3$; at the

end of n years it is $P(1+i)^n$.

This is the formula for the compound amount, S, obtainable in n years from a principal, P.

$$S = P \quad (1+i)^n \qquad (1)$$

If we express P in terms of S, i and n

$$P = S \left(\frac{1}{(1+i)^n} \right) \qquad (2)$$

P may then be thought of as the principal that will give a required amount S in n years; in other words, P is the present worth of a payment S, n years hence.

The expression $(1+i)^n$ is called the single payment compound amount actor (denoted as cu'). Its reciprocal $1/(1+i)^n$ is called the single payment present worth actor (denoted as pwf.)

Formulas for Uniform Annual Series of End-of Year Payments - If R is invested at the end of each year for n years, the total amount at the end of n years will be the sum of the compound amounts of the individual investments. The money invested at the end of the first year will earn interest for (n-1) years; its amount will thus be $R(1+i)^{n-1}$. The second years payment will amount to $R(1+i)^{n-2}$; the third years to $R(1+i)^{n-3}$; and so on until the last payment, made at the end of n years which has earned no interest. The total sum S is then given by the expression-

$$S=R[\ (1+(1+i)+(1+i)^2 \quad \ldots+(1+i)^{n-2}+(1+i)^{n-1}] \qquad (i)$$

To simplify, multiply both sides of the equation by (1+i),

$$(1+i)S= R[(1+i)+(1+i)^2+(1+i)^3 \quad \ldots +(1+i)^{n-1}+(1+i)^n] \qquad (ii)$$

Subtracting (i) from (ii)

$$iS = R[(1+i)^{n-1}]$$

$$\text{or } S = R \left[\frac{(1+i)^{n-1}}{i} \right]$$

$$\text{And } R=S \left(\frac{i}{(1+i)^{n-1}} \right) \qquad (3)$$

A fund established to produce a desired amount at the end of a given period of time by means of a series of payments through out the period is called a

sinking fund. The expression—

$$\frac{1}{(1+i)^{n-1}}$$

is called the sinking fund deposit factor (denoted as sff).

To find the uniform end-of year payment, R which can be secured for n years from a present investment P, substitute in equation (3) the value given for S in equation (I)

$$R=S\left[\frac{I}{(I+i)^{n-1}}\right] \qquad = P\text{-}(I+i)^{n}\left[\frac{i}{(I+i)^{n-1}}\right]$$

$$\text{or } R=P\left[\frac{i(I+i)^{n}}{(I+i)^{n-1}}\right] \qquad (4)$$

The expression—

$$\frac{i(1+i)^{n}}{(1+i)^{n-1}}$$

is called the capital recovery factor (denoted as crf).

When multiplied by a present debt (which, from the point of the lender, is a present investment,) it gives the uniform end-of-year payment necessary to repay the debit (the lender's investment) in n years with interest rate i.

Formulas (3) and (4) may be reversed to show S and P in terms of R as follows:

$$S=R\left[\frac{(I+i)^{n-1}}{i}\right] \qquad (5)$$

$$P=R\left[\frac{(1+i)^{n-1}}{i(1+i)^{n}}\right] \qquad (6)$$

The expression— $\left[\frac{(1+i)^{n-1}}{i}\right]$

is called the uniform series compound amount factor (denoted as caf)

The expression $\left[\frac{(I+i)^{n-1}}{i(I+i)^{n}}\right]$

is called the uniform series present worth factor (denoted as pwf).

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ANNEXURE -C (Contd.) Table-1										
Future Value Interest Factor for 1 Rupee discounted at i % for 'n' periods										
n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	1.0100	1.0200	1.0300	1.0400	1.0500	1.0600	1.0700	1.0800	1.0900	1.1000
2	1.0201	1.0404	1.0609	1.0816	1.1025	1.1236	1.1449	1.1664	1.1881	1.2100
3	1.0303	1.0612	1.0927	1.1249	1.1576	1.1910	1.2250	1.2597	1.2950	1.3310
4	1.0406	1.0824	1.1255	1.1699	1.2155	1.2625	1.3108	1.3605	1.4116	1.4641
5	1.0510	1.1041	1.1593	1.2167	1.2763	1.3382	1.4026	1.4693	1.5386	1.6105
6	1.0615	1.1262	1.1941	1.2653	1.3401	1.4185	1.5007	1.5869	1.6771	1.7716
7	1.0721	1.1487	1.2299	1.3159	1.4071	1.5036	1.6058	1.7138	1.8280	1.9487
8	1.0829	1.1717	1.2668	1.3686	1.4775	1.5938	1.7182	1.8509	1.9926	2.1436
9	1.0937	1.1951	1.3048	1.4233	1.5513	1.6895	1.8385	1.9990	2.1719	2.3579
10	1.1046	1.2190	1.3439	1.4802	1.6289	1.7908	1.9672	2.1589	2.3674	2.5937
11	1.1157	1.2434	1.3842	1.5395	1.7103	1.8983	2.1049	2.3316	2.5804	2.8531
12	1.1268	1.2682	1.4258	1.6010	1.7959	2.0122	2.2522	2.5182	2.8127	3.1384
13	1.1381	1.2936	1.4685	1.6651	1.8856	2.1329	2.4098	2.7196	3.0658	3.4523
14	1.1495	1.3195	1.5126	1.7317	1.9799	2.2609	2.5785	2.9372	3.3417	3.7975
15	1.1610	1.3459	1.5580	1.8009	2.0789	2.3966	2.7590	3.1722	3.6425	4.1772
16	1.1726	1.3728	1.6047	1.8730	2.1829	2.5404	2.9522	3.4259	3.9703	4.5950
17	1.1843	1.4002	1.6528	1.9479	2.2920	2.6928	3.1588	3.7000	4.3276	5.0545
18	1.1961	1.4282	1.7024	2.0258	2.4066	2.8543	3.3799	3.9960	4.7171	5.5599
19	1.2081	1.4568	1.7535	2.1068	2.5270	3.0256	3.6165	4.3157	5.1417	6.1159
20	1.2202	1.4859	1.8061	2.1911	2.6533	3.2071	3.8697	4.6610	5.6044	6.7275
21	1.2324	1.5157	1.8603	2.2788	2.7860	3.3996	4.1406	5.0338	6.1088	7.4002
22	1.2447	1.5460	1.9161	2.3699	2.9253	3.6035	4.4304	5.4365	6.6586	8.1403
23	1.2572	1.5769	1.9736	2.4647	3.0715	3.8197	4.7405	5.8715	7.2579	8.9543
24	1.2697	1.6084	2.0328	2.5633	3.2251	4.0489	5.0724	6.3412	7.9111	9.8497
25	1.2824	1.6406	2.0938	2.6658	3.3864	4.2919	5.4274	6.8485	8.6231	10.8347
26	1.2953	1.6734	2.1566	2.7725	3.5557	4.5494	5.8074	7.3964	9.3992	11.9182
27	1.3082	1.7069	2.2213	2.8834	3.7335	4.8223	6.2139	7.9881	10.2451	13.1100
28	1.3213	1.7410	2.2879	2.9987	3.9201	5.1117	6.6488	8.6271	11.1671	14.4210
29	1.3345	1.7758	2.3566	3.1187	4.1161	5.4184	7.1143	9.3173	12.1722	15.8631
30	1.3478	1.8114	2.4273	3.2434	4.3219	5.7435	7.6123	10.0627	13.2677	17.4494
31	1.3613	1.8476	2.5001	3.3731	4.5380	6.0881	8.1451	10.8677	14.4618	19.1943
32	1.3749	1.8845	2.5751	3.5081	4.7649	6.4534	8.7153	11.7371	15.7633	21.1138
33	1.3887	1.9222	2.6523	3.6484	5.0032	6.8406	9.3253	12.6760	17.1820	23.2252
34	1.4026	1.9607	2.7319	3.7943	5.2533	7.2510	9.9781	13.6901	18.7284	25.5477
35	1.4166	1.9999	2.8139	3.9461	5.5160	7.6861	10.6766	14.7853	20.4140	28.1024
36	1.4308	2.0399	2.8983	4.1039	5.7918	8.1473	11.4239	15.9682	22.2512	30.9127
37	1.4451	2.0807	2.9852	4.2681	6.0814	8.6361	12.2236	17.2456	24.2538	34.0039
38	1.4595	2.1223	3.0748	4.4388	6.3855	9.1543	13.0793	18.6253	26.4367	37.4043
39	1.4741	2.1647	3.1670	4.6164	6.7048	9.7035	13.9948	20.1153	28.8160	41.1448

40	1.4889	2.2080	3.2620	4.8010	7.0400	10.2857	14.9745	21.7245	31.4094	45.2593
41	1.5038	2.2522	3.3599	4.9931	7.3920	10.9029	16.0227	23.4625	34.2363	49.7852
42	1.5188	2.2972	3.4607	5.1928	7.7616	11.5570	17.1443	25.3395	37.3175	54.7637
43	1.5340	2.3432	3.5645	5.4005	8.1497	12.2505	18.3444	27.3666	40.6761	60.2401
44	1.5493	2.3901	3.6715	5.6165	8.5572	12.9855	19.6285	29.5560	44.3370	66.2641
45	1.5648	2.4379	3.7816	5.8412	8.9850	13.7646	21.0025	31.9204	48.3273	72.8905
46	1.5805	2.4866	3.8950	6.0748	9.4343	14.5905	22.4726	34.4741	52.6767	80.1795
47	1.5963	2.5363	4.0119	6.3178	9.9060	15.4659	24.0457	37.2320	57.4176	88.1975
48	1.6122	2.5871	4.1323	6.5705	10.4013	16.3939	25.7289	40.2106	62.5852	97.0172
49	1.6283	2.6388	4.2562	6.8333	10.9213	17.3775	27.5299	43.4274	68.2179	106.7190
50	1.6446	2.6916	4.3839	7.1067	11.4674	18.4202	29.4570	46.9016	74.3575	117.3909

	Annexure -C (Contd.) Table - 2									
	Future Value Interest Factor for 1 Rupee annuity compounded									
n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	2.0100	2.0200	2.0300	2.0400	2.0500	2.0600	2.0700	2.0800	2.0900	2.1000
3	3.0301	3.0604	3.0909	3.1216	3.1525	3.1836	3.2149	3.2464	3.2781	3.3100
4	4.0604	4.1216	4.1836	4.2465	4.3101	4.3746	4.4399	4.5061	4.5731	4.6410
5	5.1010	5.2040	5.3091	5.4163	5.5256	5.6371	5.7507	5.8666	5.9847	6.1051
6	6.1520	6.3081	6.4684	6.6330	6.8019	6.9753	7.1533	7.3359	7.5233	7.7156
7	7.2135	7.4343	7.6625	7.8983	8.1420	8.3938	8.6540	8.9228	9.2004	9.4872
8	8.2857	8.5830	8.8923	9.2142	9.5491	9.8975	10.2598	10.6366	11.0285	11.4359
9	9.3685	9.7546	10.1591	10.5828	11.0266	11.4913	11.9780	12.4876	13.0210	13.5795
10	10.4622	10.9497	11.4639	12.0061	12.5779	13.1808	13.8164	14.4866	15.1929	15.9374
11	11.5668	12.1687	12.8078	13.4864	14.2068	14.9716	15.7836	16.6455	17.5603	18.5312
12	12.6825	13.4121	14.1920	15.0258	15.9171	16.8699	17.8885	18.9771	20.1407	21.3843
13	13.8093	14.6803	15.6178	16.6268	17.7130	18.8821	20.1406	21.4953	22.9534	24.5227
14	14.9474	15.9739	17.0863	18.2919	19.5986	21.0151	22.5505	24.2149	26.0192	27.9750
15	16.0969	17.2934	18.5989	20.0236	21.5786	23.2760	25.1290	27.1521	29.3609	31.7725
16	17.2579	18.6393	20.1569	21.8245	23.6575	25.6725	27.8881	30.3243	33.0034	35.9497
17	18.4304	20.0121	21.7616	23.6975	25.8404	28.2129	30.8402	33.7502	36.9737	40.5447
18	19.6147	21.4123	23.4144	25.6454	28.1324	30.9057	33.9990	37.4502	41.3013	45.5992
19	20.8109	22.8406	25.1169	27.6712	30.5390	33.7600	37.3790	41.4463	46.0185	51.1591
20	22.0190	24.2974	26.8704	29.7781	33.0660	36.7856	40.9955	45.7620	51.1601	57.2750
21	23.2392	25.7833	28.6765	31.9692	35.7193	39.9927	44.8652	50.4229	56.7645	64.0025
22	24.4716	27.2990	30.5368	34.2480	38.5052	43.3923	49.0057	55.4568	62.8733	71.4027
23	25.7163	28.8450	32.4529	36.6179	41.4305	46.9958	53.4361	60.8933	69.5319	79.5430
24	26.9735	30.4219	34.4265	39.0826	44.5020	50.8156	58.1767	66.7648	76.7898	88.4973
25	28.2432	32.0303	36.4593	41.6459	47.7271	54.8645	63.2490	73.1059	84.7009	98.3471
26	29.5256	33.6709	38.5530	44.3117	51.1135	59.1564	68.6765	79.9544	93.3240	109.1818
27	30.8209	35.3443	40.7096	47.0842	54.6691	63.7058	74.4838	87.3508	102.7231	121.0999

28	32.1291	37.0512	42.9309	49.9676	58.4026	68.5281	80.6977	95.3388	112.9682	134.2099
29	33.4504	38.7922	45.2189	52.9663	62.3227	73.6398	87.3465	103.9659	124.1354	148.6309
30	34.7849	40.5681	47.5754	56.0849	66.4388	79.0582	94.4608	113.2832	136.3075	164.4940
31	36.1327	42.3794	50.0027	59.3283	70.7608	84.8017	102.0730	123.3459	149.5752	181.9434
32	37.4941	44.2270	52.5028	62.7015	75.2988	90.8898	110.2182	134.2135	164.0370	201.1378
33	38.8690	46.1116	55.0778	66.2095	80.0638	97.3432	118.9334	145.9506	179.8003	222.2515
34	40.2577	48.0338	57.7302	69.8579	85.0670	104.1838	128.2588	158.6267	196.9823	245.4767
35	41.6603	49.9945	60.4621	73.6522	90.3203	111.4348	138.2369	172.3168	215.7108	271.0244
36	43.0769	51.9944	63.2759	77.5983	95.8363	119.1209	148.9135	187.1021	236.1247	299.1268
37	44.5076	54.0343	66.1742	81.7022	101.6281	127.2681	160.3374	203.0703	258.3759	330.0395
38	45.9527	56.1149	69.1594	85.9703	107.7095	135.9042	172.5610	220.3159	282.6298	364.0434
39	47.4123	58.2372	72.2342	90.4091	114.0950	145.0585	185.6403	238.9412	309.0665	401.4478
40	48.8864	60.4020	75.4013	95.0255	120.7998	154.7620	199.6351	259.0565	337.8824	442.5926
41	50.3752	62.6100	78.6633	99.8265	127.8398	165.0477	214.6096	280.7810	369.2919	487.8518
42	51.8790	64.8622	82.0232	104.8196	135.2318	175.9505	230.6322	304.2435	403.5281	537.6370
43	53.3978	67.1595	85.4839	110.0124	142.9933	187.5076	247.7765	329.5830	440.8457	592.4007
44	54.9318	69.5027	89.0484	115.4129	151.1430	199.7580	266.1209	356.9496	481.5218	652.6408
45	56.4811	71.8927	92.7199	121.0294	159.7002	212.7435	285.7493	386.5056	525.8587	718.9048
46	58.0459	74.3306	96.5015	126.8706	168.6852	226.5081	306.7518	418.4261	574.1860	791.7953
47	59.6263	76.8172	100.3965	132.9454	178.1194	241.0986	329.2244	452.9002	626.8628	871.9749
48	61.2226	79.3535	104.4084	139.2632	188.0254	256.5645	353.2701	490.1322	684.2804	960.1723
49	62.8348	81.9406	108.5406	145.8337	198.4267	272.9584	378.9990	530.3427	746.8656	1057.1896
50	64.4632	84.5794	112.7969	152.6671	209.3480	290.3359	406.5289	573.7702	815.0836	1163.9085

	Annexure -C (Contd.) Table - 3									
	Present Value interest factor for 1 rupee discounted									
n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091
2	0.9803	0.9612	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264
3	0.9706	0.9423	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513
4	0.9610	0.9238	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830
5	0.9515	0.9057	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209
6	0.9420	0.8880	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645
7	0.9327	0.8706	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835	0.5470	0.5132
8	0.9235	0.8535	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665
9	0.9143	0.8368	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241
10	0.9053	0.8203	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855
11	0.8963	0.8043	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505
12	0.8874	0.7885	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186
13	0.8787	0.7730	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897
14	0.8700	0.7579	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633
15	0.8613	0.7430	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394

16	0.8528	0.7284	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919	0.2519	0.2176
17	0.8444	0.7142	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703	0.2311	0.1978
18	0.8360	0.7002	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502	0.2120	0.1799
19	0.8277	0.6864	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317	0.1945	0.1635
20	0.8195	0.6730	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145	0.1784	0.1486
21	0.8114	0.6598	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987	0.1637	0.1351
22	0.8034	0.6468	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839	0.1502	0.1228
23	0.7954	0.6342	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703	0.1378	0.1117
24	0.7876	0.6217	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577	0.1264	0.1015
25	0.7798	0.6095	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460	0.1160	0.0923
26	0.7720	0.5976	0.4637	0.3607	0.2812	0.2198	0.1722	0.1352	0.1064	0.0839
27	0.7644	0.5859	0.4502	0.3468	0.2678	0.2074	0.1609	0.1252	0.0976	0.0763
28	0.7568	0.5744	0.4371	0.3335	0.2551	0.1956	0.1504	0.1159	0.0895	0.0693
29	0.7493	0.5631	0.4243	0.3207	0.2429	0.1846	0.1406	0.1073	0.0822	0.0630
30	0.7419	0.5521	0.4120	0.3083	0.2314	0.1741	0.1314	0.0994	0.0754	0.0573
31	0.7346	0.5412	0.4000	0.2965	0.2204	0.1643	0.1228	0.0920	0.0691	0.0521
32	0.7273	0.5306	0.3883	0.2851	0.2099	0.1550	0.1147	0.0852	0.0634	0.0474
33	0.7201	0.5202	0.3770	0.2741	0.1999	0.1462	0.1072	0.0789	0.0582	0.0431
34	0.7130	0.5100	0.3660	0.2636	0.1904	0.1379	0.1002	0.0730	0.0534	0.0391
35	0.7059	0.5000	0.3554	0.2534	0.1813	0.1301	0.0937	0.0676	0.0490	0.0356
36	0.6989	0.4902	0.3450	0.2437	0.1727	0.1227	0.0875	0.0626	0.0449	0.0323
37	0.6920	0.4806	0.3350	0.2343	0.1644	0.1158	0.0818	0.0580	0.0412	0.0294
38	0.6852	0.4712	0.3252	0.2253	0.1566	0.1092	0.0765	0.0537	0.0378	0.0267
39	0.6784	0.4619	0.3158	0.2166	0.1491	0.1031	0.0715	0.0497	0.0347	0.0243
40	0.6717	0.4529	0.3066	0.2083	0.1420	0.0972	0.0668	0.0460	0.0318	0.0221
41	0.6650	0.4440	0.2976	0.2003	0.1353	0.0917	0.0624	0.0426	0.0292	0.0201
42	0.6584	0.4353	0.2890	0.1926	0.1288	0.0865	0.0583	0.0395	0.0268	0.0183
43	0.6519	0.4268	0.2805	0.1852	0.1227	0.0816	0.0545	0.0365	0.0246	0.0166
44	0.6454	0.4184	0.2724	0.1780	0.1169	0.0770	0.0509	0.0338	0.0226	0.0151
45	0.6391	0.4102	0.2644	0.1712	0.1113	0.0727	0.0476	0.0313	0.0207	0.0137
46	0.6327	0.4022	0.2567	0.1646	0.1060	0.0685	0.0445	0.0290	0.0190	0.0125
47	0.6265	0.3943	0.2493	0.1583	0.1009	0.0647	0.0416	0.0269	0.0174	0.0113
48	0.6203	0.3865	0.2420	0.1522	0.0961	0.0610	0.0389	0.0249	0.0160	0.0103
49	0.6141	0.3790	0.2350	0.1463	0.0916	0.0575	0.0363	0.0230	0.0147	0.0094
50	0.6080	0.3715	0.2281	0.1407	0.0872	0.0543	0.0339	0.0213	0.0134	0.0085

