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**Scheduling India's General Elections**

**by**

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## Scheduling India's General Elections

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*Conducting the General Elections for the 543 members of the Parliament of India across the 835 thousand polling stations spread over the 35 States is a mammoth exercise. Deployment of the Central Police Forces is essential to complement the role of the State police during the elections. However paucity of Central Police Forces necessitates the conduct of elections over phases. This paper proposes and demonstrates a 2-stage procedure using integer programming and transportation models to (a) schedule the elections with a minimum number of phases (b) sequencing the phases, such that the movement of Central Police Forces (measured in men-miles) is minimized and (c) sourcing the appropriate number of personnel from the most convenient Central Police Forces bases.*

### 1. Introduction

The Indian Republic comprises 28 States and 7 Union Territories. The Indian parliamentary form of government is federal in structure with legislative powers distributed between the Parliament of India and State Legislatures. The Parliament of India comprises two legislative bodies – the Upper House or the Rajya Sabha and the Lower House or the Lok Sabha. The members of the Rajya Sabha are indirectly elected by legislators of States and Union Territories comprising the Union of India. The 543 members of the Lok Sabha are directly elected by universal adult franchise by the electorate of all the 28 States and 7 Union Territories through the General Elections. The term of office each Lok Sabha is five years from the date of its first meeting, unless dissolved earlier. These General Elections have been regularly held since 1952, after adoption of the Constitution of India, as depicted in Table 1.

Lok Sabha	General Elections	Date of first meeting after constitution	Date of dissolution
1	25 October 1951 to 21 February 1952	13 May 1952	4 April 1957
2	24 February to 14 March 1957	10 May 1957	31 March 1962
3	19 to 25 February 1962	16 April 1962	3 March 1967
4	17 to 21 February 1967	16 March 1967	27 December 1970
5	1 to 10 March 1971	19 March 1971	18 January 1977
6	16 to 20 March 1977	25 March 1977	22 August 1979
7	3 to 6 January 1980	21 January 1980	31 December 1984
8	24 to 28 December 1984	15 January 1985	27 November 1989
9	22 to 26 November 1989	18 December 1989	13 March 1991
10	20 May to 15 June 1991	9 July 1991	10 May 1996
11	27 April to 30 May 1996	22 May 1996	4 December 1997
12	16 to 23 February 1998	23 March 1998	26 April 1999

13	5 September to 6 October 1999	20 October 1999	6 February 2004
14	20 April to 10 May 2004	2 June 2004	18 May 2009
15	16 April to 13 May 2009	1 June 2009	-

Table 1: General Elections held in India

The total membership of the Lok Sabha is distributed amongst the 35 States and Union Territories (which will be referred to as States in the remainder of the paper) in such a manner that the ratio of the population to number of seats allotted to any State is nearly the same. The geographical area of the State is then demarcated into a number of territorial constituencies (with geographical boundaries), equal to the number of seats allotted, such that population of all constituencies in that State is nearly the same. Since there are large variations in population densities across States, constituencies vary largely in terms of geographical area- thus Ladakh (the constituency with largest area) covers 173266 sq.km in contrast to Delhi-Chandni Chowk (the constituency with smallest area) which covers only 11 sq.km. Each constituency has a large number of polling stations distributed across the constituency such that voters can reach the polling stations to cast their vote with minimum travel. The distribution of membership of the Lok Sabha and the total number of polling stations for each state is given in Table 2.

Sl.No	State	Number of Members of the Lok Sabha	Total Number of polling stations	Sl.No	State	Number of Members of the Lok Sabha	Total Number of polling stations
1	Andhra Pradesh	42	66760	2	Arunachal Pradesh	2	2057
3	Assam	14	18828	4	Bihar	40	57020
5	Goa	2	1339	6	Gujarat	26	42568
7	Haryana	10	12894	8	Himachal Pradesh	4	7253
9	Jammu & Kashmir	6	9129	10	Karnataka	28	46576
11	Kerala	20	20510	12	Madhya Pradesh	29	47812
13	Maharashtra	48	82598	14	Manipur	2	2193
15	Meghalaya	2	2117	16	Mizoram	1	1028
17	Nagaland	1	1692	18	Orissa	21	31617
19	Punjab	13	18846	20	Rajasthan	25	42699
21	Sikkim	1	493	22	Tamil Nadu	39	52158
23	Tripura	2	3008	24	Uttar Pradesh	80	129446
25	West Bengal	42	66109	26	Chattisgarh	11	20984
27	Jharkhand	14	23696	28	Uttarakhand	5	9003
29	Andaman & Nicobar Islands	1	347	30	Chandigarh	1	422
31	Dadra & Nagar Haveli	1	161	32	Daman & Diu	1	94
33	NCT of Delhi	7	11348	34	Lakshadweep	1	40
35	Puducherry	1	856				

