

Chapter -21

Economic Appraisal



- 21.1 Introduction
- 21.2 Values Adopted for Some Important Variables
- 21.3 Economic Benefits
- 21.4 Metro Construction Cost
- 21.5 Economic Performance Indicators
- 21.6 Sensitivity Analysis
- 21.7 Quantified Benefits
- 21.8 Transit Oriented Development (TOD) & EIRR



Chapter – 21

ECONOMIC APPRAISAL

21.1 INTRODUCTION

Economic benefits are social and environmental benefits which are quantified and then converted into money cost and discounted against the cost of construction and maintenance for deriving Economic Internal Rate of Return (EIRR). When actual revenue earned from fare collection, advertisement and property development are discounted against construction and maintenance cost, interest (to be paid) and depreciation cost, Financial Internal rate of Return (FIRR) is obtained. Therefore, EIRR is viewed from socio-economic angle while FIRR is an indicator of financial profitability and viability of any project

21.1.1 Economic appraisal of a project starts from quantification of measurable economic benefits in economic money values, which are basically the savings of resource cost due to introduction of the metro line. Economic savings are derived from the difference of the cost of the same benefit components under 'with' and 'without' metro line. Total net savings/or benefit is obtained by subtracting the economic cost of the project (incurred for construction (Capital) and maintenance (recurring) costs for the metro line) from the benefits out of the project in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

21.1.2 The original DPR of Phase-IV of Delhi Metro was submitted to MoH&UA (Erstwhile MOUD), GOI and GNCTD in October 2014. MOUD vide letter no. K-14011/60/2014-MRTS-I dated 13.09.2017 has requested DMRC to resubmit the DPR as per the provisions of Metro Rail Policy 2017.

The corridor-wise total route length, underground length and elevated length are shown in Table –21.1 below.

Table –21.1

Sr. No.	Corridor	Total Route Length in KMs	Underground in KMs	Elevated in KMs
Considering 3 Corridors				
1	Aerocity to Tughlakabad	20.201	14.619	5.582
2	Janakpuri West to R.K Ashram	28.920	7.740	21.180
3	Mukundpur-Maujpur	12.558	0.000	12.558
Total		61.67	22.36	39.31

21.1.3 The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 21.2** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road.

Benefit components were first estimated applying market values then were converted into respective Economic values by using separate economic factors which are also given in table 21.2

Table 21.2: Benefit Components due to Metro

	Benefit Components
1	Annual Time Cost Saved by Metro Passengers
2	Annual Fuel Cost Saved by Metro Passengers
3	Annual Vehicle Operating Cost Saved by Metro Passengers
4	Emission Saving Cost
5	Accident Cost
6	Annual Time Cost Saved by Road Passengers
7	Annual Fuel Cost Saved by Road Passengers
8	Annual Infra Structure Maintenance Cost

21.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in **Table 21.3**.

Table 21.3: Values adopted for some important variables

	Values	Important variables
1	Rs. 1.31/min (2014)	Time Cost derived from passenger's monthly income level.
2	Market Rate (2017)	Fuel Cost (value of Petrol, Diesel and CNG).
3	Table 20.3	Vehicle Operating Cost (Derived from Life Cycle Cost of different passenger vehicles per km)
4	Table 20.4 (CPCB)	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).
5	Table 20.5 (Accident Rate & Cost)	Accident Rate (No of fatal and all accidents per one Cr.KM). Accident costs are derived from published papers at current rate.
6	38.17%	Passenger km – Vehicle km conversion factor and mode share percent values (derived from traffic volume count and modal split within study area as reported in chapter 2)
7	Road User Cost Study Model (CRRI-2010)	Fuel Consumption of vehicles at a given speed is derived
8	Rs. 1.0/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	29.35 min	Weighted Average of all mode travel time saved for average trip length km journey after Shifting (Derived)
10	23.24 kmph	Wt Avg. Journey Speed of all vehicles

Table 21.4: Vehicle Operating Cost (2014) in Rs.

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	7.32	4.70	2.64	0.18	0.15	2.92	4.49
Capital Cost	3.38	3.76	1.88	0.25	0.28	1.01	2.42
Total VOC	10.70	8.46	4.52	0.43	0.43	3.94	6.91

Table 21.5: Vehicle Emission factors 2021 (CPCB) and Cost in Rs.