	ANNEXURE -C (Contd.) Table - 4									
	Present Value Interest Factor for 1 rupee Annuity discounted									
n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091
2	1.9704	1.9416	1.9135	1.8861	1.8594	1.8334	1.8080	1.7833	1.7591	1.7355
3	2.9410	2.8839	2.8286	2.7751	2.7232	2.6730	2.6243	2.5771	2.5313	2.4869
4	3.9020	3.8077	3.7171	3.6299	3.5460	3.4651	3.3872	3.3121	3.2397	3.1699
5	4.8534	4.7135	4.5797	4.4518	4.3295	4.2124	4.1002	3.9927	3.8897	3.7908
6	5.7955	5.6014	5.4172	5.2421	5.0757	4.9173	4.7665	4.6229	4.4859	4.3553
7	6.7282	6.4720	6.2303	6.0021	5.7864	5.5824	5.3893	5.2064	5.0330	4.8684
8	7.6517	7.3255	7.0197	6.7327	6.4632	6.2098	5.9713	5.7466	5.5348	5.3349
9	8.5660	8.1622	7.7861	7.4353	7.1078	6.8017	6.5152	6.2469	5.9952	5.7590
10	9.4713	8.9826	8.5302	8.1109	7.7217	7.3601	7.0236	6.7101	6.4177	6.1446
11	10.3676	9.7868	9.2526	8.7605	8.3064	7.8869	7.4987	7.1390	6.8052	6.4951
12	11.2551	10.5753	9.9540	9.3851	8.8633	8.3838	7.9427	7.5361	7.1607	6.8137
13	12.1337	11.3484	10.6350	9.9856	9.3936	8.8527	8.3577	7.9038	7.4869	7.1034
14	13.0037	12.1062	11.2961	10.5631	9.8986	9.2950	8.7455	8.2442	7.7862	7.3667
15	13.8651	12.8493	11.9379	11.1184	10.3797	9.7122	9.1079	8.5595	8.0607	7.6061
16	14.7179	13.5777	12.5611	11.6523	10.8378	10.1059	9.4466	8.8514	8.3126	7.8237
17	15.5623	14.2919	13.1661	12.1657	11.2741	10.4773	9.7632	9.1216	8.5436	8.0216
18	16.3983	14.9920	13.7535	12.6593	11.6896	10.8276	10.0591	9.3719	8.7556	8.2014
19	17.2260	15.6785	14.3238	13.1339	12.0853	11.1581	10.3356	9.6036	8.9501	8.3649
20	18.0456	16.3514	14.8775	13.5903	12.4622	11.4699	10.5940	9.8181	9.1285	8.5136
21	18.8570	17.0112	15.4150	14.0292	12.8212	11.7641	10.8355	10.0168	9.2922	8.6487
22	19.6604	17.6580	15.9369	14.4511	13.1630	12.0416	11.0612	10.2007	9.4424	8.7715
23	20.4558	18.2922	16.4436	14.8568	13.4886	12.3034	11.2722	10.3711	9.5802	8.8832
24	21.2434	18.9139	16.9355	15.2470	13.7986	12.5504	11.4693	10.5288	9.7066	8.9847
25	22.0232	19.5235	17.4131	15.6221	14.0939	12.7834	11.6536	10.6748	9.8226	9.0770
26	22.7952	20.1210	17.8768	15.9828	14.3752	13.0032	11.8258	10.8100	9.9290	9.1609
27	23.5596	20.7069	18.3270	16.3296	14.6430	13.2105	11.9867	10.9352	10.0266	9.2372
28	24.3164	21.2813	18.7641	16.6631	14.8981	13.4062	12.1371	11.0511	10.1161	9.3066
29	25.0658	21.8444	19.1885	16.9837	15.1411	13.5907	12.2777	11.1584	10.1983	9.3696
30	25.8077	22.3965	19.6004	17.2920	15.3725	13.7648	12.4090	11.2578	10.2737	9.4269
31	26.5423	22.9377	20.0004	17.5885	15.5928	13.9291	12.5318	11.3498	10.3428	9.4790
32	27.2696	23.4683	20.3888	17.8736	15.8027	14.0840	12.6466	11.4350	10.4062	9.5264
33	27.9897	23.9886	20.7658	18.1476	16.0025	14.2302	12.7538	11.5139	10.4644	9.5694
34	28.7027	24.4986	21.1318	18.4112	16.1929	14.3681	12.8540	11.5869	10.5178	9.6086
35	29.4086	24.9986	21.4872	18.6646	16.3742	14.4982	12.9477	11.6546	10.5668	9.6442
36	30.1075	25.4888	21.8323	18.9083	16.5469	14.6210	13.0352	11.7172	10.6118	9.6765
37	30.7995	25.9695	22.1672	19.1426	16.7113	14.7368	13.1170	11.7752	10.6530	9.7059
38	31.4847	26.4406	22.4925	19.3679	16.8679	14.8460	13.1935	11.8289	10.6908	9.7327
39	32.1630	26.9026	22.8082	19.5845	17.0170	14.9491	13.2649	11.8786	10.7255	9.7570

40	32.8347	27.3555	23.1148	19.7928	17.1591	15.0463	13.3317	11.9246	10.7574	9.7791
41	33.4997	27.7995	23.4124	19.9931	17.2944	15.1380	13.3941	11.9672	10.7866	9.7991
42	34.1581	28.2348	23.7014	20.1856	17.4232	15.2245	13.4524	12.0067	10.8134	9.8174
43	34.8100	28.6616	23.9819	20.3708	17.5459	15.3062	13.5070	12.0432	10.8380	9.8340
44	35.4555	29.0800	24.2543	20.5488	17.6628	15.3832	13.5579	12.0771	10.8605	9.8491
45	36.0945	29.4902	24.5187	20.7200	17.7741	15.4558	13.6055	12.1084	10.8812	9.8628
46	36.7272	29.8923	24.7754	20.8847	17.8801	15.5244	13.6500	12.1374	10.9002	9.8753
47	37.3537	30.2866	25.0247	21.0429	17.9810	15.5890	13.6916	12.1643	10.9176	9.8866
48	37.9740	30.6731	25.2667	21.1951	18.0772	15.6500	13.7305	12.1891	10.9336	9.8969
49	38.5881	31.0521	25.5017	21.3415	18.1687	15.7076	13.7668	12.2122	10.9482	9.9063
50	39.1961	31.4236	25.7298	21.4822	18.2559	15.7619	13.8007	12.2335	10.9617	9.9148

	ANNEXURE -C (Contd.) Table - 5									
	Capital Recovery Factors									
n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	1.0100	1.0200	1.0300	1.0400	1.0500	1.0600	1.0700	1.0800	1.0900	1.1000
2	0.5075	0.5150	0.5226	0.5302	0.5378	0.5454	0.5531	0.5608	0.5685	0.5762
3	0.3400	0.3468	0.3535	0.3603	0.3672	0.3741	0.3811	0.3880	0.3951	0.4021
4	0.2563	0.2626	0.2690	0.2755	0.2820	0.2886	0.2952	0.3019	0.3087	0.3155
5	0.2060	0.2122	0.2184	0.2246	0.2310	0.2374	0.2439	0.2505	0.2571	0.2638
6	0.1725	0.1785	0.1846	0.1908	0.1970	0.2034	0.2098	0.2163	0.2229	0.2296
7	0.1486	0.1545	0.1605	0.1666	0.1728	0.1791	0.1856	0.1921	0.1987	0.2054
8	0.1307	0.1365	0.1425	0.1485	0.1547	0.1610	0.1675	0.1740	0.1807	0.1874
9	0.1167	0.1225	0.1284	0.1345	0.1407	0.1470	0.1535	0.1601	0.1668	0.1736
10	0.1056	0.1113	0.1172	0.1233	0.1295	0.1359	0.1424	0.1490	0.1558	0.1627
11	0.0965	0.1022	0.1081	0.1141	0.1204	0.1268	0.1334	0.1401	0.1469	0.1540
12	0.0888	0.0946	0.1005	0.1066	0.1128	0.1193	0.1259	0.1327	0.1397	0.1468
13	0.0824	0.0881	0.0940	0.1001	0.1065	0.1130	0.1197	0.1265	0.1336	0.1408
14	0.0769	0.0826	0.0885	0.0947	0.1010	0.1076	0.1143	0.1213	0.1284	0.1357
15	0.0721	0.0778	0.0838	0.0899	0.0963	0.1030	0.1098	0.1168	0.1241	0.1315
16	0.0679	0.0737	0.0796	0.0858	0.0923	0.0990	0.1059	0.1130	0.1203	0.1278
17	0.0643	0.0700	0.0760	0.0822	0.0887	0.0954	0.1024	0.1096	0.1170	0.1247
18	0.0610	0.0667	0.0727	0.0790	0.0855	0.0924	0.0994	0.1067	0.1142	0.1219
19	0.0581	0.0638	0.0698	0.0761	0.0827	0.0896	0.0968	0.1041	0.1117	0.1195
20	0.0554	0.0612	0.0672	0.0736	0.0802	0.0872	0.0944	0.1019	0.1095	0.1175
21	0.0530	0.0588	0.0649	0.0713	0.0780	0.0850	0.0923	0.0998	0.1076	0.1156
22	0.0509	0.0566	0.0627	0.0692	0.0760	0.0830	0.0904	0.0980	0.1059	0.1140
23	0.0489	0.0547	0.0608	0.0673	0.0741	0.0813	0.0887	0.0964	0.1044	0.1126
24	0.0471	0.0529	0.0590	0.0656	0.0725	0.0797	0.0872	0.0950	0.1030	0.1113

25	0.0454	0.0512	0.0574	0.0640	0.0710	0.0782	0.0858	0.0937	0.1018	0.1102
26	0.0439	0.0497	0.0559	0.0626	0.0696	0.0769	0.0846	0.0925	0.1007	0.1092
27	0.0424	0.0483	0.0546	0.0612	0.0683	0.0757	0.0834	0.0914	0.0997	0.1083
28	0.0411	0.0470	0.0533	0.0600	0.0671	0.0746	0.0824	0.0905	0.0989	0.1075
29	0.0399	0.0458	0.0521	0.0589	0.0660	0.0736	0.0814	0.0896	0.0981	0.1067
30	0.0387	0.0446	0.0510	0.0578	0.0651	0.0726	0.0806	0.0888	0.0973	0.1061
31	0.0377	0.0436	0.0500	0.0569	0.0641	0.0718	0.0798	0.0881	0.0967	0.1055
32	0.0367	0.0426	0.0490	0.0559	0.0633	0.0710	0.0791	0.0875	0.0961	0.1050
33	0.0357	0.0417	0.0482	0.0551	0.0625	0.0703	0.0784	0.0869	0.0956	0.1045
34	0.0348	0.0408	0.0473	0.0543	0.0618	0.0696	0.0778	0.0863	0.0951	0.1041
35	0.0340	0.0400	0.0465	0.0536	0.0611	0.0690	0.0772	0.0858	0.0946	0.1037
36	0.0332	0.0392	0.0458	0.0529	0.0604	0.0684	0.0767	0.0853	0.0942	0.1033
37	0.0325	0.0385	0.0451	0.0522	0.0598	0.0679	0.0762	0.0849	0.0939	0.1030
38	0.0318	0.0378	0.0445	0.0516	0.0593	0.0674	0.0758	0.0845	0.0935	0.1027
39	0.0311	0.0372	0.0438	0.0511	0.0588	0.0669	0.0754	0.0842	0.0932	0.1025
40	0.0305	0.0366	0.0433	0.0505	0.0583	0.0665	0.0750	0.0839	0.0930	0.1023
41	0.0299	0.0360	0.0427	0.0500	0.0578	0.0661	0.0747	0.0836	0.0927	0.1020
42	0.0293	0.0354	0.0422	0.0495	0.0574	0.0657	0.0743	0.0833	0.0925	0.1019
43	0.0287	0.0349	0.0417	0.0491	0.0570	0.0653	0.0740	0.0830	0.0923	0.1017
44	0.0282	0.0344	0.0412	0.0487	0.0566	0.0650	0.0738	0.0828	0.0921	0.1015
45	0.0277	0.0339	0.0408	0.0483	0.0563	0.0647	0.0735	0.0826	0.0919	0.1014
46	0.0272	0.0335	0.0404	0.0479	0.0559	0.0644	0.0733	0.0824	0.0917	0.1013
47	0.0268	0.0330	0.0400	0.0475	0.0556	0.0641	0.0730	0.0822	0.0916	0.1011
48	0.0263	0.0326	0.0396	0.0472	0.0553	0.0639	0.0728	0.0820	0.0915	0.1010
49	0.0259	0.0322	0.0392	0.0469	0.0550	0.0637	0.0726	0.0819	0.0913	0.1009
50	0.0255	0.0318	0.0389	0.0466	0.0548	0.0634	0.0725	0.0817	0.0912	0.1009

ANNEXURE -D
Rate Of Return- Using Discounted Cash Flow Method

To simplify calculations, a project evaluation sheet (Exhibit I) together with an Interpolation Chart (Exhibit II) has been prepared to obtain rate of return using the discounted cash flow method.

Procedure- Using project evaluation sheet:

a) In column Trial I enter as disbursements the net estimated investment by years. Enter estimated annual returns for the years in which they will occur, and include terminal salvage value (if any) as a return in the year in which it will be realized.

b) Total the disbursements and the annual returns for trial I and enter the results in A and B lines respectively.

c) To obtain the interest rate which equates the present value of the disbursements and annual returns, calculate their present worth in trials 2,3,4 and 5 by multiplying the amounts in trial I by the factors indicated in trials 2 to 5. Add columns to obtain totals A and B.

d) Calculate the ratio of A to B for each trial by dividing the total present worth of disbursements, Totals (A), by the total present worth of annual returns, Totals (B).

Note - Trial 5 should be completed only if trial 4 has a ratio of A to B less than 1

e) On interpolation chart, plot ratios A/B against the trial rate at which they were calculated.

f) Join points with a smooth curve and read rate of return on the vertical axis opposite the intersection of the smooth curve with the vertical line representing a ratio of A to B of I. This is the interest rate which equates the present value of investments with the present value of annual returns.

Note- If a smooth curve does not result from joining the four points plotted, an error has been made in calculations or plotting. A minimum of 4 points is, therefore, necessary to check accuracy.

Exhibit I

PROJECT EVALUATION SHEET

Timing	Trial 1 0% Int. Rate	Trial 2 10% Int. Rate		Trial 3 25% Int. Rate		Trial 4 40% Int. Rate		Trial 5 60% Int. Rate	
Period	Disbursement	Factor	Present worth	Factor	Present worth	Factor	Present worth	Factor	Present worth
5th Year	..	1.46		2.44		3.84		6.56	
4th	..	1.33		1.95		2.74		4.10	
3rd	..	1.21		1.56		1.96		2.56	
2nd	..	1.10		1.25		1.40		1.60	
1st	..	1.00		1.00		1.00		1.00	
Totals (A)		…							

ANNEXURE -D –(Concld.)

Period	Annual Return	Factor	Present worth	Factor	Present worth	Factor	Present worth	Factor	Present worth
		10% Int. Rate		25% Int. Rate		40% Int. Rate		60% Int. Rate	
1st Year	..	.91		.80		.71		.63	
2nd	..	.83		.64		.51		.39	
3rd	..	.75		.51		.36		.24	
4th	..	.68		.41		.26		.15	
5th	..	.62		.33		.19		.10	
6th	..	.56		.26		.13		.06	
7th	..	.51		.21		.09		.04	
8th	..	.47		.17		.07		.02	
9th	..	.42		.13		.05		.01	
10th	..	.39		.11		.03		.01	
11th	..	.35		.09		.02		.01	
12th	..	.32		.07		.02			
13th	..	.29		.06		.01			
14th	..	.26		.04		.01			
15th	..	.24		.04					

16th	..	.22		.03					
17th	..	.20		.02					
18th	..	.18		.02					
19th	..	.16		.01					
20th	..	.15		.01					
21st	..	.14							
22nd	..	.12							
23rd	..	.11							
24th	..	.10							
25th	..	.09							
26th	..	.08							
27th	..	.08							
28th	..	.07							
29th	..	.06							
30th	..	.06							
Totals (B)									

Exhibit II

INTERPOLATION CHART

RATE OF RETURN	60																
	55																
	50																
	45																
	40																
	35																
	30																
	25																
	20																
	15																
	10																
	5																
	0																
	0		0.5			1.0			1.5			2.0			2.5		3.0		3.5	

RATIO A/B

*****

ANNEXURE- E

EXAMPLE (I) :-

Yard re-modeling and provision of crossing stations on X-Y section of N. Railway.

Estimated capital cost	Rs. 27,56,000
Interest during construction	Rs. 3,93,011
Total	Rs. 31,49,011

Financial Implications-

Revenue in 2021-22-

(i) Additional traffic expected-

Wagon per day

		2021-22	2022-23
Inward	LSHS	28	38
	Coal	20	27
		48	65
Outward		38	50
	G. Total	86	115

(ii) Lead from X to Y — 157 Km.

(iii) Average load per 4-wheeler LSHS/HSHS — 18 tonnes in tank wagons
Other heavy merchandise — 19.5 tonnes.
Coal. — 21.3 tonnes.
Over all average load — 19.5 tonnes.

(iv) Tare weight of a wagon — 10 tonnes.

(v) Turn round on A Division — 3.71 days.