Table 2: Number of constituencies and polling stations in each State

The General Elections of India are the world's biggest election exercise. During the 2009 General Elections, a 717 million strong electorate exercised their franchise through 1.3 million Electronic Voting Machines deployed in 835 thousand polling stations spread across the length and breadth of India to elect 543 Members of the Lok Sabha from amongst 8

thousand candidates contesting the elections. The only other comparable elections are the European Parliament elections with an electorate of 500 million and the US Congress elections with electorate of 312 million.

The responsibility for conduct of elections to the Parliament is vested in the Election Commission of India vide provisions of Article 324 of the Constitution of India. The Election Commission operates through its secretariat based at New Delhi manned by about 300 officials. It is assisted at the State level by the Chief Electoral Officer of the State, who is appointed by the Election Commission in consultation with the State government. The Chief Electoral Officer is assisted by District Election Officers, Electoral Registration Officers and Returning Officers at the constituency level. In addition, the Election Commission co-opts a large number of officials from the Central (or federal) and State governments for about two months during each General Election, for conducting the elections. About 5 million officials were deployed during the 2009 General Election.

Elections in the past have been marked by instances of voter intimidation through violence or harassment in various forms, as well as clashes between political opponents(Scharff). These incidences have been largely arrested through deployment of additional police forces during the polling process in order to bring peace, restore confidence in candidates and voters and thereby ensure fair and free elections.

The Constitution of India mandates that maintenance of law and order is the responsibility of the States. Thus while all States maintain police forces totaling about 1.5 million, the average police-population ratio for all the States is only 133 police per 100,000 (National Crime Records Bureau, 2010) in comparison with average international ratio of 342(Stefan Harrendorf, 2010). The Central Government therefore maintains Central Police Forces to complement the State police, whenever and wherever required. The Central Police Forces numbering about 800 thousand comprise: (i) Central Reserve Police Force having strength of about 260 thousand (ii) Border Security Force having strength of about 210 thousand (iii) Central Industrial Security Force having strength of about 110 thousand (iv) Railway Protection Force having strength of about 69 thousand (v) Assam Rifles having strength of about 65 thousand (vi) Sashastra Seema Bal having strength of about 55 thousand and (vii) Indo-Tibetan Border Police having strength of about 57 thousand(Bureau of Police Research & Development).

Since the State police are the arm of the State governments, allegations of partisan conduct of police in enforcing law and order during the campaign closing phases and during the day of elections are likely. It has therefore become universal practice to deploy Central Police Forces, in addition to State police at all polling stations during the General Elections. However, only about a quarter of the Central Police Forces can be spared for deployment during the elections. Thus General Elections are spread over different days with each day covering a few states only, such that the required number of Central Police Forces can be deployed across all polling stations of all constituencies of those states. The days of elections are spread a few days apart to allow re-deployment of paramilitary personnel and allow them to be familiar with their constituencies. For example, the 2009 General Election was conducted in five phases on 16 April, 23 April, 30 April, 7 May and 13 May.

The movement of Central Police Forces from their bases to the polling stations in the different phases and their subsequent return to the bases is a gigantic exercise, requiring coordination between different agencies such as Central Police Forces' operations, Election Commission and State Chief Electoral Officers, District Election Officers, Railways, airlines and the Indian Air Force. In the 2009 General Election, 119 special trains, 65 sorties by Indian Air Force transport aircraft, 600 sorties by Indian Air Force helicopters and Air India chartered flights were used for the cross-country movement of Central Police Forces (Election Commission of India, 2009).

However the process of scheduling the elections and movement of police personnel is done manually by the Election Commission. This paper proposes an operations research methodology to enable conduct of the General Elections for all the 543 parliamentary constituencies in the minimum possible time, with the available Central Police Forces and with minimum police movement. The author is not aware of any previous published work of this nature. The paper is organized as follows: the methodology and results are described in Section 2, followed by discussion in Section 3 and conclusions in Section 4.