VEHICLE	FUEL	CO	HC	NOX	PM	SO2	CO2
BUS	CNG	3.72	0.16	6.53	0.24	0.025	787.72
2W-2STR	PETROL	1.4	1.32	0.08	0.05	0.003	24.99
2W-4STR	PETROL	1.4	0.7	0.3	0.05	0.003	28.58
MINI BUS	CNG	2.48	0.83	8.26	0.58	0.02	358.98
4W-Small	PETROL	1.39	0.15	0.12	0.02	0.003	139.51
4W-Large	DISEL	0.58	0.05	0.45	0.05	0.003	156.55
TATA MAGIC	DISEL	1.24	0.17	0.58	0.17	0.01	160.00
3W	CNG	2.45	0.75	0.12	0.08	0.006	77.89
Damage Cost (Rs.)		200000	200000	200000	200000	200000	1000

**Table 21.6: Accident Rate\$ and Cost in Rs**

Type	Accident Rate per Cr. Vehicle KM	Accident Cost in Rs(2014)
Average of all types.	1.5	2,21,058
Fatal Accident.	0.2	11,96,270

\$ On the basis of a research paper

Traffic parameter values used for economic analysis are given in **Table 21.7**.

Table 21.7: Traffic parameter values

Particulars	2024	2025	2031	2041
Trips/day	609000	651065	972000	1403000
Line Length	62	62	62	62
Average Trip length	16.84	16.86	17	17.2
Passenger km	10255560	10976954	16524000	24131600
Passenger km/km	165412	177048	266516	389219

21.3 ECONOMIC BENEFITS

Benefits in terms of money value are estimated directly from the projected passenger km saved for the horizon years (2024, 2025, 2031 and 2041) and values for other years are interpolated on the basis of projected traffic. Market values are used for calculating costs and then appropriate economic factors (see table 21.1) are applied. For each year values of each benefit components are obtained and thus benefit stream is estimated. **Accrued** Benefit Components are shown in **Table 21.8** and **Figure 21.1**.

Table 21.8 Accrued Benefit Values

Benefit Components	Accrued Benefit Values between 2024-2047 Rs in Cr.	Percent
TIME COST	248285	52.0%
FUEL COST	33025	6.9%
VOC	150008	31.4%
OTHER	46464	9.7%
	477782	100.0%

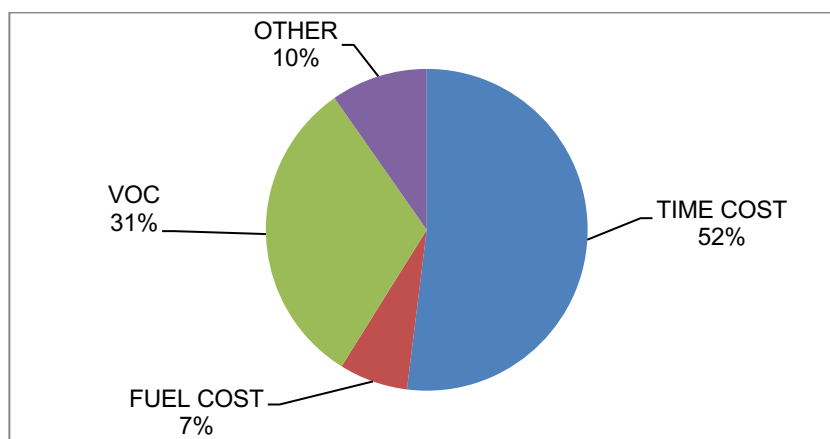


Figure 21.1 Percent of Accrued Benefits

It is seen that total cost of time saving by shifted passengers and road users is about 52%. **Figure 21.1** also shows that benefits are also coming from VOC cost including fuel cost (38%), by shifted metro passengers and relieved road passengers. Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 10%.

Benefit stream is given in **Table 21**.

21.4 METRO CONSTRUCTION COST

21.4.1 Total actual cost of metro construction (**Capital Cost**) is derived for the year of estimation (2018) after considering cost of all major component such as Relocation and Rehabilitation(RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signaling and Telecommunication, Power traction line, Rolling stock, Man power etc.

Recurring Cost includes energy cost, maintenance cost, and operation cost. Economic analysis period is taken from 2019-20 to 2048-49 out of which 5 years (2019-2024) are construction years and operation will start in 2024-2025. Additional capital expenditure may be incurred in the years 2027-28 (Rs. 133 Cr.), 2032-33 (Rs. 1189 Cr.), 2037-38 (Rs 3250 Cr) & in 2042-43 (Rs. 6637 Cr.) for purchase of more rolling stock. In 2044-2046 major replacement cost (Rs.6852 Cr) is contemplated. This cost stream is generated with all taxes. Detail is shown in Tables 21.9.