(vi) Revenue per tonne.-
Fertillizer — 4.71
Coal — 3.26
LSHS/HSHS — 8.33

(vii) Revenue for 2021-22 for entire year

$$= \text{Rs}\frac{(28\times18\times8.33)}{100}+\frac{(20\times21.3\times3.26)}{100}+\frac{(38\times19.5\times4.71)}{100}$$

$$= \text{Rs } 41.98 + 13.88 + 34.90$$

$$= \text{Rs. } 157\times365\times90.76 = \text{Rs. } 52,01,001.80$$

Cost of moving additional traffic-

i)	Traction		Diesel		
ii)	Number of marshalling yard/yards		…		
iii)	Number of engine changing points		…		
iv)	Total wagon days		365x86x3.71	=	116457
v)	Total No. of wagons run loaded		365x86	=	31390
vi)	trip Total No. of wagons run empty trip		365x66	=	24090
vii)	Documentation charges @ Rs 1.78 per invoice.	Rs.	31390x1.78	= Rs.	55874.20
viii)	Other terminal charges @ Rs. 12.41 per wagon.	Rs.	31390x12.41	= Rs	389549.90
ix)	Provision and maintenance of carrying units @ Rs1.49 per wagon per day	Rs.	116457x1.49	= Rs	173520.93
x)	(a) GTKM for diesel engines loaded trip	Rs.	31390x29.5x157	= Rs	145382785
	Haulage charges @ Rs. 3.73 per 1000 GTKM.	Rs.	(145382785x3.73)/ 1000	= Rs	5,42,277.78
	(b) GTKM for diesel engines empty trip	Rs.	24090x10x157	= Rs	37821300
	Haulage charges @ Rs. 3.73 per 1000 GTKM.	Rs.	(37821300x3.73)/ 1000	= Rs	141073.45
	(c) Line haul (movement) service- other than transportation expenses, including train passing staff @ Rs. 1.53 per 1000 GTKM For loaded trip	Rs.	(31390x29.5x157x 1.53)/ 1000	= Rs	2,22,453.60
	--do—For empty trip.	Rs.	(24090x10x157x 1.53)/ 1000	= Rs	57,866.59
	(d) Line Haul (movement) services cost of track and signalling @ Rs. 1.33 For loaded Trip	Rs.	(31390x29.5x157x 1.33)/ 1000	= Rs	1,93,359.10

	For empty trip	Rs.	(24090x10x157x 1.33)/ 1000	= Rs	50,302.33
(e)	Marshalling yard cost	Nil			
(f)	Engine changing cost	Nil			
(g)	Total haulage cost	Rs.	18,26,260.04		
(h)	Add allowance for 10%	Rs.	20,08,886.04		
(i)	Marginal cost @ 78%	Rs.	15,66,931.11		
(j)	Annual maintenance charges per first and subsequent years	Rs.	1,14,564.00		
	Total working expenses	Rs.	16,81,495.11		

Net earnings in 2021-22-

Revenue		Rs	52,01,001.80
Working expenses	(-)	Rs	16,81,495.11
Net revenue per year		Rs	35,19,506.69

Revenue in 2022-23 and onwards-

(i) Revenue per year Rs. $157 \times 365 \left[\frac{(38 \times 18 \times 8.33)}{100} + \frac{(27 \times 21.3 \times 3.26)}{100} - \frac{(50 \times 19.5 \times 4.17)}{100}\right]$

Rs. 157x365x56.98 + 18.74 + 45.92

Rs. 157x365x121.64 = Rs. 69,70,580.20

Cost of moving additional traffic

(i) Total wagon days	365x115x3.71	=	155727	
(ii) Total No. of wagons run- loaded trip	365x115	=	41975	
(iii) Total No. of wagons run- empty trip	365x85	=	31025	
(iv) Documentation charges @ Rs 1.78 per invoice.	Rs. 41975x1.78	=	Rs.	74715.50
(v) Other terminal charges @ Rs. 12.41 per wagon.	Rs. 41975x12.41	=	Rs.	520902.75
(vi) Provision and maintenance of carrying units @ Rs1.49 per wagon per day.	Rs. 155727x1.49	=	Rs.	232033.23

(vii)	(a)	GTKM for diesel engines- loaded trip	Rs.	41975x29.5x157	=	Rs. 194407212

	Haulage charges @ Rs. 3.73 per1000/GTKM	Rs.	$\frac{194407212 \times 3.73}{1000}$	=	Rs.	725139
(b)	GTKM for diesel engine empty trip	Rs.	31025x10x157	=	Rs.	48709250
	Haulage charges @ Rs. 3.73 per1000/GTKM	Rs.	$\frac{48709250 \times 3.73}{1000}$	=	Rs.	181685.50
(c)	Line haul (movement) service-other than transportation expenses including train passing staff @ Rs. 1.53 per 1000 GTKM:	Rs.	$\frac{41975 \times 29.5 \times 157 \times 1.53}{1000}$	=	Rs.	297443.00
	For loaded trip					
	For empty trip	Rs.	$\frac{51025 \times 10 \times 157 \times 1.53}{1000}$	=	Rs.	74525.15
(d)	Line Haul (movement) services: For loaded trip	Rs.	$\frac{41975 \times 29.5 \times 157 \times 1.33}{1000}$	=	Rs.	258561.52
	cost of track and signalling trip @Rs. 1.33	Rs.	$\frac{31025 \times 10 \times 157 \times 1.33}{1000}$	=	Rs.	64,783.30
	--do— For empty trip.					
(e)	Marshalling yard cost	Nil				
(f)	Engine changing cost	Nil				
(g)	Total haulage cost	Rs	24,29,798.00			
(h)	Add allowance for 10%	Rs.	26,72,775.00			

(viii)	Marginal cost @ 78%	Rs	20,84,765.00
(ix)	Annual maintenance charges for first and subsequent years	Rs.	1,14,564.00
(x)	Total working expenses	Rs.	21,99,329.00
	Net earnings 1997-98 and onwards-	Rs	69,70,580.00
	Earnings	Rs	21,99,329.00
	Working expenses (-)		
	Net earnings per year	Rs	47,71,251.00

Rolling Stock Requirement in 2022-23 and onwards-

(1) Diesel engines (cost Rs. 21,00,000)

	(a)	Average lead of a diesel	65 wagons
	(b)	engineLead from C to D	157 Km
	(c)	Total No. of trains per day 100/65	1.5
	(d)	Train Kms. Per day .	1.5x2x157 =471
	(e)	Engine Km. Per day per engine in use	387
	(f)	(diesel)Bare No. of diesel engine required	471/387 = 1.2
	(g)	Add for spares @ 6.96%	1.2 x106.96 =1.28 100 Say 1.3
	(h)	Cost of 1.3 engines @ Rs. 21,00,000	Rs. 27,30,000
(ii)		Covered wagons (Cost Rs.21,014).	
		Wagons required per day for carrying coalfor carrying urea	27 (15 to be back loaded) 35
		Total	62

Total bare number of covered wagons required (62x3.71 turn round) 230.02

Add spares @ Rs. 5.32% 230.02x105.32 / 100 = 242.25

Say 242

Cost of 248 wagons @ Rs 21,014 ..Rs. 21014x242 = 50,85,388

(iii) Tank wagons (cost bare number of wagons Required) Rs. 45,696

(38x3.71 turn round) = 140.98

Add for spares @ 5.32% 140.98x105.32 / 100 = 148.43

Say 148

Cost of 148 wagons @ Rs. 45,696 Rs. 45696x148 = Rs. 67,63,008

Grand total of rolling stock as per items (i), (ii), (iii) above Rs. 1,45,78,396

Cost of work including interest for 4 years as per details given below Rs. 31,49,011

Cost of rolling stock 1,45,78,396

Total **1,77,27,407**

Interest during construction:-

1st Year	10,00,000					$\frac{1000000 \times 6}{2 \times 100}$	= Rs.	30,000
2nd Year	6,00,000	[	$\frac{600000}{2}$	+ 1030000	] x	$\frac{6}{100}$	= Rs.	79,800
3rd Year	6,00,000	[	$\frac{600000}{2}$	+ 1709800	] x	$\frac{6}{100}$	= Rs.	1,20,588
4th Year	5,60,000	[	$\frac{5,60,000}{2}$	+ 2430388	] x	$\frac{6}{100}$	= Rs.	1,62,623
Total	27,60,000						=	3,93,011

Rate of return by DCF method-

(i) Capital cost	Rs.	1,77,27,407
(ii) Life of assets		30 Years
(iii) Salvage value @ 10% (excluding earth work)	Rs.	2,17,413
(iv) Net earnings 2021-22	Rs.	35,19,507
Net earnings 2022-23	Rs.	47,71,251

(v) Present worth calculations-

@ 25% (-177.27) + [(35.20) (0.8)] + [47.71 (3.995-0.8)] + [(2.17x.0012)]

- 177.27 + 28.16 + 152.43 + 0.0026

- 177.27 + 180.59

+ 3.32

ROR is about 25%

Note - in this computation, at 25% discount rate

0.8 is the single payment PWF for the Ist Year, 3.995 is the PWF for uniform cash Flow in the 30th year 0.0012 is the

PWF for
Single payment in the 30th year.

EXAMPLE (2) :-

Provision of departmental line wires on A-B Section of X Railway.

Estimated initial cost : Rs.25.08 lakhs (including Rs.1.47 lakhs for staff quarters).
Outflow of cash during the Project Construction stage-

Year	0%	6%	10%	15%
- 2	(-) 6,00,000	(-) 6,54,000	--	--
- 1	(-) 12,00,000	(-) 12,72,000	--	--
0	(-) 7,08,000	(-) 7,08,000	--	--
	(-) 25,08,000	(-) 26,34,000	--	--

NPV of the Project, assuming even cash flow of Rs.2,81,184 (details given below), at 10% over a lifeof 60 years will be 2,81,184 x 9.967 = 28,02,561.

As the NPV is more than the initial investment inclusive of interest during construction, the project isfinancially justified.

Details of the anticipated annual saving of Rs.2,81,184
Financial Implication:-

		Increase	Decrease
1.	Annual repairs and maintenance charges on Rs.25,08,000 @ 3%	75,240	-
2.	Annual rental savings		
	(a) Iron wire per mile @ Rs.54.23 x4 per conductor (136 miles)	-	29,501
	(b)Copper wire per mile @ Rs.72.27 x 4 per conductor (136miles)	-	39,314
3.	Annual operational savings as per details attached	-	2,83,764
4.	Financial implications arising out of Engg's portion as per details attached	-	3,845
5.	Total	75,240	3,56,424

Net saving during 1st and subsequent years = 3,56,424 –75,240 = 2,81,184

Details of item 4 :-

	Increased by	Decreased by
Annual rent recoverable from type II quarters (7 units) $\frac{7x(110+380)x12}{2}$ @ 10%	...	2,982
Annual rent recoverable from staff of type I quarters(7 units) $\frac{7x(70+110)+47x12}{4}$ @ 7.1/2%	....	863
	....	3,845

Net annual increase during the first and the subsequent year = Rs.3845

Details of items 3

Details of operational savings -It is expected that with the provision of ACSR line wire, the control efficiency will be 90% and above. The efficiency below 90 is primarily due to copper wire thefts. During February, 1970 for 13 days the efficiency was 90% and above and average hours per train is 4 hrs-55 mts. as against 5 hrs-45 mts. per train during the balance of 15 days. The difference in the hours on road is 50 mts or
.83 mts per train.

1.	Average number of trains (only Dn trains excluding one works train as per line capacity statement 1968-69)	=		13.1
2.	Total T.G. accounted for	=		370
3.	Number of trains effected below 90% efficiency	=		197
4.	Percentage of trains effected to total trains accounted for	=	$\frac{197 \times 100}{370}$ =	53.24
5.	Percentage of average trains effected to total T.G. running onsection i.e. 13.1	=	$\frac{53.24 \times 13.1}{100}$ =	6.97
6.	Average load per train on branch line	=		56

'A' Saving on wagons:-

a)	No. of hours to be save	=	6.97x56x .83 wagon hrs.

b) Converting wagon hours into wagon days = $\frac{6.97 \times 56 \times .83}{24}$

c) By adding spares @ 3.23% = $\frac{6.97 \times 56 \times .83}{24} \times \frac{103.23}{100} = 13.87$

d) Saving on one wagon = Rs. 2229/-

e) Annual saving on 13.87 = 2229x13.87 = Rs.30916

'B' Saving on engine :-

a. Total detention to be saved = 6.97 x .83

b. Converting into No. of Diesel Engine @ 19.1 hrs. (Daily effective hourse) = $\frac{6.97 \times .83}{19.1}$

c. By adding spare @ 8.22% = $\frac{6.97 \times 83}{19.1} \times \frac{108.22}{100} = .32$

d. Saving on .32 engine @Rs.7,90,152(fraction of an engine W/O interest and depreciation) = 790152 x .32 = Rs.2,52,848

e. Total saving of 'A' and 'B' = 30916 + 252848 = Rs.2,83,764

EXAMPLE (3):-

Provision of line capacity of 'X' Railway.

A section (82 Kms) is partially doubled in two patches over two stretches totalling 52 Kms. On the 30 Kms. long single line section, there are 4 block stations and all these stations have two reception lines at present thereby limiting the capacity of the stations either to crossing of a train or merely to give precedence at the station, both crossing and precedence cannot take place at the same time.

2. The traffic is expected to increase from 20 trains each way on the single line section at present to 24 trains in the course of a year or two. At the end of 5 years, one more passenger train and two goods trains are expected to be introduced, increasing the train density to 27 either way. As against the projected line capacity required at 80% utilization for the above level of traffic at 30 and 34 in the 1st and the 5th the year respectively, the line capacity at present is restricted to 27. All capacity calculations assume diesel traction.

3. The following alternative are being considered for increasing the line capacity to match theprogressive traffic requirement :-

Alternative (1) : Doubling of the entire 30 Kms section - Cost Rs.1.90 crores; capacity 44 paths either way.

Alternative (2) : Doubling the section in two phases:

(a) Immediate doubling of 20 Kms section - Cost Rs.1 crore; capacity 32 paths either way.

(b) Doubling of the remaining 10 Kms length at a cost of Rs.90 lakhs in 5th year - capacity44 paths each way

Alternative (3) : (a) Provision of one additional reception line at each of the 4 block stations at an approximate cost of Rs. 10 lakhs straightaway; capacity 30 paths each way.

(b) Doubling of the entire 30 Kms section in 5th year-cost Rs.1.90crores; capacity 44 paths each way.

The additional Revenue likely to accrue on account of additional traffic worked out, commodity wise, as apportioned to the section in the 1st and the 5th years on the traffic projections for these years assuming the level of traffic to remain constant during this period and 5th year and beyond, are tabulated below :-

Sr. No.	Commodities	2016-17 and onwards	2019-20 to 2020-21	2021-22 and onwards
1.	Cement	56,450	1,25,823	1,95,197
2.	Pulses	19,549	46,149	72,843
3.	Salt	1,28,745	2,37,120	3,45,495
4.	Onions	15,626	38,756	61,887
5.	Rock Phosphate	46,097	1,23,315	2,00,534
6.	Vegetable Oil	89,363	1,69,253	2,49,143
7.	POL	4,84,477	6,01,383	8,38,289
	TOTAL	8,40,307	14,01,799	19,63,288
		(a)	(b)	(c)

(a) Plus 1 goods train.
(b) Plus 1 + 1 = 2 goods train.
(c) Plus 2 + 1 = 3 goods train.

4. The financial implications for the three alternatives worked out on the D.C.F. technique are given inthe statements annexed. It may be pointed out that only goods earnings have been taken for working out the financial implications and unit cost data with interest has been applied.

Alternative (1)

Full Doubling:

If doubling is done straightaway, the return comes to 8%. In this case the cash out-flow is Rs.1.90 crores during 2016-17 and 2017-18 while the cash in flow is at the level of 8,40,000 for 2016-17 to 2018-19, Rs.14,01,800 from 2019-20 to 2020-21 and Rs.19,63,000 for the remaining period 2021-22 to 2046-2047.

Year	Cash flow	Cumulative discount (8%) factor for			
		1st Year	Next 2 Years	Remaining 25 years	Present Value
2016-17	1,00,00,000	-	-	-	-100,00,000
2017-18	90,00,000x.85	-	-	-	-76,50,000
2016-17 to 2018-19	8,40,000 each year	2.57	-	-	+21,58,000
2019-20 to 2020-21	14,01,800	-	1.42	-	+19,90,500
2021-22 to- 2046-47	19,63,000 each year	-	-	7.26	+142,51,000
				TOTAL	+7,49,000

Note: It is assumed that simultaneously with the doubling work in progress, it will be possible tocarry the additional traffic in 2016-17 and 2017-18.

Alternative (2)

Doubling in two Phases:

In case the doubling is taken up in two Phases, the first phase of doubling A-B taken up immediately, i.. e. in 2016-17, and the second phase viz, doubling of B-C taken up in 2021-22, the rate of return would be about 9% as worked out below:-

Cost of first phase	Rs.100,00,000
Cost of second phase	Rs. 90,00,000

Year	Cash flow	Cumulative discount(8%)	Present Value

		Factor for 1st 3 years	Next 2 years	For remaining 25 years	
2016-17	100,00,000	-	-	-	-100,00,000
2016-17 to 2018-19	8,40,000	2.57	-	-	+21,58,000
2019-20 to 2020-21	14,01,800	-	1.42	-	+19,90,500
2021-22	90,00,000	.68	-	-	-61,20,000
2021-22 to 2051-52	19,63,000	-	-	7.26	+142,51,000
				TOTAL	+22,79,00

At 10% the computation will be:

(-100,00,000)+(8,40,000x2.49)+(14,01,800x1.30) - (90,00,000x0.62)+(19,63,000x5.64)
= -100,00,000+20,91,600+18,22,34 - 55,80,000+110,71,320 = - 5,94,740
The return is a little over 9%

Alternative (3)

(Extra reception lines followed by full Doubling: -)

The complete project inclusive of the first phase viz., provision of additional reception line at threestations and the second phase viz., doubling (after 5 years) the total life span being 30 years.

The rate of return works out to slightly above 13% as under :-

Year	Cash flow	Cumulative discount factor in 30 years at 12%		Present Value
		1st 5 year	Remaining 25years	
2016-17	10,00,000	-	-	- 10 lakh
2016-17 to 2020-21	8,40,000 each year	3.605	-	+30.28 lakh

2020-21	100,00,000	.5674	-	-56.74 lakh
2021-22	90,00,000	.5066	-	-45.59 lakh
2021-22 to 2046-47	19,63,000 each year		4.45	+87.35 lakh 5.30 lakh

With this scheme an extra goods train cannot be introduced for two years during (2019-20 to 2020-21). This entails an annual loss of Rs.1.26 lakh. (Extra wagons Rs.14175, extra locos 1,12,704 because of detentions as capacity utilization over 80%). Discounted to present values, this will reduce the above net figure of Rs.5.30 lakhs by further Rs.1.80 lakh but the rate of return will not be altered significantly.