## 2. Methodology and results

2.1 The total number of polling stations of all the 543 parliamentary constituencies, spread over 36 states is 833,701. If 4 Central Police Forces personnel are deployed at each polling station, the total requirement of police personnel is 3.3 million. Since, only about a quarter of Central Police Forces can be spared for deployment during the elections it is not possible to conduct elections for all the 543 parliamentary constituencies on a single day.

Thus elections will have to be conducted in phases, with Central Police Forces personnel movement between constituencies in the phase intervals. The proposed method assumes that the Central Police Forces personnel movement will be entirely by air, except the ‘last mile’ movement to and from the constituencies.

While conducting the elections in phases, the following two principles are observed by the Election Commission to the extent possible: (a) Elections for all constituencies in a State are held on a single day (b) As far as preferable, elections for contiguous States must be held simultaneously. The proposed method attempts to incorporate both the principles in the model.

	State	Constituency	No. of Polling Stations	Nearest Airport	Distance to Airport (miles)
1	Andhra Pradesh	Adilabad	1464	Ramagundam	85.24
2	Andhra Pradesh	Srikakulam	1790	Visakhapatnam	61.49
3	Arunachal Pradesh	Arunachal East	851	Pasighat	52.21
4	Assam	Karimganj	1229	Silchar	27.13
5	Assam	Nowgong	1514	Tezpur	21.65
6	Bihar	Purvi Champaran	1193	Muzaffarpur	46.44
7	Bihar	Purnia	1294	Malda	66.12
8	Goa	South Goa	660	Dabolimgoa	0.00
9	Gujarat	Kachchh	1689	Bhuj	0.00
10	Gujarat	Anand	1510	Vadodara	22.70
11	Haryana	Kurukshetra	1263	Chandigarh	52.91
12	Haryana	Gurgaon	1308	Delhi	10.97
13	Himachal Pradesh	Mandi	1921	Kulu	20.27
14	Jammu & Kashmir	Anantnag	1502	Srinagar	31.83
15	Karnataka	Bagalkot	1503	Hubli	69.97
16	Karnataka	Dharwad	1455	Hubli	12.49
17	Kerala	Wayanad	988	Kozhikode	40.40
18	Kerala	Alappuzha	1130	Kochi	31.49
19	Madhya Pradesh	Bhind	1659	Gwalior	44.52
20	Madhya Pradesh	Balaghat	1754	Nagpur	84.62
21	Maharashtra	Dhule	1624	Aurangabad	79.65
22	Maharashtra	Yavatmal-Washim	1881	Akola	75.64
23	Meghalaya	Shillong	1326	Shillong	0.00
24	Orissa	Sambalpur	1401	Rourkela	79.05

25	Orissa	Cuttack	1319	Bhubaneswar	13.40
26	Punjab	Jalandhar	1764	Ludhiana	34.05
27	Punjab	Sangrur	1417	Ludhiana	44.98
28	Rajasthan	Sikar	1574	Jaipur	63.45
29	Rajasthan	Rajsamand	1791	Udaipur	36.58
30	Tamil Nadu	Sriperumbudur	1613	Chennai	0.00
31	Tamil Nadu	Viluppuram	1376	Pondicherry	19.64
32	Uttar Pradesh	Kairana	1382	Muzaffarnagar	31.10
33	Uttar Pradesh	Rae Bareli	1576	Lucknow	46.25
34	West Bengal	Jalpaiguri	1560	Bagdogra	27.69
35	West Bengal	Jadavpur	1629	Kolkata	4.88
36	Chattisgarh	Raigarh	2166	Bilaspur	81.13
37	Chattisgarh	Mahasamund	1905	Raipur	31.82
38	Jharkhand	Kodarma	2097	Gaya	43.94
39	Jharkhand	Jamshedpur	1626	Jamshedpur	0.00
40	Uttarakhand	Garhwal	1876	Dehradun	46.34
41	Andaman & Nicobar Islands	Andaman & Nicobar Islands	347	Portblair	0.00
42	Chandigarh	Chandigarh	422	Chandigarh	0.00
43	Dadra & Nagar Haveli	Dadar & Nagar Haveli	161	Daman	15.14
44	NCT OF Delhi	New Delhi	1540	Delhi	9.15
45	Lakshadweep	Lakshadweep	40	Agatti	0.69
46	Puducherry	Puducherry	856	Pondicherry	0.00