Table 21.9 Estimated Completion and Recurring Cost(Changed)

Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2019	2020	988	0
2020	2021	5955	0
2021	2022	4730	0
2022	2023	6710	0
2023	2024	6506	0
2024	2025	0	730
2025	2026	0	902
2026	2027	80	945
2027	2028	0	991



Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2028	2029	0	1048
2029	2030	0	1103
2030	2031	0	1163
2031	2032	712	1228
2032	2033	0	1298
2033	2034	0	1426
2034	2035	0	1504
2035	2036	0	1539
2036	2037	1947	1646
2037	2038	0	1761
2038	2039	0	1896
2039	2040	0	2029
2040	2041	0	2173
2041	2042	3976	2327
2042	2043	0	2494
2043	2044	0	2797
2044	2045	2063	2997
2045	2046	2166	3211
2046	2047	0	3443
2047	2048	0	3692
2048	2049	0	3961



Table 21.10 Year wise Economic Values of Benefit Components (Stream)

Year		Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Operating Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2024	2025	1688	447	965	120	14	106	3	166	3509
2025	2026	2148	523	1234	153	18	141	4	212	4433
2026	2027	2422	566	1395	173	20	163	5	240	4985
2027	2028	2732	612	1578	196	23	189	5	272	5606
2028	2029	3081	662	1785	222	26	218	6	307	6307
2029	2030	3475	717	2019	251	29	252	7	347	7097
2030	2031	3920	776	2282	284	33	291	7	393	7986
2031	2032	4290	816	2504	311	37	326	8	431	8723
2032	2033	4695	857	2748	341	40	366	9	473	9529
2033	2034	5139	901	3015	375	44	410	9	519	10412
2034	2035	5624	948	3308	411	49	459	10	569	11378
2035	2036	6155	1103	4017	499	54	614	12	691	13146
2036	2037	6736	1162	4413	548	59	690	13	760	14381
2037	2038	7372	1224	4847	602	65	774	14	834	15734
2038	2039	8195	1316	5441	676	73	893	16	937	17546
2039	2040	9109	1414	6107	759	82	1030	17	1051	19569
2040	2041	10126	1520	6855	852	91	1188	19	1180	21830
2041	2042	11255	1633	7695	956	102	1369	22	1324	24357
2042	2043	12511	1755	8637	1073	114	1579	24	1487	27180
2043	2044	13907	1886	9695	1205	128	1821	27	1669	30336
2044	2045	15459	2027	10882	1352	143	2100	30	1873	33865
2045	2046	17183	2178	12215	1518	160	2422	33	2102	37810
2046	2047	19101	2340	13710	1703	179	2792	37	2360	42223
2047	2048	21232	2515	15389	1912	200	3220	41	2649	47158
2048	2049	23600	2703	17274	2146	223	3713	46	2973	52680



In this area, personalized modes (car and two wheelers) are dominant which have made vehicle by passenger ratio high (38%). Average modal split (with motorized vehicle class) obtained from the traffic volume count survey shows that 42.78% passenger (91.39% vehicular) trips are made by private modes and 5.63% (5.14% vehicular) are made by IPT. Trips carried by Bus is about 51.59% (3.47% vehicular) as may be seen in **table 21.11**.

Table 21.11: Average modal split in study area

Vehicles	% Vehicle on Road	% PASS on Road	% Vehicle Shifted	% PASS Shifted
BUS	3.21%	49.82%	1.24%	17.65%
MINI BUS	0.26%	1.76%	2.19%	17.65%
CAR	27.58%	15.99%	5.48%	5.88%
TAXI	0.54%	1.24%	6.26%	11.76%
2 WH	63.81%	26.79%	58.40%	23.53%
AUTO	4.60%	4.39%	26.43%	23.53%

21.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, economic performance indicators are derived and are presented in **table 21.12**. Project period is 2018-2047, With reference to completion cost of capital with tax, EIRR is found to be **19.81 %** and B/C ratio as 5.7 and with 12 % discount, EIRR is **6.97 %** and B/C ratio is 1.99. NPV without discount is Rs **394074.7** Cr. and with 12% discount rate, NPV is Rs.**26136.2** Cr. which shows that the project is economically viable.

Table 21.12: Economic Indicator Values (on 2048-49)

Delhi Metro Phase IV Network	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Total cumulative cost	83707.27	26397.66
Total cumulative benefit	477782	52534
Benefit Cost Ratio	5.7	1.99
NPV	394074.7	26136.2
EIRR	19.81%	6.97%

21.6 SENSITIVITY ANALYSIS

Sensitivity test on EIRR and B/C ratios was carried out and the output is given in the **table 21.13** 2048-49 is taken for the year of comparison.