EXAMPLE (4):-

Providing a Diesel Loco Shed for homing 50 mainline B.G. DieselElectric Locomotives 'X' Railway

(A) Capital costs (estimated) and phasing of expenditure (Rs. lakhs)

(1) Diesel	Total	Loco Shed	Loco Motives	
2019-20	295	25	270	(10 WDM 2 Locos at Rs.27 lakhs each)
	320	50	270	- do -
2020-21				
2021-22	311	41	270	- do -
2022-23	270	..	270	- do -
2023-24	270	..	270	- do -
		116	1350	
Scrap value of locos (at Rs.1,00,000 per loco)			(-)50	
			1300	

(II) Steam (replacement of existing locos)	Loco Shed	Loco Motives

2019-20	..	145	2.5 steam taken as equivalent to one WDM2
2020-21	..	145	Cost per Steam Loco assumed at Rs.5.8 lakhs.
2021-22	..	145	
2022-23	..	145	
2023-24	..	145	
	..	725	
Estimated scrap value (at Rs.23000 per loco)		(-)29	
		696	

Estimated economic life : Even though 40 years per steam and 30 years per diesel, the life is assumed to be 30years in both cases. (Discount factor after 30 years is negligible).

(B) Operating and Maintenance costs:-

(i) Basic Data:-

		Steam	Diesel
(a)	Km. per day for goods services(for steam and all Railway B.G. for diesel loco)	83	323
(b)	Average gross load per train (excluding loco)	1329 t	1591 t
(c)	Locos in use daily (with 17.6% repairs allowance for steam, or 15% of total holding and 12.1/2% for diesels)	...	43.75 WDM2
(d)	Steam locos on line equivalent to 50 WDM2Locos- vide (a) to (c) above. (This gives a ratio of 4.68 steam equal to one diesel however in the computations for this appraisal, the conservative and generally accepted ratio of 2.5 steam to one diesel has been adopted.)	234	$\frac{43.75 \times 323 \times 1591}{85 \times 1329} \times \frac{100}{85}$
(e)	Km per loco per annum (derived from dieselloco operation).	$\frac{103.158 \times 1591}{1329 \times 2.5}$ = 49.398	$\frac{323 \times 365 \times 7}{8}$ = 103.158
(f)	Cost of fuel per 1000 GTKM	Rs.2.94	Rs. 2.31

(g)	Cost of repairs and maintenance per engineKm.	Rs.0.71	Rs. 0.45
(h)	Consumption of lubricating oil per 100 engineKm.	4.50 litres	11.2 litres
(i)	Cost of lubricant per litre (in terms of latest purchase rate etc.)	Rs.1.71	Rs.2.42

(ii) Cost Data

(a)	Repairs and maintenance per annum	0.71x49,398 =Rs. 35,073	0.45x103,158 Rs.46,421
(b)	Cost of fuel per annum	1329x49398 x2.94x.001 =Rs. 1,93,011	1,591x103.158 x2.31x.001 = Rs. 379,127
(c)	Cost of lubricating oil per annum	49,398x4.5x1.71 / 100 = Rs. 3801	103,158x11.2x2.4 / 2 / 100 = Rs. 27,960
(d)	Wages of running staff per annum (estimated for staff requirement)	Rs.23,493	Rs.28,458
(e)	Kilometrage allowance per annum	Rs.8,052	Rs.13,411
(f)	Total cost per locomotive per annum	Rs.2,63,430	Rs.4,95,377
(g)	Equivalent cost at 2.5 steam : 1 diesel	Rs.6,58,575	Rs.4,95,377
(h)	Saving in diesel operation per loco per annum	Rs.1,63,198 (say) Rs.1.63 lakh	.....

(C) Financial Analysis (DCF) (Cash outflows) Rs. lakhs

Year	Index	Interest/ Discount factor @ 10%	Steam	Diesel	Saving (+) Additional (-)	
					Absolute	Discounted
2019-20	-2	1.21	(145+66)*	(295+49)*	-133	-161
2020-21	-1	1.10	(145+132)	(320+98)	-141	-155
2021-22	0	1.0	(145+198)	(311+147)	-115	-115
2022-23	1	0.91	(145+263)	(270+198)	-50	-45
2023-24	2	0.83	(145+329)	(270+245)	-41	-34
2024-25 to 2054-55	3 to 30	6.93	329	245	+84	+582

Residual value	30	0.057	+29	+50	+21	+1
						+23

* Capital and Revenue cash outflows are shown separately for easy reference. This analysis shows that the proposed diesel shed to home 50 WDM2's is financially justified, the return underDCF being a little over 10%

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ANNEXURE -F

ECONOMIC EVALUATION OF RAILWAY INVESTMENTS

A purely financial appraisal of investment proposals does not necessarily lead to the selection of projects which best serve the needs of the community. The inadequacy of. financial analysis in this regard derives from the fact that projected cash inflows and outflows associated with feasible investment alternatives do not correctly reflect the actual benefits to the community flowing from them or the costs that they impose on the economy. Financial and economic appraisals, however, need not always lead to conflicting decisions a financially viable project will also be acceptable on economic grounds whenever the economic return on investment is likely to be at least as high as its financial yield. But, there can be instances of financially sound investment proposals which may not turn out to be worthwhile propositions because the relevant cash outflows do not include all the associated costs to the economy. Again, on investment which is not expected to be profitable, may still yield an adequate, or even a fairly high, economic return if the projected cash. revenue represent only a part of the benefits or incomes that are likely to be generated by it.

2. Economic benefits attributable to a particular investment can, for a number of reasons, exceed the revenues directly accruing to the Railways in the form of fare and freight receipts. In the first place, most users of a facility may be willing and able to pay somewhat more than what they are actually charged by the Railways. Secondly, there may also be instances where what the consumers are actually able to pay for rail transportation is (because of uneven-income distribution) less than the benefit they derive from it. This, indeed, is the main justification for a preferential fare structure for certain passenger and suburban services. Finally, for economic or social policy reasons freight rates on certain key commodities may be set at levels which do not fully cover rail transportation costs. The entire benefit derived by the users of Railways can never be qualified; however, at least that part of it which consists of the difference between cost of transportation and fares or freight rates actually charged-can be precisely ascertain. *The provision of a rail transport facility thus directly adds to the well-being of the community by more than the receipts that accrue thereby to the Railways.

*Likewise, the difference between the cost to the consumer of rail transportation and that of other modes of transport replaced (partly or wholly)

by it is a tangible and measurable social gain.

Productivity test may not be required for projects sanctioned on considerations other than hurdle rate/IRR. Further, all projects sanctioned on the basis of ROR, should be subjected to mid term review at the time of every revision of estimated cost. Such review shall consist of review of both existing projection in current scenario, revised estimated cost and consequential change in ROR. Financial feasibility of project need be assessed and commented by General Managers of Zonal Railway. As IR will be shifting from the existing Economic Internal Rate of Return (EIRR) based project assessment to a more comprehensive method i.e. Modified Economic Internal Rate of Return (MEIRR) to capture the economic and social network impact of any project interventions comprehensively, MEIRR at different levels will be compared and examined before reaching any investment decision.

3. Rail transportation, however, can make a substantial indirect contribution as well to general well- being by facilitating economic expansion. A new line, in a backward region not well endowed with alternative modes of transportation, stimulates the growth of output and employment by widening the market for local products as well as by creating a market for some hitherto unexploited natural resource. The quantification of such indirect benefits can at best be approximative. For one thing, the expected expansion of regional or local economic activity is difficult to forecast. For another, the quantification of "developmental benefits" poses the problem of allocating expected additions to output and incomes between the Railway project and other complementary investments in industry, agriculture or commerce.

4. Great care should be taken in estimating social benefits for the purpose of economic appraisal of railway investments. Such benefits should, to the extent possible, be quantified with a reasonable degree of accuracy. Thorough investigations at the traffic survey stage would help in identifying the "developmental effects" and in estimating broadly the magnitude the complementary investments that may be required. Also, the assumptions and reasons underlying any judgement about non-quantifiable benefits. should be clearly spelt out. Fortunately, the assessment of social benefits is necessary only in the case of proposed investments in new rail lines or operations ; as regards investment for modernisation and improvement, which constitute the bulk of the Railways' capital outlay, one need only estimate the social costs entailed by investment alternatives In order to pick out the least cost solution from the point of view of the economy.

5. The expenditure flows associated with Railway projects can, to varying extents, diverge from the cost to the economy of acquiring resources needed for their implementation and operation. The prices at which certain inputs and resources are made available to the Railways, for instance, may understate or exaggerate their, real cost to the economy. Similarly ,the rupee equivalent of direct foreign exchange expenditure may differ from the cost of saying or earning an equivalent amount of foreign exchange. Moreover, the relative prices of various types of equipment and materials purchased by the railways will be different from the comparative costs of producing them for the reason that the rates of indirect taxes (or subsidies) vary from product to product. Lastly, there are certain types of real costs which do not at all get recorded in the financial cash flows. Environmental damage can, for example, be a major unrecorded element of cost.

6. In selecting investments which impose the least cost on the economy, cash out flows have to be recomputed in such a way as to minimise the distortions caused by the use of prices actually paid for inputs (including the prices of capital and foreign exchange) and by the neglect of other costs which do not figure at all in expenses. Environmental effects of investments are the most difficult to estimate However in a number of cases the choice of projects may be influenced much more by the interest and exchange rate, that are utilised than by the correction of distortions introduced by indirect taxes, subsidies and environmental effects. A preliminary sensitivity analysis is useful for picking out the more important, of the factors distorting costs; such factors can then be subjected to a detailed investigation.

7. For economic evaluation of Railway Projects, the interest or discount rate is currently set at 10 percent. This implies that the cost of capital comprises a depreciation or capital recovery factor and interest charged at 10 per cent per annum; a project is thus just acceptable if the expected earnings from it during its lifetime make it possible to recover the investment with a return if 10 per cent per annum, that is, if the DCF rate of return on it is 10 percent.

8. In the cash flows utilised for economic, evaluation of high speed diesel oil is not valued at the price actually paid by the Railways for it. Instead, all taxes and duties payable on it are excluded from the price; and, the duty-free price is adjusted upwards so as to allow for the comparative scarcity of crude oil in the Indian economy. At present this adjustment factor is exactly half the current rate of excise duty on high-speed diesel oil.

9. There is no direct readjustment of the official exchange rate for the purpose of computing the scarcity value of imported. equipment, spares and materials. However, there is an implicit adjustment in as much as the duty paid on imports is retained as a cost item in the cash-flows ideally, other indirect taxes like excise duties, sales taxes, local taxes and other cesses and levies, should be excluded from the cost of domestically procured inputs. But in many cases it has been found, particularly in the analysis of investment for modernisation of traction, that the exclusion of indirect taxes and similar levies does not make any material difference to the ranking of the proposed alternatives.

10. Electric power is valued not at the price at which it is sold to the Railways by the State Electricity Boards but at its estimated cost to the economy. The latter is derived from actual production cost by revaluing its interest component at the rate of 10 per cent per annum and its foreign exchange component at an exchange rate 33 per cent-higher than the current official rupee price of foreign currencies.

FINANCIAL AND ECONOMIC EVALUATION OF-INVESTMENT ALTERNATIVES

An Example

A highly simplified hypothetical example of choice between diesel and electric traction is presented here for the purpose of illustrating the essential difference between financial and economic evaluation. This type of choice is basically a problem of minimising the cost of handling a given volume of traffic over specified sections.

The two project alternatives, dieselisation and electrification, are defined as follows-

(i) The project life, which includes the construction period, extends in both cases upto 44 years.

(ii) The level of traffic remains unchanged over the life time of the project.

(iii) Annual operating expenses exclude depreciation and do not vary from one year to another.

(iv) Capital costs exclude interest during construction**

(v) Capital outlay on dieselisation is spread over a period of

three years; it comprises the expenditure on acquisition of rolling stock and construction of sheds.

(vi) Capital outlay on electrification is phased over four years; it comprises the expenditure on rolling stock and construction of OHE.

**If the income flows are computed from the date of completion of the project, the capital outlay will be compounded at the desired interest rate.

Given these assumptions, the financial cost cash-flows associated with the two illustrative traction alternatives can be presented in the following manner :

Financial cost to Railways (Rs. crores).

Year	Diesel	Electric
1	..	3.0
2	0.5	6.0
3	0.5	15.0
4	10.0	6.0
5^{th} to 44^{th} (each year)	4.0	2.5

Discounted Present Worth of Financial Costs.

Interest Rate.	Diesel	Electric
6%	56.5	55.3
7%	49.2	50.3

It would be seen that when discounted at 6 per cent the present worth of the financial cost flow relating to electrification works out to be lower than that of the financial cost flow associated with dieselisation by Rs. 1.2 crores. But the situation is reversed when the cost flows are discounted at 7 per cent, in which case dieselisation turns out to be cheaper by Rs. 1.1 crores. Thus, in this hypothetical case, the depreciation inclusive financial cost of electrification is lower only at rates of interest below 7 per cent. The rate of interest at which the two alternatives will impose identical costs can be found out by linear interpolation.

This turns out to be 6.5 percent; at lower rates of interest electrification is the cheaper alternative; but becomes the costlier one at interest rates exceeding 6.5 per cent. This is as it should be; for electrification is the more capital intensive mode of traction.

The estimation of cash-flows relevant for the computation of the cost to the economy is based on the following assumptions :-

(i) The basic price, inflated to the extent of 50 per cent of the excise duty, is taken as the appropriate scarcity value of high-speed diesel oil.

(ii) The cost to the economy of electricity generation and transmission is assumed to be 7 paise per KWH as compared to 10 paise per KWH assumed to be actually paid by the railways.

(iii) Fuel costs constitute 70 per cent of operating expenses under diesel and 50 per cent of operating expenses under electric traction.

Under these assumptions, the cost to the economy of the uniform annual operating expenses associated with dieselisation and electrification works out to be Rs. 3.00 and Rs. 2.12 crores respectively. But, the cost to the economy of capital outlays continues to be the same as the financial cost. The discounted present worth of the cash flow corresponding to the cost to the economy at 3 and 4 percent interest rates is as follows:

Discounted Present Worth of Costs to the Economy.

Interest Rate	Diesel	Electric
3%	71.4	70.8
4%	60.2	62.4

It will be seen from the above that in this hypothetical case, from the point of view of cost to the economy, electrification turns out to be cheaper than dieselisation only at rates of interest which do not exeed 4 per cent. The break even rate of interest, at which both alternatives involve identical costs, is approximately 3.2 per cent.

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ANNEXURE - G

(See Paragraph 240)

The examples given below are intended to illustrate the principles set out in paragraph 238 et seq. The data assumed are hypothetical and the conclusions arrived at in these examples are purely illustrative. The methodsadopted are not to be regarded as exhaustive or as precluding the use of alternative methods which may be found to be more appropriate.

1. Renewal of a Locomotive.-

(i) Whether to recondition or to renew a locomotive, given the following data :-

Particulars.	Old Locomotive.	New Locomotive
Cost of the locomotive	Rs. 50,000 (Second-hand cost).	Rs. 5,00,000 (New cost).
Cost of reconditioning	Rs. 50.000	.....
Rate of interest	10 percent.	10 percent.
Life	10 years	40 years
Scrap Value	Rs. 10,000	Rs. 20,000
Maintenance Operation and Repair Charges	Rs. 50,000 a year.	Rs. 40,000 a year

(ii) The average annual cost of the existing locomotive after reconditioning would be Rs. 65,643 made up of the following :-

	Rs.
(a) Cost of maintenance, operation, repairs, etc.	50,000
(b) Interest at 10 per cent on Rs. 1,00,000 (Rs. 50,000 Plus Rs. 50,000)	10,000
(c) Sinking Fund Payment at 10 per cent (90,000 x 0.0627)	5,643
Total	65,643

(iii) The average annual cost of the new locomotive would be Rs. 95,104 made up of the following:-

		Rs.
(a)	Cost of maintenance, operation, repairs, etc.	40,000
(b)	Interest at 10 per cent on Rs.5,40,000 (i.e., new cost Rs.5,00,000+ the second hand cost of the old locomotive, Rs.50,000- the scrap value of old locornotive Rs. 10,000).	54,000
(c)	Sinking Fund Payment at 10 per cent (4,80,000 x 0.0023).	1,104
	Total	95,104

(iv) It follows from the above figures that, with the data assumed, it is cheaper to recondition the old locomotive than to replace it by a new one.

(v) Applying the DCF method also, it is observed that for an initial investment of Rs. 5 lakhs, the NPV for 40 years on the basis of the saving of Rs.10,000/- reckoned at 10 per cent p.a. adds up to Rs.1,02,210 only (10,000x9.779)+(20,000x0.0221). The purchase of new locomotive is, therefore, not justified.

2. Renewal of a Bridge.- (i) Whether to recondition or to renew a bridge, given the following data:-

Particulars.	Old Locomotive.	New Locomotive.
Cost	10,000	40,000
Scrap Value	2,000	4,000
Scrap Value (after reconditioning)	4,000	.....
Interest	10 per cent	10 per cent
Life	30 years	60 years
Reconditioning Cost	10,000	.....

Note.-Maintenance cost is the same for both the reconditioned and new bridge

(ii) The annual cost of service of the reconditioned unit will be Rs. 1,402 vide details given below:-

	Rs.
(a) Interest at 10 percent on Rs.20,000 (i.e. Rs:10,000+10,000)	1,200
(b) Sinking Fund Payment at 10 percent on Rs16,000 (i.e. 16,000 x 0.0061)	98
Total	1,298

(iii) The annual cost of service of the new girders ,will be Rs.2,948 vide details below.-

	Rs.
(a) Interest at 10 per cent on Rs.48,000, i. e., on cost of new girders + second hand value of old girders-scrap, value of old girders) Rs. 40,000+ Rs 10,000-Rs.2,000).	2,880
(b) Sinking Fund Payment at 10 per cent on Rs.36,000 (Rs,40,000-Rs.4,000) 36,000 x 0.0003)	11

Total	2,891

(iv) It follows that reconditioning is cheaper.

3. Renewal of Permanent Way- (i) To determine whether a line of 85 lb. B. H. rails should be fitted with 2 additional sleepers, one, Duplex joint sleeper and new fish-plates and bolts, or replaced with 90 lb. F. F. rails, given the following data :-

For providing additional fittings.		Fitting new 901b.rails	
Cost of two additional sleepers including fittings	Rs 60	Cost of 2 new 90 lbs. rails	Rs.550
Cost of Duplex joint sleepers including fittings	64	Including carriage and laying.....	
Cost of fish-bolts and plates	10	Life	60 years.
Cost of fitting these in each	7	Scrap value	Rs. 207
Life of 85 lb. rails	30 years	Rate of interest	10 per cent.
Scrap value of rails 36 ft. long	Rs. 100		
Scrap value of fittings	5		
Second-hand cost of two 85 lb. rails, 36 ft. long.	243		
Rate of interest	10 per cent		

Note -(1) Maintenance and repair cost are considered to be the same in both cases.

(2) Steel scrap has a very high price in the market and new rails are comparatively cheapfrom indigenous sources.

(3) The old rails cannot be used elsewhere.

(ii) The average annual cost of service of the existing 85 lb. track after additional fittings are made will be Rs.26.27 vide calculations below:-

(a) Interest at 10 per cent on the—

	Rs.
Cost of 2 sleepers	60
Cost of Duplex Joint sleepers new	64
Cost of fish-plates and bolts	10
Cost of fitting	7
Second-hand value of old rail	243
	384
Less scrap value of fish- plates and bolts	5
	379
Interest at 10 percent	37.90
(b) Sinking Fund Payment at 10 percent on Rs. (60+64+10+7+243) - (100+5) or Rs.279 = 0.0061 x 279)	1.70
Total	39.60

(iii) The average annual cost of service of new rails will be Rs.41.93, vide calculations below.-

	Rs.
(a) interest at 10 percent on-	
.	
Cost of new rails and fittings, etc.	550
Plus second-hand cost of old rails.	243
	793
Less scrap value of old rails and fittings.	105
	688
Interest at 10%	68.80
(b) Sinking Fund Payment at 10 per cent on Rs.550 -207= (343 x 0.0003)	0.10
Total	68.90

(iv) With the data assumed it is cheaper to provide 2 extra sleepers 1 Duplex Point sleepers and new fish- plates and bolts to the existing track than to replace it with 90 lb. F. F. rails. If, however, it were possible to use the B. H. rails elsewhere on the line, it might be cheaper to provide new rails than to provide these additional fittings.

4. Re-alignment of Line.-(i) To determine whether the re-alignment of a track by abandoning thearc and following the chord, is justifiable, given the following data :-

Length of arc		15 miles
Length of chordCost of chord		10 miles
	Rs.	5,00,000
Scrap value of items recoverable from the arc Scrap value of items recoverable from the chordSecond-hand value of all assets of the arc Savings in operation and maintenance costs Loss on tickets owing to reduction of mileage Extra traffic expected. Rate of interest.	Rs.	50,000
	Rs.	40,000
	Rs.	3,00,000
	Rs.	70,000
	Rs.	10,000
	Rs.	15,000
		10 per cent

Note.-There is keen bus competition on the section running along the arc and the chord will cut this competition as the road runs along the arc and not the chord, and it is very unlikely another road will be built along the chord.

(ii) The net saving due to re-alignment is Rs.75000 (70,000-10,000+ 15,000).

(iii) The average annual cost excluding the cost of operation and maintenance of the realigned track will be Rs.76,702 vide calculations below.-

	Rs.
(a) Interest on Rs. 7,50,000 (i.e. Rs. 5,00,000 + Rs. 3,00,000 - Rs. 50,000) at 10 per cent.	75,000
(b) Sinking Fund Payment at 10 percent required to provide Rs.4,60,000 (i. e.5,00,000 -Rs.40,000) at the end of 35 years - (0.0037 x 4,60,000)	1,702
Total	76,702

Note.-There are many assets on the track having varying normal lives. For the purpose of this calculation, a life of 35 years has been taken as a fair average for all the assets involved.

iv) Hence it may be seen that realignment is not justified since, it will involve an excess of Rs.1,702 p.a.

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ANNEXURE-H

(See Paragraph 242)

The examples given below are intended to illustrate the principle set out in paragraph 241 The dataassumed are hypothetical and the results arrived at in these examples are purely illustrative.

1. If, in the case of an asset where the average annual cost of service is the basis on which the secondhand value has to be fixed.-

the normal life is	N years.
the first cost is	Rs. C
the scrap value is	Rs. S
life as second-hand asset is	n years.
the annual cost of operation and maintenance, repairs, etc. of the asset while new is.	Rs. 0
the annual cost of operation and maintenance, repairs, etc. in the second-handcondition r is the annual rate of interest.	Rs. 01

dN is the sinking fund Payment required to be paid annually so that at the end of N years, the sinking fund provides Re. 1.

dn is the sinking fund Payment required to be paid annually so that at the end of n years the sinking fund provides Re. 1.

then, 'X', the second-hand value of the asset is such that the average annual cost of the second hand asset is equal to the average annual cost of the new asset, or Xr + (X-S) dn+01 = Cr + (C-S) dN+O. Simplifying the equation, we have .-

$$Xr+X\,dn-Sdn+01$$
$$=Cr+(C-S)\,dN+0.$$
$$X\,(r+dn)=Cr+(C-S)\,dN+0+Sdn-01.$$
$$X=\frac{Cr+(C-S)\,dN+0+Sdn-01}{r+dn}$$

Illustration. - If Rs. 10,000 be the first cost of an asset with 60 years of normal life and a scrap value of Rs.2,500, the rate of interest is 3 percent or .03 per rupee and the average maintenance and repair cost for the first 20 years is Rs.250 and for the next 40 years Rs.35O, then applying the above formula, the second-hand value at the end of 20 years will be.

$$\text{Rs. } \frac{10{,}000 \times 0.1 + (10{,}000 - 2{,}500)\,0.0003 + 250 + 2{,}500 \times 0.0023 - 350}{0.1 + 0.0023}$$

Or $\frac{908}{0.1023}$ i.e., Rs.8876

2. In the case of an asset the second-hand value of which is to be determined on the basis of 'the average cost per unit of service; if the same notation as in Example (1) were used and.-

if u is the average number of annual units of service rendered by the asset while new, and u1 the average number of units of service rendered by the asset while second-hand, then, X the second-hand value of the asset is such that-

$$\frac{Xr+(X-S)\,dn+01}{U1} = \frac{Cr+(C-S)\,dN+0}{u}$$

$$\text{There fore, } X = \frac{u1/u\,[\,Cr+(C-S)\,dN+0]-01\,Sdn}{r+dn}$$

Illustration.- If Rs. 1,00,000 be the cost of an asset with a normal life of 35 years and a scrap value of Rs.10,000; if the rate of interest is assumed to be 3 percent or .03, the average operation, maintenance and repairs costs while new, Rs. 1,20,000 per annum and the average operation, maintenance and repairs costs in the second-hand condition Rs. 1,03,000 per annum; and if, the average serviceability of the asset while new be 1,20,000 units per annum and 1,00,000 units in the second-hand condition, then applying the formula above, the second-hand value of the asset at the end of 20 years will be.-

$$\frac{1,00,000/1,20,000\ [\ 1,00,000 \times 0.10 + (\ 1,00,000 - 10,000\ )\ 0.0037 + 1,20,0000\ ] - 1,03,000 + 10,000 \times 0.0315}{0.10 + 0.0315}$$

i.e. Rs.45063.37

ANNEXURE – I

Railway Project Economic Appraisal Framework Note

1. Comprehensive Economic IRR approach factoring Network effect

Project economic analysis aims at ensuring efficient allocation of scarce resources and raising the welfare of its citizens, so that it benefits the country as a whole. All resource investments have an opportunity cost because, if the resource is not allocated to the project, it will create value elsewhere in the economy.

The Philosophy of economic valuation of railway investments is indicated in the Annexure "F" of Chapter II, Indian Railway Financial Code (Vol-1). Some of the fundamental principles on which economic evaluation of Railway investments should be carried out are as follows:

- Economic benefits attributable to a particular investment can, for a number of reasons, exceed the revenues directly accruing to the Railways in the form of fare and freight receipts.
- Rail transportation can make a substantial indirect contribution as well to general wellbeing by facilitating economic expansion. A new line, in a backward region not well endowed with alternative modes of transportation, stimulates the growth of output and employment by widening the market for local products as well as by creating a market for some hitherto unexploited natural resource. The quantification of such indirect benefits can at best be approximative.
- Great care should be taken in estimating social benefits for the purpose of economic appraisal of railway investments. Such benefits should, to the extent possible, be quantified with a reasonable degree of accuracy. Thorough investigations at the traffic survey stage would help in identifying the "developmental effects" and in estimating broadly the magnitude the complementary investments that may be required.
- The expenditure flows associated with Railway projects can, to varying extents, diverge from the cost to the economy of acquiring resources needed for their implementation and operation. The prices at which certain inputs and resources are made available to the Railways, for instance, may understate or exaggerate their real cost to the economy.

It is, however, noticed that different methods are being used for the economic valuation of railway investments. With a view to standardise the procedure, and bring clarity, a comprehensive approach for economic IRR analysis of Indian Railway Line Projects is indicated below.

It is pertinent to highlight that as prescribed in above code viz. "*Thorough investigations at the traffic survey stage would help in identifying the "developmental effects*", it is critical that traffic studies are based on required primary and secondary data. A brief guidance on traffic demand assessment based on various primary and secondary data is appended as 'D'.

It is clarified that this note is applicable only for mainline projects viz. new line or multi-tracking projects.

1.1. Basis adopted for EIRR Analysis

For the appraisal of a Railway project proposal, the economic IRR analysis should be done based on various parameters such as the project's economic benefits, economic costs, and sensitivity analysis (against variation in key project parameters) to assess economic rationale and economic viability on the basis of project life cycle costs. The approach, prescribed herein, takes into account a number of direct and indirect benefits to be accounted for in the economic cost benefit analysis, in line with national and global relevant best practices (MoUHA, MoRTH and ADB). The proposed approach also considers the recommendations from the report prepared by Multi- disciplinary Committee of Additional Members on Comprehensive Project Appraisal System for sanctioning new projects by factoring in the "Network Effect". The framework takes certain assumptions from the MoUHA guidelines, and these guidelines are taken as a base as it is updated from time to time and accepted across national infrastructure projects. This note aims at providing a comprehensive approach to analyse economic IRR of Indian Railway Line Projects.

1.2. Proposed Economic IRR analysis framework

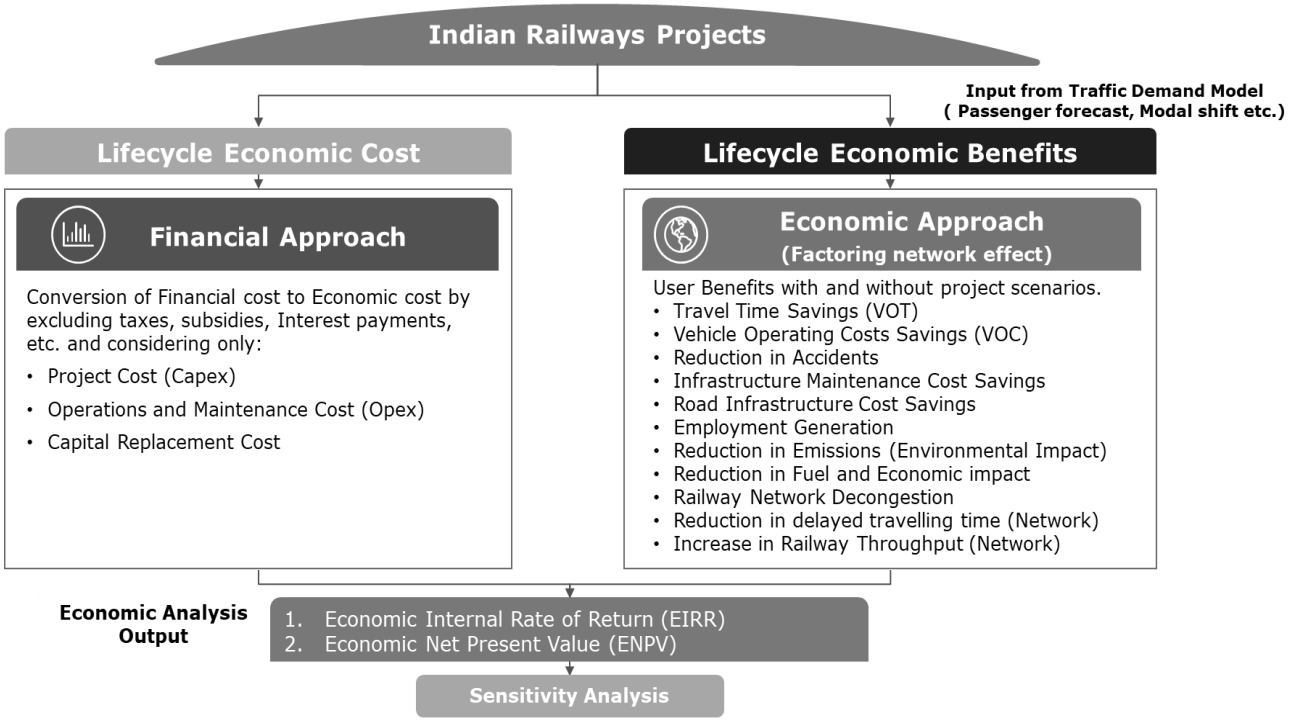


Figure 1 Proposed Economic IRR analysis framework

Railway projects provide larger economic and social benefits to the society in terms of reduction in cost and time of travel, a substantial reduction in emissions reducing chronic diseases, reduction in road accidents, etc. A railway project improves mobility of people and efficiency of commodity flow by providing seamless connectivity with the rest of network. In

addition, new railway projects can also influence the existing rail network and create benefits outside the local area of the project depending upon the scale and size of the project. This can be referred to as "Network effects".
The proposed economic IRR analysis framework incorporates Direct and Indirect benefits of the project, factoring network effects. The methodology and source list for the proposed economic analysis framework is summarized and given below (**A,B,C,D**).

A) Steps for Calculating Economic IRR factoring Network effect

The steps in economic analysis are as described below:

Step 1: Define Project Horizon

The project horizon comprises of construction and operation period of the Railway project. During the project horizon, the cost and benefits associated with the project should be estimated. The horizon period for the purpose of economic analysis may be taken as 30 years in line with codal life of track assets as per para 219, Chapter 2, Volume 1 of Indian Railway Finance Code.

Step 2: Develop Alternative Scenarios

This step involves development of alternative project scenarios to which a comparison with the project case that is undertaken is to be made. For example, economic cost and benefits of undertaking a Railway project ("With Project") are to be compared with the base case i.e. "Without Project" or "Do Nothing" scenario or any other alternative project in order to arrive at incremental costs and benefits.

Step 3: Determine Economic Cost of the Project

The steps involved in determining the Economic Cost of the project are specified below:

Table 1 Steps for estimating Economic Cost of Project

Steps	Methodology
Project Cost[1,2]	The Project cost covers both the implementation period of major investments and operating years, known as the project operating life. Costs are measured in constant prices of a base year. The Project Cost includes: 1. Capital Cost 2. Operations and Maintenance Cost

[1] Capital replacement cost has not been assumed in the project cost during the Economic IRR calculation. In case it is assumed, the project horizon period needs to be extended accordingly to account for benefits over replaced asset's life horizon. Accordingly, it is recommended that the project horizon should be equal to the prescribed life of asset as per the applicable IR code.
[2] Rolling stock cost is not assumed in the project cost during the Economic IRR calculation, given that the rolling stock is not dedicated to the project.

Project Economic Cost	The economic costs of the capital works and annual operation and maintenance costs are calculated from the financial cost estimates using economic conversion factors given in table 1 to exclude the impact of: 1. Price contingencies/price escalations 2. Import duties and taxes 3. Sunk costs 4. Interest payment, principal payment and interest during the construction period.

Source: MoHUA Appraisal Guidelines for Metro Rail Project Proposals

Step 4: Estimation of Economic Benefits of the Project

Year wise project benefits should be estimated during the project operation period. The "With project" scenario should be compared with the option of "Without project" scenario to determine the incremental economic benefits. The economic benefits of the projects should capture the economic and social network impact on any railway project.

The following quantifiable benefits are accrued to the society owing to implementation of the Railway project.

Direct and Indirect Benefits	Network Benefits
Travel Time Savings (VOT)	Reduction in Emissions (Environmental impact)
Vehicle Operating Costs Savings (VOC)	Reduction in Fuel and Economic impact
Reduction in Accidents	Railway Network Decongestion
Infrastructure Maintenance Cost Savings	Reduction in delayed travelling time (Network)
Road Infrastructure Cost Savings	Increase in Railway Throughput (Network)
Employment Generation	

a) Direct and Indirect benefits

The railway investments provide substantial direct and indirect benefits to the economy. The components and steps involved in determining the direct and indirect economic benefits are:

i) Travel Time Savings (VOT)

Railway projects significantly contribute to modal shift owing to higher speeds and comfort to passengers. This leads to travel time savings for passengers travelling on rail system over the existing transport modes because of faster speed of Railway.
The formula for calculation of travel time savings is presented below.

Travel Time Savings (VOT)	=	Passenger Time Savings (Hour)	X	Value of Passenger time (INR per Hour)
Source		(Traffic demand studies/surveys)		(Estimate based on per capita income of the region on new railway line corridor; concerned State Economic Survey documents, take weighted average based on OD patterns of traffic and passenger profile (basis traffic surveys) in case of multiple states involved)

The formula for calculation of Freight time savings is presented below.

Freight Time Savings	=	Difference in the freight time savings between rail and the next dominant mode (hour)	X	Volume of Freight that derives benefit over next predominant mode (ton)[3]	X	Value of Freight time (INR per ton hour)[4]
Source		(Estimate based on freight demand studies/surveys)		(Freight demand studies/surveys)		$\frac{(Weighted\ Average\ commodity\ price \times MIBOR\ Rate\ per\ annum \times Economic\ price\ Conversion\ factor\ (0.85))}{365 \times 24}$

ii) Vehicle Operating Cost Savings (VOC)

Vehicle operating costs (VOCs) are the cost to the owner of operating a motor vehicle. Savings in vehicle operating costs of different modes arise due to a decrease in the number of vehicle trips on the roads. The VOC cost varies based on vehicle type (2-wheelers, 3-wheelers, cars, buses or any other prevalent mode) and is calculated using the equations and guidelines given in the "Manual on Economic Evaluation of Highway Projects in India, 2019" by the Indian Road Congress (IRC).

The formula for calculation of travel time savings is presented below.

Vehicle Operating Cost (VOC)	=	No of trips (Difference between with & without scenario)	X	Average Lead (Km)	X	Vehicle Operating Cost (INR per Km)
Source		(Traffic demand studies/surveys)		(Estimate based on Traffic demand studies/surveys)		Manual on Economic Evaluation of Highway Projects in India, 2019[5]

iii) Reduction in Accidents

The reduction in traffic volumes on roads due to the modal shift to rail is expected to reduce road accidents on the project corridor. Reduction in accidents will lead to saving of lives, reduction in damages to vehicles and savings towards medical, insurance expenses, administrative expenses on police and the intangible psychosomatic cost of pain to people involved in the accidents and their families.

The economic benefits due to the reduction in accidents are calculated as follows:

Accident Costs	=	Vehicle Km (Difference between with & without scenario)	X	Accident rate (per vehicle Km)	X Accident Cost (INR)
Source		(Traffic demand		Collection of past accident data along	Toolkit on Finance and

[3] In case the next pre-dominant mode is Railway itself, for eg.in case of coal lines, then entire projected freight on new line shall benefit from improved speed and hence included. In case road is the pre-dominant mode for a commodity, then only the incremental traffic shifted from road to rail shall benefit and accordingly taken as much.

[4] Inputs in different currency shall be converted in INR.

[5] https://www.scribd.com/document/522057946/IRC-SP-30-2019-Manual-on-Economic-Evaluation-of-Highways-in-India

	studies/surveys)	the project corridor; MoRTH report on Road accidents in India[6]	Financial Analysis, 2013 by MoUHA[7]

iv) Infrastructure Maintenance Cost Savings

Infrastructure Maintenance Cost Savings will arise due to reduced need for maintenance of the existing road infrastructure owing to reduced traffic on account of modal shift. The benefits can be calculated using the reduction in vehicle kilometres due to modal shift and the road infrastructure maintenance cost per km.