Table 21.13 Sensitivity of EIRR

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	19.81%	5.71	83707	6.97%	1.99	26398
-10%	0%	19.20%	5.44	83707	6.43%	1.90	26398
-20%	0%	18.57%	5.18	83707	5.87%	1.80	26398
0%	10%	18.64%	5.19	92078	5.92%	1.81	29037
0%	20%	17.60%	4.76	100449	5.00%	1.66	31677
-10%	10%	18.05%	4.95	92078	5.40%	1.72	29037
-20%	20%	16.43%	4.32	100449	3.96%	1.50	31677

21.7 Quantified Benefits.

21.7.1 Environmental Benefits Quantified

Environmental Benefits monetary values are shown in previous tables. These benefits are estimated (in terms of quantity) first and then converted into money value. For brevity, only 5 year estimates are shown in **table 21.14** (Reduction of Vehicle gas Emission). It is seen that in 2024, CO₂ gas emission saving will be 1.13 lakh ton. Other emissions are toxic gases which will also be reduced due to less emission from the vehicles.

Table 21.14A: Environmental Benefits Quantified

Tons/Year	2024	2025	2026	2027	2028
CO	2671	2863	3069	3290	3527
HC	1297	1390	1490	1597	1713
NOX	719	770	826	885	949
PM	123	132	142	152	163
SO ₂	7.6	8.1	8.7	9.3	10.0
CO ₂	113308	121464	130208	139585	149638
Total Emission Saved	118125	126628	135744	145519	156000

20.7.2 Travel Benefits Quantified

Quantified Travel Benefits are shown in **Tables 21.15**. It may be seen that in 2024, Time saving will be 12.53 Cr (1 Cr. =10 million) hours, fuel saving 86 thousand tons. Amount of travel in terms of road passenger vehicle-km reduced (due to shifting to Metro Rail) is 43



thousand vehicle km. 31 fatal accidents and 205 other accidents may also be avoided. Hence it is expected that there will be some improvement of the overall ambience of the city.

Table 21.15: Travel Benefits Quantified

Quantified Benefits in Horizon Years	2024	2025	2026	2027	2028
Annual Time Saved by Metro Passengers in Cr. Hr.	12.53	13.39	14.3	15.3	16.4
Annual Fuel Saved by Metro Passengers in thousand Tons.	86	93	101	109	118
Daily vehicles reduced (off the road)	82562	88505	94877	101709	109034
CO2 reduced in thousand tons	113	121	130	140	150
Other gases reduced in thousand tons	5	5	6	6	6
Reduced No of Fatal Accidents in Year	31	34	36	39	42
Reduced No of Other Accidents in year	205	221	238	256	275
Annual Vehicle km Reduced in Thousand Km.	43	46	50	53	57

21.8 Transport Oriented Development (TOD) & EIRR

In sensitivity analysis, effects of less traffic and more expenditure are shown. On the other hand, there may be generation (addition of extra trips) of ridership on Metro due to Transport Oriented Development. Introduction of Modern Mass Transit System (Metro) will have an impact on city's land-use in near future. Values of land which are closer to the metro line will increase very quickly, commercial activities near station areas will increase and people will not hesitate to live in remote areas of the city (but near to metro station). Due to presence of metro existing bus routes may change, some old routes may stop operation and some new routes may be introduced. A detail study will be needed to identify, quantify and to estimate economic impact of such likely changes. Detail discussion and evaluation is beyond the scope within this chapter.

Nevertheless, it will be interesting to know, for 10% increase of ridership, EIRR value will be 20.40%, keeping other traffic and cost inputs unchanged.



14.7.2 Impacts on Structures

Table 14.14 indicates impact of the proposed project on the different types of structures i.e. residential, commercial, residential cum commercial and other types. Based on the alignment drawing the structures likely to be affected have been identified on the ground level during site visit. However, due to non-availability of reference point near Azadpur, the structures which are likely to be affected have not been counted. The total number of structures impacted in two corridors are 441 including 225 illegal structures/jhugies. Out of the total structures, 253 are residential, 180 are commercial, and remaining eight are such structures which includes public toilet, religious structures.

Table 14.14- Corridor wise Impact on Structures

Corridor	Type of Structures			Total
	Residential	Commercial	Others	
Janakpuri to R.K. Ashram	36	130	3	169
Aero City to Tuglakabad	217	50	5	272
Total	253	180	8	441

14.7.3 Magnitude of Project Impact on the Structures

The magnitude of project impact on the structures, which is categorized as partially and fully affected structures are given presented here. Out of total 441 structures, 314 structures are partially affected and remaining 127 structures are fully affected.

14.7.4 Impact on PAFs/PAPs

About 549 families consisting 2494 persons will be affected due to the propose metro project. Majority of families will be affected at proposed Ghanta Ghar, Pull Bangash, Peeragarhi Chowk and Meera Bagh station in Janakpuri to R.K. Ashram corridor and Rangpuri Pahari, Tuglakabad Mahipalpur station in Aero City to Tuglakabad corridor. Exact number of displaced families will be found out during detailed baseline socio-economic survey.

14.7.5 Demographic and Social Profile of the PAFs

Demographic & Social Profile: Demographic and social profile of project affected families and persons is presented in **Table 14.15**. Sex Ratio is very helpful indicator to know the participatory share of males and females in a region, which is also an important indicator for human development index. Among the surveyed population, it is observed that there are 54.4% males and 45.6% are females.

The majority (42.5%) of family members belong to the age group of 36-60 years and 37 % belong to the age group to 15-35 years. Remaining 12.8% and 7.7% of family members belong to the age below 14 years and above 60 years respectively. The majority of the population are Hindus (75.5%), 22.6% are Muslims and 1.9% are Jain. A look at the data regarding the caste heritage reveals that the majority of the people (37.7%) come from OBC/BC. But the second largest group of the people in project-



affected areas belong to general caste (35.8%) and remaining 26.4% belong to Schedule Caste. It is observed that 19% persons have studied up to primary, 19% studied up to Secondary, 28.8% studied up to High School and 6.6% up to college. It is important to be noted that 26.5% of project affected people are illiterate.

Table 14.15 - Demographic and Social Profile of PAFs/PAPs

S.No	Description	Frequency	Percentage (%)
1.	Sex		
1.1	Male	129	54.4
1.2	Female	108	45.6
2.	Age Composition		
2.1	0-14 yrs	30	12.8
2.2	15-35yrs	87	37.0
2.3	36-60yrs	100	42.5
2.4	>60	18	7.7
3.	Religion		
3.1	Hindu	40	75.5
3.2	Muslim	12	22.6
3.3	Jain	1	1.9
4.	Social Group		
4.1	SC	14	26.4
4.2	ST	0	0
4.3	OBC/BC	20	37.7
4.4	General	19	35.8
5.	Education		
5.1	Illiterate	60	26.5
5.2	Primary	43	19.0
5.3	Secondary	43	19.0
5.4	High School	65	28.8



S.No	Description	Frequency	Percentage (%)
5.5	College	15	6.6

14.7.6 Economic Conditions of PAFs

Main occupation of the head of household is business (64.2%) followed by labour (34%). About 60.4% of families have their income less than Rs. 50,000/-. About 18.9% of the families have an income range between Rs.50, 001 to 1, 00000 per annum. About 20.7% of the families have an income between Rs.1, 00,000 to 2, 00,000/- per annum

Table 14.16 - Economic Condition of PAFs

S.No.	Description	Frequency	Percentage (%)
1.	Occupation		
1.1	Agriculture	0	0
1.2	Labour	18	34.0
1.3	Business	34	64.2
1.4	Service	1	1.8
2.	Family Income (Annual Rs.)		
2.1	< 25,000	16	30.2
2.2	25,001-50,000	16	30.2
2.3	50,001-1,00000	10	18.9
2.4	1,00001-1,50000	5	9.4
2.5	1,50001-2,00000	6	11.3
2.7	Avg. Annual Income(Rs.)		

14.7.7 Family Pattern and its Size

The family particulars of PAFs are given in **Table 14.17**. Out of total surveyed families majority (84.9%) are nuclear, 13.2% are joint. Family size has been classified into four categories i.e., individual, small (2-4), medium (5-7) and large (7 & above). Majority of the families (64.1%) are small, 20.8% are medium and 13.2% families are large.

**Table 14.17 - Family Particulars**

S.No.	Description	Frequency	Percentage (%)
1	Type of Family		
1.1	Joint	7	13.2
1.2	Nuclear	45	84.9
1.3	Individual	1	1.88
2	Size of Family		
2.1	Small (2-4)	34	64.1
2.2	Medium (5-6)	11	20.8
2.3	Large (7 & above)	7	13.2
	Individual	1	1.9

14.8 POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions, potential impacts have been identified that are likely to result from the proposed metro project and where possible these are quantified. The positive environmental impacts are listed in following paragraphs.

- Employment Opportunities,
- Benefits to Economy due to
 - Quick Service and Safety
 - Reduction in number of vehicles
 - Reduction in Fuel consumption
 - Less Air pollution
 - Carbon Credits

14.8.1 Employment Opportunities

The civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. In post-construction phase, about 4,710 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed for allied activities.