Infrastructure Maintenance Cost Savings	=	Reduction in vehicle km due to modal transfer (km)	X	Infrastructure maintenance cost (INR/Vehicle km)
Source		(Estimate based on traffic demand studies/surveys)		(MoRTH Annual Report[8]; Estimate based on published values on annual expenditure on roads and traffic and annual vehicle km)

v) Road Infrastructure Cost Savings

Additional road infrastructure or upgrading the existing road infrastructure will be required to solve the congestion problem and accommodate growth in traffic in case the railway line is not introduced. The new railway line will bring savings in investment in road infrastructure due to shifting of passengers to Rail and withdrawal of vehicles in the project corridor. The road infrastructure savings will be calculated using the below formula.

Road Infrastructure savings	=	Additional express highway lanes required in without Project situation (km)	X	Cost of road construction (INR per km)
Source		(Estimate based on traffic demand (Number of PCU trips saved /road PCU capacity, ideally 1600 Passenger Car Unit (PCU) per hour))		(Normative Cost Norms for the National Highways by MoRTH)

vi) Employment Generation

During the period of construction, manpower will be needed for various project activities. In post-construction phase, manpower will be employed for the operation and maintenance of the system. Thus, the project would provide substantial direct employment. In addition to these, more people would be indirectly employed in allied activities.

Employment benefits	=	Capex (INR)	X	Employment cost as a % of Project Cost (INR)	X	Share of Skilled vs Unskilled employment	X	Direct/Indirect employment multiplier

[6] https://morth.nic.in/sites/default/files/RA_2020.pdf
[7] https://smartnet.niua.org/sites/default/files/resources/finance_and_financial_assessment_toolkit.pdf
[8] https://morth.nic.in/annual-report

Source	(Project DPR Cost chapter)	(Project DPR Cost chapter)	(20:80 ratio assumption; To be adjusted based on project requirement)	ADB guidelines for the economic analysis of projects[9]

b) Network Benefits

Railway investments can influence the entire railway network and generates Network benefits in terms of reduction in environmental impact due to a decrease in emissions, reduction in railway network congestion and improvement in travel time reliability etc. The components and steps involved in determining the economic benefits factoring network effects are:

i) Reduction in Emissions

Railway projects significantly contribute to pollution reduction, and these should be considered in economic analysis. The significant environmental savings come from decrease in air pollution associated with existing non-railway traffic due to the modal shift from the existing modes of transport to rail.

The reduction in emissions will be calculated based on the decrease in vehicle kilometres, volume of pollutants emitted from different modes and the cost of treatment per ton.

Emission Costs	=	Vehicle Km (Difference between with & without scenario)	X	Volume of Pollutant released per Km (grams per km)	X	Treatment cost/ton (INR)
Source		(Traffic demand studies/surveys)		(Source Profiling for vehicular Emissions Report by CPCB[10])		(MoHUA Appraisal Guidelines for Metro Rail Project Proposals[11])

ii) Reduction in Fuel and economic impact

Reduction in the number of vehicles on the roads and decongestion effect with the construction of new railway line gives benefits to the economy in terms of reduction in fuel consumption. A decrease in fuel consumption will result in a reduction in the import of crude oil.

Fuel and economic savings impact	=	Vehicle Km (Difference between with & without scenario)	X	Fuel economy (Average mileage of each mode)	X	Avg fuel cost (INR per liter)
Source		(Traffic demand studies/surveys)		Bureau of Energy Efficiency[12]		Petroleum Planning & Analysis Cell[13]

iii) Railway Network Decongestion

Construction of a new railway line will reduce congestion on the existing line or section of the rail network and will help in improving line capacity of the section. This will also reduce the lead time of trains moving via new railway line instead of moving via existing rail route. The savings due to the railway network decongestion can be calculated using the below

[9] https://www.adb.org/sites/default/files/institutional-document/32256/economic-analysis-projects.pdf
[10] https://cpcb.nic.in/displaypdf.php?id=U291cmNlX1Byb2ZpbGVfVmVoaWNsZXMucGRm
[11] https://mohua.gov.in/upload/whatsnew/59c21852a4874Appraisal%20Framework%20Sept%202017.pdf
[12] https://beeindia.gov.in/content/fuel-efficiency
[13] https://www.ppac.gov.in/content/149_1_PricesPetroleum.aspx

formula.

Railway Network Decongestion	=	Increase in average speed on the section or adjacent network	X	Average Lead on network (Km)	X	Value of Passenger Time	-	Value of Time Travel Savings estimated in #i)
Source		(To be estimated by Project Team using Rail network data)		(To be estimated by Project Team)		(Estimate based on per capita income on railway network)		Travel Time Savings on proposed rail corridor

iv) Reduction in delayed travelling time (Travel Time Reliability)

Travel time reliability refers to reaching the destination in a consistent journey time. Construction of a new railway line will result in an improvement in travel time reliability due to the reduction in rail congestion and predictability of travel time. The value of travel time reliability is estimated from the reduced travel time variability and associated buffer time that passengers have allowed before making trips. The savings due to the travel time reliability or reduction in delayed travel time will be calculated using the below formula.

Improvements in Travel Time Reliability	=	No of Trips (Difference between with & without scenario)	X	Reduction in Buffer time per trip	X	Reliability Ratio	X	Value of Passenger time (INR per Hour)
Source		(Traffic demand studies/surveys)		(Traffic demand studies/surveys)		(80%; Project team assumptions)		Estimate based on per capita income on railway network)

v) Increase in Railway Throughput

Construction of a new railway line will result in additional passenger traffic on the rail network due to a reduction in travel time and an increase in the number of choices for a passenger. The economic benefit due to the increase in the railway throughout can be calculated using increase in passenger traffic and average revenue generated per passenger.

Increase in Railway Throughput	=	Increase in passenger and Freight traffic due to modal shift	X	Average revenue per passenger and Freight Ton km (INR)
Source		(Traffic demand studies/surveys)		Indian Railways Annual Report

Step 5: Economic conversion factors

The financial cost and benefits of the railway project are converted to economic cost and benefits using economic conversion factor. Economic conversion factors are used to adjust for taxes, subsidies, inefficient land or wage markets, and other transfer payments, before performing the economic analysis. The conversion factors for different categories are given in Table 1.

Table 2 Economic Conversion Factor

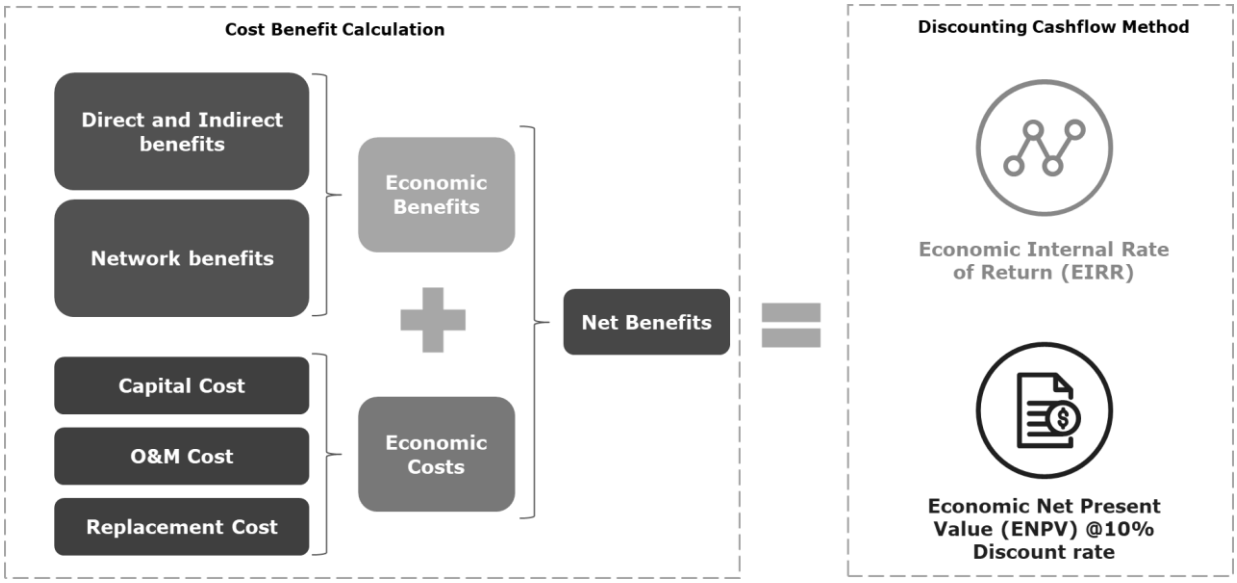
Type	Components	Economic factor
Economic Cost	Capital Cost	0.83
	Operations and Maintenance Cost	0.87
	Capital Replacement Costs	0.87
Economic Benefits (factoring network effect)	Travel Time Savings (VOT)	1.00
	Economic Price conversion coefficient	0.85
	Vehicle Operating Costs Savings (VOC)	0.90
	Accident Costs	0.90
	Infrastructure Maintenance Cost Savings	0.87
	Road Infrastructure Cost Savings	0.80
	Employment Generation	1.00
	Emission Costs	1.00
	Reduction in Fuel and Economic impact	0.80
	Railway Network Decongestion	1.00
	Reduction in delayed travelling time (Travel Time Reliability)	1.00
	Increase in Railway Throughput	1.00

Source: MoHUA Appraisal Guidelines for Metro Rail Project Proposals

<u>Step 6: Economic Analysis Output</u>

The outputs of economic analysis are calculated using two parameters.

1. Economic Net Present Value (ENPV)– ENPV is the sum of differences between the discounted benefits and cost flows.
2. Economic Internal Rate of Return (EIRR)– EIRR is the discount rate at which the ENPV becomes zero.



Step 7: Sensitivity Analysis

The range of sensitivity can be carried out to see the impact of change in critical parameters in the range of 5% to 20% on EIRR. The critical factors such as

1. Cost overruns due to delay or other factors
2. Increase in Operations and Maintenance Cost
3. Reduction in passenger traffic
4. Reduction in economic benefits
5. Combination of reduction in benefits and increase in cost.

B) List of Data sources

Parameter	Items	Source
Economic Costs		
Capital Cost		Project DPR
Operations and Maintenance Costs		Project DPR
Capital Replacement Costs		Project DPR
Economic Benefits		
Travel Time Savings (VOT)	Passenger Time Savings	Traffic demand studies/surveys
	Value of Passenger time	To be estimated based on per capita income on new railway line corridor; State Economic Survey document. Weighted average based on OD patterns of traffic and passenger profile (basis traffic surveys) to be adopted in case of multiple states involved
Freight Time Savings	Difference in the freight time between rail and the next fastest mode (hour)	To be estimated by Project Team based on freight demand studies/surveys
	Volume of Freight (ton)	Freight demand studies/surveys
	Value of Freight time (INR per ton hour)	$= \frac{(Weighted\ \text{Average commodity price (basis stakeholder consultation and traffic study)} \times \text{MIBOR Rate per annum} \times \text{Economic price Conversion factor (0.85)})}{365 \times 24}$ • Weighted Average Commodity Price: $\Sigma(\text{share of commodity in total volumes}\ (\%)$ • For eg. If total traffic volumes is 10 tonn comprising Coal (20%, average value INR 4000 per ton), Steel (70%, average value INR 35000 per ton) and Cement (10%, average value INR 7000 per ton), then weighted average commodity price is = (0.2×4000)+ (0.7×35000)+0.1×7000 = INR 26000 • Average 3 month Mibor Rate or short term interest rate for the year,

		sourced from Financial Benchmarks of India Ltd[14]
Vehicle Operating Cost (VOC)	No of trips	Traffic demand studies/surveys
	Average Lead (Km)	Traffic demand studies/surveys
	Vehicle Operating Cost	Manual on Economic Evaluation of Highway Project[15]
Reduction in Accidents	Vehicle Km	Traffic demand studies/surveys
	Accident rate	Road Accidents in India, MoRTH[16]; Collection of past accident data along the project corridor
	Accident Cost	Toolkit on Finance and Financial Analysis, 2013 by MoHUA[17]
Infrastructure Maintenance Cost Savings	Vehicle Km	Traffic demand studies/surveys
	Infrastructure maintenance cost	Ministry of Road Transport and Highways[18]
Road Infrastructure Cost savings	Length of Road	To be estimated based on Demand estimation (Number of PCU trips saved /road PCU capacity, ideally 1600 PCU per hour)
	Road construction cost	Ministry of Road Transport and Highways[19]
Employment benefits	Capex	Project DPR (Cost Chapter)
	Employment cost as a % of Project Cost	Project DPR (Cost Chapter)
	Share of Skilled vs Unskilled employment	20:80
	Direct employment multiplier	ADB guidelines[20]
Reduction in Emissions	Vehicle Km	Traffic demand studies/surveys
	Volume of Pollutant	CPCB Source Profiling for vehicular Emissions Report[21]
	Treatment cost/ton	MoHUA Appraisal Guidelines for Metro Rail Project Proposals[22]
Fuel and	Vehicle Km	Traffic demand studies/surveys

[14] https://www.fimmda.org/modules/securitiesApproval/securitiesApproval.aspx?op=mibor
[15] https://www.scribd.com/document/522057946/IRC-SP-30-2019-Manual-on-Economic-Evaluation-of-Highways-in-India
[16] https://morth.nic.in/sites/default/files/RA_2020.pdf
[17] https://smartnet.niua.org/sites/default/files/resources/finance_and_financial_assessment_toolkit.pdf
[18] https://morth.nic.in/annual-report
[19] https://morth.nic.in/sites/default/files/circulars_document/Revision_of_Normative_Cost_Norms_for_National_Highways.pdf
[20] https://www.adb.org/sites/default/files/institutional-document/32256/economic-analysis-projects.pdf
[21] https://cpcb.nic.in/displaypdf.php?id=U291cmNlX1Byb2ZpbGVfVmVoaWNsZXMucGRm
[22] https://mohua.gov.in/upload/whatsnew/59c21852a4874Appraisal%20Framework%20Sept%202017.pdf

economic Savings impact	Fuel economy	Bureau of Energy Efficiency[23]
	Fuel Price	Petroleum Planning & Analysis Cell[24]
Decongestion of Railway Network	Increase in average speed on the section or adjacent network	To be estimated by Project Team using Rail network data
	Average Lead (Km)	To be estimated by Project Team using Rail network data
	Passenger throughout on Network	To be estimated based on per capita income on railway network
	Value of Passenger time	Traffic demand studies/surveys
Improvements in Reduction in delayed travelling time (Travel Time Reliability)	No of trips	Traffic demand studies/surveys
	Buffer time	80%;
	Reliability Ratio	To be estimated based on per capita income on rail network
	Value of Trave time	Traffic demand studies/surveys
Increase in Railway Throughput	Passenger traffic	To be estimated by Project Team using Rail network data
	Average revenue per passenger	Indian Railways Annual Report and Accounts[25]
	Freight Traffic	Traffic demand studies/surveys
	Average revenue per Freight ton	Indian Railways Freight Tariff schedule X length of line
Economic conversion factors		MoHUA Appraisal Guidelines[26]; Assumptions

[23] https://beeindia.gov.in/content/fuel-efficiency
[24] https://www.ppac.gov.in/content/149_1_PricesPetroleum.aspx
[25] https://indianrailways.gov.in/railwayboard/uploads/directorate/stat_econ/Annual-Reports-2020-2021/Annual-Report-English.pdf
[26] https://mohua.gov.in/upload/whatsnew/59c21852a4874Appraisal%20Framework%20Sept%202017.pdf

C) Data to be filled by Project team to calculate Financial and Economic IRR of Railway Projects

DATA FOR FIRR, EIRR, NETWORK EFFECT & COMMON USER FACILITY					
Name of Project (NL/DL/GC):					
SN	**Item**		**Description**		
1	**FIRR:**				
a	Data for calculation of FIRR and FIRR values				
	As per existing Financial Code				
b	FIRR of the project				
2	**EIRR:**				
a	Field data for calculation of EIRR, including network effect				
Sr No	**Parameter**	**Items**	**Description***		
			Passenger	**Freight**	**Whether filled or not#**
1	Travel Time Savings (VOT)	Passenger Time Savings by each mode			
		Value of Passenger time			
		Value of freight time savings			
2	Freight Time Savings	Difference in the freight time between rail and the next fastest mode (hour)			
		Volume of Freight (ton)			
		Value of Freight time (INR per ton hour)			
3	Vehicle Operating Cost (VOC)	No of trips (Difference between with & without scenario) by each mode			
		Average Lead (Km)			
		Vehicle Operating Cost by each mode			
4	Reduction in Accidents	Vehicle Km (Difference between with & without scenario)			
		Road accident rate			
		Accident Cost (Fatal vs non-fatal accident)			
5	Infrastructure Maintenance Cost Savings	Vehicle Km (Difference between with & without scenario)			
		Infrastructure maintenance cost per km			

6	Road Infrastructure Cost savings	Additional express highway lanes required in without Project situation			
		Road construction cost per km			
7	Employment benefits	Project Capex			
		Employment cost as a % of Project Cost			
		Share of Skilled vs Unskilled employment			
8	Reduction in Emissions	Vehicle Km (Difference between with & without scenario)			
		Volume of Pollutant-CO2 by each mode			
		Volume of Pollutant Others by each mode			
		Treatment cost/ton - CO2			
		Treatment cost/ton- Others			
9	Fuel and economic Savings impact	Vehicle Km (Difference between with & without scenario)			
		Fuel economy by each mode			
		Fuel Price			
10	Decongestion of Railway Network	No of trips			
		Average Lead (Km)			
		Value of Passenger time			
11	Improvements in Reduction in delayed travelling time (Travel Time Reliability)	No of Trips (Difference between with & without scenario)			
		Reduction in Buffer time (Difference between with & without scenario) per trip			
		Reliability Ratio			
		Value of Passenger time			
12	Increase in Railway Throughput	Increase in passenger and Freight traffic (Difference between with & without scenario)			
		Average revenue per passenger and per Ton-km for freight			
3	**Network effect of the Project (paragraph)**				
4	**The work is a common user facility essentially required to improve mobility movement of passengers and goods for improving loading to achieve mission 3,000 MT**				

Dy.COM/GS or CTPM or PCOM

 # If the data is not filled, please provide the appropriate explanation and approval from designated

authority.
**Inputs in different currency shall be converted in INR assuming the exchange rate on the day of analysis.*

D) Demand assessment methodology

Demand assessment for Railway traffic requires a combination of activities such as hinterland demarcation, extensive field surveys, primary interactions with the stakeholders and other required research towards developing a base year demand matrix and undertaking demand projections. The methodology for the demand assessment is given below:

Task 1: Delineation of project influence area/ hinterland

The first task would be to identify influence areas/hinterland for the planned railway line, as well as accompanying port and industrial clusters. The influence zone within all states through which the proposed corridor would pass needs to be evaluated for the purpose of identifying the hinterland.

Based on extensive review of assessing passenger and freight movement on rail corridors, the hinterland/catchment area of rail corridors can typically be categorized into:

a) Primary hinterland: which includes end to end network of the proposed corridor including originating point, terminating point, all key regions falling along the corridor, or within a 150 km range from the corridor

b) Secondary hinterland: which includes regions from which cargo is either originating or terminating on the corridor, and

c) Tertiary hinterland: which includes region from which cargo is neither originating nor terminating on the proposed corridor but passing through the significant part of the corridor. It may be noted that only such regions will be considered under tertiary hinterland, wherein significant amount of cargo is currently moving from/to.

While identifying the hinterland, the study team should also consider main feeder lines connecting to the proposed corridor alignment. Further, in case, proposed corridor is expected to connect to ports, hinterland of identified ports should also be considered.

Task 2: Assessment of Base year demand

The next task would be to assess the base year traffic in the project hinterland. For this, traffic moving across different modes (road, railways and IWT) needs to be assessed. A robust data collection strategy combining primary and secondary surveys should by used to carve out the base year demand.

Traffic Surveys

a) Primary surveys

Name of Survey	Purpose	Method/ location	Duration of survey

Road Side Origin and Destination (OD) survey (sample survey)	To capture key flow attributes including: • vehicle origin, destination, • commodity (for freight), number of passengers (for passenger vehicles) • trip distance, • Travel time, and cost • frequency, • vehicle type (car, bus container, axles etc.)	Interview with drivers/ passengers at survey points on NHs and SHs. Toll locations are preferable.	At least 3 days (2 weekdays and 1 weekend) 16-24 hrs
Classified Volume count survey for roads #	To expand the Road O-D volumes for arriving at 24-hour traffic volume.	Traffic counts at the OD locations.	At least 7 days. 24 hrs.
Passenger Survey at Intercity Bus Terminal	To assess the demand for long distance passenger demand in the catchment. The following data should be captured during the survey: • Passenger boarding and alighting • Passenger OD • Frequency of travel • Fare • Travel time	Interview with passengers at the bus terminal and Ticket data from the operator (if available).	8-16 hours (depending upon the timetables)
Operator/industry survey (for freight)	To capture the time/ cost in each segment of supply chain. To understand various issues that an operator faces during transport movement.	Interview with Vehicle operators, Drivers, transport agencies.	
Stated preference survey for passengers and major cargo players	To capture the potential shift of passenger, cargo from other modes to Railways based on: • time and cost savings across ODs • Special value added services etc.	Interview with shippers, industries etc.	

 # This survey is undertaken by NHAI and same can be sourced from the regional offices of NHAI wherever available.

b) <u>Secondary data collection:</u>

Data points	Purpose	Source

Railway ODs for passenger and freight	To capture the existing railway traffic (if any) in the primary, secondary and tertiary catchment.	Indian Railways FOIS data and PRS data
Petrol sales data	To assess the periodicity of road transport demand. Also, the data is a key input in expanding daily traffic to average annual daily traffic (AADT).	Petrol Pump operators
Reports/ studies/ guidelines published by IWAI, NHAI and any other government and multilateral agencies for assessing financial and economic costs.		

Transport demand projections

Demand for transport is a derived demand, and therefore, it depends on how the transport-requiring industry grows over time. A top-down assessment needs to be undertaken for projecting transport demand. It will start with a compilation of existing transport demand, which will be informed by section 1.2. The transport demand must be projected based on appropriate macroeconomic indicators, past trends and econometric models to arrive at projected transport demand for a period upto 20-30 years from the baseline year. Along with this there needs to be a holistic review of industry plans, upcoming SEZs and other proposed traffic intensive activities in the catchment. All such inputs must factor in during transport projections.

Rail transport demand is a subset of the transport demand projections. Hence, rail modal share for future years can be estimated based on mode choice models (based on time and cost analysis) and outputs from stated preference surveys in section 1.2.1.

ANNEXURE – J

Proforma for submission of Detailed Project Report

DETAILED PROJECT REPORT: VOLUME I	
CHAPTER -1 : EXECUTIVE SUMMARY	
1.1	**Introduction**
1.2	**Project Overview and justification**
1.3	**Methodology of preparation of DPR / Feasibility Report**
1.4	**Criteria for alignment finalization for New Lines** (Traffic survey, obligatory points, **BISAG verification**, site constraints, techno economic factors, Protected monuments, wildlife sanctuaries, interaction with various stake holders etc.)
1.5	**Traffic survey and Traffic forecast (including existing and projected line capacity utilization, anticipated additional Goods traffic etc). Anticipated additional Goods traffic (both incoming & outgoing), expected passenger traffic. Names of Seaports, SEZ, Logistic Parks, and Industrial corridors, Airports, Tourists place & pilgrimage centre to be connected.**
1.6	**Alignment of proposed New Line / Doubling etc. along with station names and key plan** (**Colour**) showing surrounding Railway Network also
1.7	**Alignment parameters** (Horizontal Curves, Vertical Curves, Ruling Gradient etc., turnouts etc.)
1.8	**Brief description about alignment and Terrain characteristics** (Length, states/districts covered giving brief reference to **Aspirational districts** covered , stations / tunnels (if any) / major rivers / canals / nallahs / important bridges / major bridges / crossing of National Highway / State Highway / major District Roads / Towns / ROBs / Power Crossings / Climate characteristics etc.)
1.9	**Topographical survey and soil investigation**
1.10	**Design standards** (speed potential / formation / track structure / tunnel cross section / bridge loading standard / interlocking standards / electrification / Telecom / building standards etc.)
1.11	**Land requirement** (brief details of Private, Government & Forest Land) and brief methodology for calculation of the same.
1.12	**Permanent way (Route** length/total track length/No of loop lines/ Turnout details/Ballasted deck/Ballastless track/LWR / Loop speed etc.)
1.13	**Major civil Engineering features** (Brief details of bridges, spans of Major & important bridges, Tunnels, RoBs, RuBs/LHS, Level crossings, RoRs etc)
1.14	**Railway stations & yards (** list of stations and brief details of facilities being proposed in each station e.g. station building area, no & length of loop lines, Platforms, FoBs, CoPs, etc**)**
1.14	**Offices and Other service buildings (** Panel building**,** workshops, sheds etc**)**
1.15	**Residential Buildings (** staff quarters, Rest houses, Running rooms etc**)**
1.16	**Shifting of Utilities (** LT/HT lines, Telecom, Sewers, cables etc**)**

1.17	**Electrical (General) (** brief details being proposed in every station, buildings etc, source of Power supply, etc**)**
1.18	**Electrical (Traction) (** Type, source, TSS etc**)**
1.19	**Signaling** (Brief of Signaling system at each station, Type of Block working, Standards of Interlocking, Telecom facilities etc)
1.20	**Telecomm** (Control communication, PA system, coach guidance, display boards etc)
1.21	**Statutory clearances required (** From NMA, wildlife , FCA etc)
1.22	**Environment and Social Impact Assessment**
1.23	**Salient Features of Project**
1.24	**Summary of Cost estimate**
1.25	**Traffic projection and Earnings**
1.26	**Non Fare revenue**
1.27	**Source of Funding, Financial Rate of Return and Economic Rate of Return**
1.28	**Phasing and Construction time lines**
1.29	**Annual Fund requirement**
1.30	**Conclusion & Recommendations**
CHAPTER-2 : Traffic Survey	
	It should include objective of Traffic Survey, Analysis of existing capacity and line capacity utilization , Analysis of alternatives, Origin – Destination survey, stations Traffic characteristics and composition, Travel / transport pattern, Regional distribution, Passenger traffic estimation and forecast, Facilitation provided by this project to passengers of nearby Airport, Tourist hub, Pilgrimage centre, Goods traffic projection , Facilitation to freight traffic by its connection with any existing or upcoming Seaport, SEZ, Logistic Park, Industrial hub, Airport. Anticipated passenger & freight traffic shift from other modes of transport (roadways, airways, inland & coastal shipping) to railways, Expected decongestion of roads, Goods and coaching earnings, Assessment of working expenses, Goods traffic projection, Goods and coaching earnings, Assessment of working expenses etc. (All data sources and methodology to be followed in accordance with extant policy guidelines and codal provisions. Confirmation to same shall be part of traffic checklist).
CHAPTER -3 : Engineering Survey	
3.1	Methodology of Topographical Survey (Survey of India Maps, DGPS Survey, permanent and temporary bench marks, Arial Photogrammetry by Drones, LIDAR Survey, Total Stations etc.). List of bench marks along with their coordinates.
3.2	Alternative alignments and route selection. Verification / validation of alignment in consultation with BISAG
3.3	Description of alignment. Station location and criteria for choosing them.
3.4	Geometric design of alignment (Chainage wise list of Horizontal Curves, Vertical Curves, Gradients). List of longitudinal section and plan of the alignment
3.5	Details of soil investigation and type of strata along the alignment

Chapter-4: Land requirement

4.1 Criteria for requirement of land for track, stations, bridges etc.

4.2 Break up of land requirement state-wise and district wise for Private land, Government land and Forest land

4.3 Details of land requirement in the following format:

SN.	Chainage (M)		Length (Cum)	Width of land (M)	Area of land (Sqm)	Private/ Govt/ Forest	Purpose for which land required
	From	To					

Chapter-5: Permanent Way

5.1 Details of total track length including loop line etc.

5.2 Design speed for Main line and Loop Line

5.3 Cant excess and deficiency

5.4 Track structure (Rail, Sleepers, Fittings, Ballast cushion etc.) for Main line and Loop Line

5.5 Turnouts, SEJs, Glued joint etc.

Chapter-6:Formation, Tunnels & Bridges

6.1 List of important, major and minor bridges incorporating liner waterway in metre, chainage of bridge, span arrangement, river name, type of bridge etc. in the following format:

SN.	Bridge Nos	Chainage (M))	Waterway (M)	Span arrangement	Type of Bridge	River name

6.2 Details and list of road crossing works such as ROBs, RUBs / LHS and Level Crossings.

6.3 List of Rail Over Rail Flyovers, if any.

6.4 Tunnel details and type of strata. Typical Cross Section of Tunnel. List of Tunnels in the following format:

SN.	Tunnel No	Length (RM)	Chainage (From)	Chainage (To)	Cross section area of Tunnel (Sqm)	Maximum over burden over Tunnel (M)

6.5 Earth work in embankment and cutting.

List of embankment in the following format:

SN.	Length (M)	Height of embankment (M)	Chainage (From)	Chainage (To)	Quantity of earth work (Cum)

List of cutting in the following format:

SN.	Length (M)	Depth of	Chainage	Chainage	Quantity of

			cutting (M)	**(From)**	**(To)**	**earth work (Cum)**

Chapter-7: Stations & Yards	
7.1	Stations and their Demographic details, MSL, Climate etc.
7.2	Facilities proposed at each station (station building area, FOB details, platform details, platform shelter details, circulating area. Standard of construction for station buildings
7.3	No. of loop lines and their length at each station, Turnout details at each station
7.4	Conceptual Yard Plan of each station
Chapter-8: Service buildings (including offices, workshops, shed etc.	
8.1	List of all service building station-wise along with plinth area and justification
8.2	Standard of construction for the service buildings
Chapter-9: Residential buildings (staff quarters, running rooms, rest houses, RPF barracks etc.)	
9.1	Details of type wise and station wise residential quarters proposed and the basis of same
9.2	Details of station wise running rooms / rest houses / RPF barracks etc. if proposed along with justification
9.3	Standard of construction
Chapter-10: Shifting of utilities	
10.1	Transmission Line Modification payment to SEBs Voltage Level-wise (LT/11KV/33KV/110KV/220KV/400KV/765KV) including numbers, unit cost and total cost of each voltage level line requiring modification
10.1	Details of Telecom Lines required to be shifted
10.2	Details of civil utilities (sewer line / water pipe line / drains etc.) required to be shifted.
Chapter-11: Electrical Traction & General	
11.1 Electrical Traction	
a.	Type of OHE system & design speed
b.	Pegging plan
c.	Traction power supply system (TSS,SP,SSP location & spacings)
d.	Modifications in existing OHE system
e.	Requirement of communication channel for SCADA
f.	Details of feasibility of EHV power supply at nearest GSS for feeding to proposed TSS. Alignment & expected ROW.
g.	Provision of fire suppression system in transformer
11.2Electric General	

a)	Details of 11kv & 33 kv power supply points
b)	Electrification of Tunnels/service building etc.details
c)	Ventilation of tunnels details
Chapter-12: Signal & Telecommunication	
12.1	Details of Signaling Arrangement (type of signaling, block working, standard of interlocking etc)
12.2	Details of survey regarding type of soil for cable laying, cable route, track crossing, approach/location of S&T installations, infringements, RSSI etc
12.3	Requirements of S&T service building along with electrical requirements including power budget etc.
12.4	Utility/ cable shifting for S&T works.
12.5	Alterations in existing Signaling systems.
12.6	Specifications and testing procedure of S&T equipments.
12.7	Provision of EI, ABS, ATP, CTC, LTE etc as per extant guidelines
12.8	Details of Telecommunication arrangement for operations and passenger amenities.
12.9	Standard Checklist and Performa for Signaling & Telecomm items
12.10	Mandatory clearances required (ISA, WPC, RDSO approvals etc)
12.11	Testing and training required before commissioning.
CHAPTER-13: Environmental Assessment and Social Impact Assessment (if applicable)	
13.1	Introduction
13.2	Existing Scenario, water bodies, noise level, land environment, biological environment, socio economic survey, archaeological sites etc
13.3	Environmental Policy Framework
13.4	Detailed Environmental Impact assessment due to project location, design and construction including the impact of operation and maintenance facilities.
13.6	Environment Management Plan
13.7	Environmental Monitoring Plan including for Pre Construction, construction phase, Operations Phase, Implementation of environmental Management Plan and setting up an Environment management System.
13.8	Social Impact Assessment including resettlement/rehabilitation alternatives, public consultation, resettlement assistance plan, cost monitoring and evaluation.
13.9	Analysis of Alternatives
13.10	Summary of Costs
Chapter-14: Statutory clearances	
	List of Forest/Wildlife sanctuaries through which proposed project is passing. Details of clearances required such as ASI/NMA, Wild Life, Forests under FCA act, Tree cutting permission etc.

Chapter-15: Cost Estimates	
15.1	Basis of rates for working out, cost of land, civil engineering structures, P-way, Electrical, S&T, Utility shifting etc.
15.2	Summary of the cost estimates (detailed estimate to be attached as Vol-II of DPR)
Chapter-16: Traffic earning projections	
16.1	Details of anticipated goods traffic (both incoming &outgoing)and goods earning
16.2	Details of passenger traffic projection and earnings
16.3	Savings due to avoidance of detention of trains
Chapter-17: Non fare revenue	
17.1	Various existing & anticipated sources of NFR, Details of projected non-fare earnings
CHAPTER 18 : FINANCIAL ANALYSIS	
18.1	Estimation and Phasing of Investment
18.2	Estimation of operations and maintenance cost, overheads
18.3	Earning potential of the Project : Fare Revenue as well as non fare revenue
18.4	Terminal Value Estimation
18.5	**Calculation of Project IRR**
18.6	Sensitivity Analysis with respect to Expected Traffic (range of +/- 20%), Cost Escalation (+/- 20%) and Time Overrun (+/-20%)
18.7	Assumptions with respect to both cash inflows and outflows
18.8	Analysis and Results
CHAPTER 19: ECONOMIC ANALYSIS	
19.1	Basic Approach of Economic Analysis
19.2	Demand Assessment Methodology.
19.3	Quantification of Economic Costs and Economic Benefits.
19.4	Checklist for Economic Cash flows. (refer Annexure III of Railway Project Economic Appraisal Framework Note for checklist, circulated vide letter no.2022/ Gati Shakti/EU/49 dated19/08/2022.)
19.5	Cash flows of Economic Internal Rate of Return (EIRR)
19.6	Sensitivity Analysis for critical factors in the range of 5% to 20% on EIRR: a. Cost overruns due to delay or other factors b. Increase in Operations and Maintenance Cost c. Reduction in passenger traffic d. Reduction in economic benefits e. Combination of reduction in benefits and increase in cost.
19.7	Details of Network effect alongwith map.
19.8	Model Input data used along with sources. (refer Annexure II of Railway Project Economic Appraisal Framework Note for list of data sources, circulated vide letter No.2022/ Gati Shakti/EU/49 dated 19/08/2022.)
CHAPTER 20 : RISK ANALYSIS	
20.1	Cost Risk

20.2	Schedule Risk
20.3	Operational Risk
20.4	Market Risk
20.5	Risk Mitigation Measures

Salient Features of Project		
Name of Project (NL/DL/GC):		
SN	**Item**	**Details**
1	**Route length (Km)**	
(i)	State-wise and District wise breakup of route length	
2	**Current Estimated cost (In crores of Rs.)**	
2(i)	**Estimated Completion cost (In crores of Rs.) (taking into account 5% escalation every year)**	
3	**Completion period (years)**	
4	**RoR : (i) FIRR**	
	(ii) EIRR (As per guidelines issued by Board and including network effect)	
5	**Land requirement (Ha) (Statewise and Districtwise)**	
(i)	Private	
(ii)	Government	
(iii)	Forest	
6	**Total Track Km (incl loops/siding etc.) (Km)**	
7	**Maximum permissible speed (Kmph)**	
8	**Maximum Degree of Curvature**	
8(i)	Curve Track (% of total length)	
9	**Ruling Gradient**	
9(i)	**% length on Ruling Gradient**	
10	**No. of PSRs**	
11	**Earthwork in embankment (Cum)**	
11(i)	Maximum Bank Height (m)	
12	**Earthwork in Cutting (Cum)**	
(i)	**Maximum Cutting Depth (m)**	
13	**Total no. Tunnels (nos.)**	
(i)	**Total Tunneling length (Km)**	
(ii)	**Longest Tunnel (m)**	
14	**Total Adits/Shafts and their length**	
15	**Total Linear waterway (m)**	

(i)	**Important bridges (nos.)**	
(ii)	**Major bridges (nos.)**	
(iii)	**Minor bridges (nos.)**	
16	**Loading standards**	
17	**Total stations (including Originating and Destination stations, junction stns, crossing staions, halts) (nos.) (statewise)**	
(i)	**Junction stations (nos.) (including Originating and Destination stations if they are junctions) (nos.) (statewise)**	
(ii)	**Crossing stations (nos.)(including junction stations, Originating and Destination stations if they are crossing stations)**	
(iii)	**Halts (nos.)**	
18	**Total loop lines (nos.)**	
(i)	**loop line length (CSR) (m)**	
19	**RoBs (nos.)**	
(i)	**RuBs/LHs (nos.)**	
(ii)	**Level crossings (nos.)**	
20	**Rail over Rail flyover (RoRs)**	
21	**Track structure (Both for Main lines and Loop lines separately)**	
22	**Track centre (m)**	
23	**Signalling system (MACLS std. II/III etc.)**	
24	**Traction**	
25	**Projected Passenger traffic (Lakh passengers/annum)**	
25 (i)	**Projected Coaching trains in case of NL (pairs of trains per day)**	
26	**Projected Freight traffic/Additional freight traffic (MTPA)**	
26 (i)	**Projected goods train/additional goods train per day**	
27	**Existing line capacity utilisation incase of Doubling etc. without maintenance Block and with maintenance Block at current year level**	
28	**Projected gross earning and net earning per annum (In Crs of rs)**	
	CPM/GS or CAO or CE/Construction	

Summary of Main items of DPR/ Detailed Estimate for New Projects						
Name of Project (NL/DL/GC):						
SN	**Item**	**Unit**	**Quantity**	**Unit cost (Rs in Crores/ lakhs)**	**Amount (Rs in crores)**	**Remarks**
1	**Route length**	Km		Total estimated cost/ Route length		
(i)	Total Track Km (incl loops/siding etc)	Km		Total estimated cost/ Total track length		
Civil Engg Items						
2	**Preliminary expenses**					
3	**Total Land requirement**	Ha				
(i)	Pvt land	Ha				
(ii)	Govt land	Ha				
(iii)	Forest land	Ha				
4	**Earthwork in Embankment**	Cum				
(i)	Upto 5 m high	Km				
(ii)	5-10 m high	Km				
(iii)	More than 10 m high	Km				
(iv)	Maximum Bank height	m				
4(a)	**Blanketing quantity**	**Cum**				
5	**Earthwork in cutting**	Cum				
(i)	Upto 5 m depth	Km				
(ii)	5-10 m depth	Km				
(iii)	More than 10 m depth	Km				
(iv)	Maximum Cutting depth	m				
6	**Main Tunnels(cross sectional area of tunnel)**	**nos**				
(i)	Total Main Tunnel length	Km				
(ii)	Maximum length of	Km				

	Tunnel					
(iii)	Tunnels more than 2 Km long	Nos				
7	**Adit/ shafts/cross passages length and cross sectional area of Adit/cross passage etc)**	Km				
8	**Walling length**	Km				
9	**Drain length**	Km				
10	**Rails and fastenings**	Km				
11	**Sleepers and fastenings**	Km				
12	**Ballast**	Km				
13	**Points and crossings**	Nos				
(i)	1 in 16	nos				
(ii)	1 in 12	Nos				
(iii)	1in 8.5	Nos				
(iii)	Others (DS etc.)	Nos				
14	**Ballastless Track (wherever required)**	**Km**				
15	**Fencing (stations/LC etc.)**	**m**				
16	**RoBs**	**Nos**				
17	**RUB/LHS (new/extension)**	**Nos**				
18	**Level crossings (new/extension)**	**Nos**				
19	**Rail over rail flyovers (RoRs)**	**Nos**				
20	**Linear waterway**	**m**				
(i)	Important bridge	Nos				
(ii)	Major bridge	Nos				
(iii)	Minor bridge	Nos				
21	**Total no. of stations (incl originating and destination station)**	**Nos**				

(i)	No. of junction stations	Nos				
(ii)	No. of Crossing stations (excluding junction station)	Nos				
(iii)	No. of Halts	Nos				
22	**Total no. of loop lines/sidings**	**Nos**				
(i)	Total length of loop lines/sidings	Km				
23	**Station buildings**	**Sqm**				
24	Office buildings	Sqm				
25	Workshops and sheds	Sqm				
26	Other service buildings	Sqm				
27	**Total H/L Platform length**	**m**				
(i)	H/L Platform area	Sqm				
28	**Cover over Platforms**	**Sqm**				
29	**Residential quarters**	**Nos**				
(i)	Type II	Nos				
(ii)	Type III	Nos				
(iii)	Type IV	Nos				
(iv)	Type V	Nos				
30	**FoBs**	**Nos**				
(i)	**FoBs length**	**m**				
31	**officers/Subordinate rest house**	**Sqm**				
32	**Plants & Equipments**					
Electrical						
33	**OHE**	**Km**				
34	**TSS**	**Nos**				
35	**SSP**	**Nos**				
36	**General Services**					
37	**Shifting/Modification of electrical crossings**	**nos**				
(i)	400 kv	**nos**				
(ii)	200 kv	**nos**				
(iii)	132 kv	**nos**				
(iv)	33 kv	**nos**				
(v)	11 kv	**nos**				

Signalling & Telecom						
38	**Signalling System**					
(i)	No. of stations upto 100 routes	**nos**				
(ii)	100 to 200 routes	**nos**				
(iii)	200 to 500 routes	**nos**				
(iv)	More than 500 routes	**nos**				
(v)	Interlocked LC gates	**nos**				
39	**Telecom**					
Mechanical						
40	**Mechanical cost**					
(i)	Maintenance facilities					
(ii)	Watering facilities					
(iii)	Disaster management facility					
(iv)	Wayside detection equipments					
41	**Environmental charges**					
						CPM/GS or CAO or CE/Construction

Cash Out Flows:

A. Construction Cost

1. Whether cost of land acquisition has been incorporated?
2. Whether state's share of project cost has been excluded?
3. Whether construction cost of each department has been incorporated?
4. Whether the cost of construction has been projected year-wise as per the schedule of Construction?
5. Whether CRRM is incorporated as per Para 233 of IRFC Vol 1?

B. Working Expenses:

6. Whether maintenance cost of each department has been incorporated as per extant maintenance schedules?
7. Whether the repair cost of each department has been considered?

8. Whether the cost of replacement of assets as per the latest available policy instructions has been factored in?
9. Whether it is verified that depreciation and interest has not been considered as per Para 215 of IRFC Vol 1?
10. Whether operational expense is considered based on the latest traffic costing/Statistical data?

Cash Inflows:

A. Traffic earnings:

11. Whether both outward and inward traffic data is considered?
12. Whether savings in engine days or wagon days or both is worked out as per Para 202 of IRFC Vol 1?
13. Whether reduction in revenue of other lines/ railways due to diversion has been considered?
14. Whether any non-fare revenue is considered?
15. Whether the latest available Statistical data has been used?

B. Residual value:

16. Whether Residual value of assets at the end of project period is considered as per Para 233 of IRFC Vol 1?
17. Whether Land has been factored in as per Book Value?
18. Whether Second hand value of assets has been calculated as per Para 241, IRFC Vol 1?

Checklist for Detailed Financial Cash Flow in DPR for Estimating FIRR		
Name of Project (NL/DL/GC):		**Railway:**
SN	**Item**	**Description**
1	Total capital cost (states's share to be excluded, if any)	
2	Total land to be acquired and cost	
3	Total capital cost of the project, with department wise (Civil, mechanical, electrical and S&T) phasing of costs for each year of construction	
4	Cost of rolling stock in year zero, and additional rolling stock cost in subsequent years, if applicable	
5	Renewal & replacement cost	
6	Gross coaching working expenses for 1st/6th/11th year of the project (Cr.)	
7	Gross coaching earnings for 1st/6th/11th year of the project (Cr.)	
8	Gross goods earning for 1st/6th//11th year of the project (Cr.)	
9	Gross goods working expenses for 1st/6th/11th year of the project (Cr.)	
10	(i) Have savings due to avoidance of detention to rolling stock (both, one time capital and recurring operational), wherever applicable, been duly accepted/vetted by the associated finance. (ii) Passenger and goods savings to be stated separately. In case of doubling, tripling, etc. project only goods savings to be taken into account.	
11	CRRM if accounted for gauge conversion/doubling etc., project to be indicated.	
12	Rate of return (use excel formula).	
13	FIRR of the project	
	Encl. : FIRR calculation sheet	
	Note: Excel Sheet to be shared by Zonal railway.	
Dy CPM/GS/Traffic or CTPM/PCOM, Zonal Railway		

SALIENT FEATURES OF ELECTRICAL ESTIMATE

Electrical TRD:

1. **Name of Section:**
2. **RKM:**
3. **TKM:**

SN	Name of item	Unit	Qty	Unit Rate	Cost
1	OHE	TKM			
2	TSS	Nos.			
3	PQCE/Shunt Capacitor	Nos.			
4	SP	Nos.			
5	SSP	Nos.			
6 (a)	SCADA: RCC cost	Nos.			
6 (b)	SCADA: RTU cost	Nos.			
7	Bay charges to SEBs				
8	Transmission line (SEB)	km			
9	Cables (Size)	km			
10	Construction of siding if any	km			
11	M&P	Nos.			
12	OHE depot	Nos.			
13	PSI depot	Nos.			
14	Contingencies	@1%			
15	D&G charges as per Bd's letter no. 2017/E&R/3(2)/2 dt 20.02.2019	@9.964%			

Electrical General:

SN	Name of item	Unit	Qty	Unit Rate	Cost
1	Modification in power line crossings payment to SEBs (LT/11KV/33KV/110KV/220KV/400KV/765KV)	Nos.			
2	Tunnels:,				
	a. Cost of lighting (Wattage-wise and Nos. of lighting fixtures of each wattage)	No.			
	b. Ventilation (Spec. of Fans & No.of each specification)	No.			
	c. Power supply (No. of transformers, panels, ckt breakers, isolators, size of cables & their qty)	No.			
	d. Fire fighting system (Major items)	No.			
	e. SCADA	No.			
3	Electrification of staff qtrs (Type wise)	No.			
4	Electrification of service buildings (Stn bldg, platform,	No.			

	offices etc separately)				
11	Gysers (no. of each rating)	Nos.			
12	Air conditioners with spec. (window, split)	Nos.			
13	Air conditioner centralised with spec.	Tonnage			
14	DG set with spec.	Nos.			
15	Lifts/escalators	Nos.			
16	Contingencies				
17	D&G charges as per Bd's letter no. 2017/E&R/3(2)/2 dt 20.02.2019	@9.964%			

Checklist for Signaling Sub-estimates submitted with DPRs

SN	Items	Policy/Guidelines	Yes/No
1	Provision of PI/EI/RRI	As per Railway Board's policy, provision of EI should be made in all estimates. Railway Board's letter No. 2003//Sig/G/5 dated 28.04.2016 (SN-33 to 34). Centralized/Distributed EI up to 100 routes based on physical layout of yard, complexity involved, maintainability aspect etc. (letter No. 2021/Sig/25-Conf/5/SSC dated 26.02.21 (SN-31 to 32) of Special SSC)	
2	Point Machine	Non-Trailable Electric Point Machines 143-mm throw with internal locking and non-trailable electric point machines 220 mm. (IRS - S 24-2002)	
3	LED Signal	Procurement of Main Signals and subsidiary signals should be as per RDSO specification i.e. RDSO/SPN/199/2010 Rev 1.0 and of RDSO/SPN/153/2011 ver. 4.1 respectively.	
4	Cable	Usage of cable as per policy (85th SSC) (a) 6 core X 1.5 sq. mm. Copper conductor cable. (b) 12 core X 1.5 sq. mm. Copper conductor cable. (c) 24 core X 1.5 sq. mm. Copper conductor cable. (d) 2 core X 2.5 sq. mm. Copper conductor cable. (e) 2 core X 25 sq. mm. Aluminum conductor power cable. (f) 2 core X 70 sq mm power cable. (g) 6 Quad cable. (h) OFC.	
5	Power Supply (IPS)	There should be provision of IPS.	

6	BPAC	Dual detection should be there. JPO issued by Board (ML & MT) vide letter No. 2015/Sig/PLN/Pt. dated 02.11.2005 (SN-28 to 30)	
7	MSDAC	Dual detection should be there depending on local conditions. MSDAC type complete equipment with minimum 5DP and 4 track section	
8	HASSDAC	As per RDSO specification No. RDSO/SPN/177/2012 (Ver 3.0) or latest	
9	Provision of Automatic signaling.	To be provided as per policy issued vide L No ABS No 2021/Sig/WP/Action Plan dated 14.06.2022.	
10	Double line Block instrument	Double line Block instrument complete with block bell equipment, HMT set with induction coil & condenser, 3-position polarised relay, filter unit etc for working in RE area as per RDSO specification.	
11	Datalogger	Data Logger for Relay Hut, Front end processor, RTU (64DI & 16 DI), station monitoring panels, High end data base server.	
12	Double Distant	As per Railway Board's latest policy dated 29.08.2017 (SN-27), provision of double distant shall be made on Doubling/Tripling works on A & B routes	
13	Fire alarm and smoke detector system	To protect from fire the panel interlocking equipment, indication cum operating panel, S&T equipments in Panel room, Relay room, power supply room, battery room, diagnostic panel room and OFC room.	
14	Automatic Fire Detection & Suppression system	As per Rly. Board's policy letter no. 2013/Sig/Specifications dated 22.06.2015, firefighting equipment shall be kept in the power supply equipment room. Automatic fire suppression system along with Automatic fire detection & alarm system may be provided at stations with more than 400 routes. (Sub-Para 21.18.2 Correction Slip No. 10)	
15	Interlocking of LC Gates	There should not be provision of LC Gate on GQ & GD Routes. Instead of LC Gate, provision of RUB/ROB be made in the estimate. Provision of Emergency Sliding Boom should be made in the estimate.	
16	Standard of Interlocking	As per Rly Board's letter No.2020/Sig/35-Policy/4/Interlocking dated 20.10.2020 (SN-9 to 25), all new stations being opened under gauge conversion/new lines shall be provided with Standard-II(R) Interlocking and Colour Light Signalling.	

17	Cable laying & Trunking	Laying of cable should be with trunking and there should be path protection of cable. Provision of Horizontal Directional Drilling (HDD) for cable laying work may be done as per site feasibility	
18	D&G Charges	As per Rly. Board's latest policy dated 04.03.2020 (a) 16.33% for projects requiring Traffic Blocks (b) 12.19% for projects not requiring Traffic Blocks	

To Be Signed By Concerned CSTE/C or CSTE/Project.

Checklist for Telecom Sub-estimates submitted with DPRs

SN	Items	Policy/Guidelines	Yes/No
1	IP-MPLS, IP-Exchange and Data Network for PRS, UTS, FOIS and SCADA	To be followed Railway Board's policy vide letter no. 2011/Tele/9(2)/1 dated 25.02.2020 as Telecom Circular no.4/2020 and Technical Advisory Note issued by RDSO vide letter No RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/ RDSO dtd 16.12.2020	-
1a	Provision of IP-MPLS System at stations	All future works/replacement of SDH/PDH works, including works where tender is yet to be floated shall be with IP-MPLS standards.	
1b	Provision of IP Exchange	All future exchange works/replacement shall be done with IP exchanges. All exchanges can be integrated into one at the Divisional level, where feasible, with provision of suitable bandwidth and ring connectivity/protection. In addition to that, for IP-Exchange, telecom Circular 04/2022 should be followed.	
1c	Provision of Data network	The telecom backbone of all future works/ replacement of Data networks such as PRS/UTS/ FOIS/SCADA shall be with IP-MPLS equipment by providing separate VPN network, if required	
2	Provision of VOIP based TCCS at station	As Para 5.4 of Telecom manual, VoIP Based TCCS among the various control communication systems to be used in Indian Railways as per RDSO specification.	

3	LC gate communication	Phone communication to all manned level crossing gates controlled from the station preferably with voice logging facility.	
4	25 W VHF set and 5W VHF sets	25W VHF sets with proper standby power supply at each station and 5 W warlike-Talkie set as per requirement.	
5	Provision of LTE in section where Kavach is provided	Vide Board Letter No 2020/Tele Dev/Umbrella works dtd 21.10.2021, Provision of LTE in section where Kavach is provided/being provided.	
6	Cable	Usage of cable as per Telecom manual 6 Quad cable (Quad Cable 0.9 or 1.4 mm conductor dia. as per IRS specification No. IRS:TC 30/05. 1.4 mm conductor dia cable is used for longer block sections longer than 12 kms.) Multi pair (from 10 pairs to 200) Multi Dia (0.5mm/0.63mm/0.9mm) PIJF (Polythene insulated Jelly Filled) Cable as per IRS specification No.IRS:TC 41/97 used for exchange subscriber lines or branch cables branching off from the main Quad cable Twisted Pair Switch Board Cable of sizes 0.5 mm /0.6mm copper conductor dia. as per IRS/TEC specification used for indoor applications such as distribution to various telephone subscribers in a building, MDF to exchange wiring etc OFC (24/48 Fibres Optical Fibre Cable as per latest RDSO specification) to be laid in HDPE pipe.	
7	Power Supply (IPS)	All Telecom Equipments shall be provided with a reliable Power Supply	
8	IP based Video Surveillance System	**CCTV system at stations** - As per RDSO spec (Spec no RDSO/SPN/TC/65 /2021 Rev 6.0 issued by Tele Dte/RDSO or latest). **CCTV at non critical locations**- To be procured either RDSO spec or Rly's own specifications with approval of GM as per RB letter No 2017/Tele/3(8)/1 dtd 28.11.2017. **CCTV system in Divisional & Zonal Hospitals-** Type of system and its specifications to be	

		decided by Zonal Rlys as per RB Letter No 2018/Trans Cell/Health/MR Review dtd 14.09.2018. **CCTV at Railway offices**- Type of system and its specifications to be decided by Zonal Rlys as per RB letter No 2018/Tele/6(4)/1 dtd 16.01.2020 **CCTV system in relay rooms**- an extension of the existing/proposed CCTV system at stations as RB Letter No 2017/Tele/3(8)/1 Pt-1 dtd 20.04.2020 **CCTV at RPF Thana/Posts**- an extension of the existing/proposed CCTV system at stations as RB Letter No 2020/Sec(CCB)/210/CCTV dtd 23.11.2021.	
9	Passenger Information System at station	Followed Comprehensive instructions for provision of Passenger Amenities and user facilities at Stations issued vide Lt.No.2018/LM(PA)/03/06 Dtd. 09.04.2018	
10	Fire Alarm system at Telecom Installations	As per Rly Board's policy letter no 2019/Tele Dev/ Fire Alarm dtd 27.07.2019, Automatic Fire Detection & Alarm System is to be provided as per RDSO specification No. RDSO/SPN/217/2018 ver 2.0 or latest at Telecom installations like major Exchanges, Test Room/Telecom Control Room, Data Centre locations, CCTV Control & Equipment Rooms, Main Switching Centre (MSC) & Base Station Controller (BSC) of MTRC, main QFC centres /Quad repeater stations, Satellite Hubs, etc	
11	Tunnel communication	In Section where Tunnel exist, Tunnel communication is to be provided as per RDSO spec (Spec no RDSO/SPN/TC/109 /2019 Rev 0.0 issued by Tele Dte/RDSO or latest).	
12	Utility shifting of Telecom assets	Like in doubling, Gauge conversion project, existing utility pertaining to telecom cables and other accessories have to be shifted, Hence, its shifting provisions should be ensured	
13	Remote diagnostic & predictive maintenance tool for Telecom assets.	To ensure uninterrupted communication services, 24x 7 working of Telecom assets has to be ensured. Hence, Provision of Remote diagnostic & predictive maintenance tool for Telecom assets should be ensured.	

14	D&G Charges	As per Rly. Board's latest policy dated 04.03.2020 16.33% for projects requiring Traffic Blocks. 12.19% for projects not requiring Traffic Blocks.	

Signature of SAG officer In-charge

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