Table 3: Number of polling stations and nearest airport of select constituencies

2.2 The following data is used in the proposed method:

- Number of polling stations for each of the 543 parliamentary constituencies, spread over 36 states.* For example Adilabad parliamentary constituency of Andhra Pradesh has 1464 polling stations. The data for few representative parliamentary constituencies is given in Table 3 (Election Commission of India, 2009).
- Number of police personnel to be assigned to each polling station.* It is assumed to be the same (4 numbers) for all polling stations.
- Nearest airport (with road distance) for each of the 543 parliamentary constituencies, spread over 36 states.* Latitudes and longitudes of the approximate geographical centre of all the 543 parliamentary constituencies and 127 airports were obtained using iTouchMap.com (iTouchMap.com). The nearest airport for each of the 543 parliamentary constituencies was computed using the latitudes' and longitudes' information. The road distance was further obtained using Google Maps(Google).

For example Ramagundam (18.76 N, 79.41 E) is the nearest airport for Adilabad (19.67 N,78.53 E) parliamentary constituency at a distance of 85 miles by road. The data for few representative parliamentary constituencies is given in Table 3.

- d. *Central Police Forces personnel bases, along with number of personnel available at each base.* These bases are assumed to be located next to nearest airports. For example Shillong police personnel base (in the State of Meghalaya) has a hundred thousand policemen for deployment through Shillong airport. The other bases are assumed to be located at Agartala(Tripura), Mumbai(Maharashtra), Kolkata(West Bengal), Chandigarh(Chandigarh), Delhi(Delhi), Guwahati(Assam), Hyderabad(Andhra Pradesh), Imphal(Manipur), Jaipur(Rajasthan), Jammu(Jammu & Kashmir), Jorhat(Assam), Lucknow(Uttar Pradesh), Patna(Bihar) and Raipur(Chattisgarh). All these bases have a hundred thousand policemen for deployment through adjoining airports. The total number of police personnel available for deployment is thus 1.5 million.
- e. *Airport to airport distances for all the 127 airports in the vicinity of constituencies and Central Police Forces personnel bases.* The aerial distances were obtained using the latitudes and longitudes of the airports (The Airport Authority). For example, the aerial distance between Shillong (25.57 N,91.90 E) and Ramagundam(18.76 N, 79.41 E) is 928 miles.





Fig 1: Political Map of India showing the States

2.3 A two stage method is proposed, with the number of phases being determined in Stage 1, followed by determination of optimal phase sequencing and Central Police Forces personnel movement.

2.3.1 Stage 1: Here the minimum number of phases, over which the elections are to be conducted, is determined using the following integer program.

Indices used:

$m$ : index used for election days

$r$ : index for states of India

$b$ : index for police bases

Sets used:

$\bar{M}$ : set of election days

$\bar{R}$ : set of states of India

Notation for data elements:

$M$ : maximum number of election days (assumed to be 10 days)

$R$ : total number of States of India

$B$ : total number of police bases

$c_r$ : number of polling stations in State  $r$

$c_b$ : number of police personnel available at base  $b$

$k_r$ : number of contiguous states of State  $r$  (for example as seen from Fig.1, Andhra Pradesh has 5 contiguous States of Karnataka, Chattisgarh, Maharashtra, Tamil Nadu and Orissa)

$s_{ir}$ : the  $i^{\text{th}}$  contiguous State of State  $r$

Decision Variables:

$x_{mr}=1$ , if election for all constituencies in State  $r$  is held on day  $m$

$=0$ , if election for all constituencies in State  $r$  is not held on day  $m$

$y_m=1$ , if election for any State is held on day  $m$

$=0$ , if no election in any State is held on day  $m$

$z_m$ =variable to measure the extent to which the elections for contiguous States are not being held simultaneously and is defined as: $\sum_{r=1}^R |k_r x_{mr} - (\sum_{i=1}^{k_r} x_{ms_{ir}})|$ .

The Stage 1 objective is to minimize is the number of days the elections are held (given by  $y_m$ ), and the extent to which the elections for contiguous States are not being held simultaneously (given by  $z_m$ ). Thus the objective function is given by:

$$\text{Minimize } \sum_{m=1}^M (y_m + z_m)$$

Subject to the constraints:

- (1)  $\sum_{m=1}^M x_{mr} = 1, \forall r \in \bar{R}$
- (2)  $\sum_{r=1}^R x_{mr} \leq 50000 y_m, \forall m \in \bar{M}$
- (3)  $\sum_{r=1}^R (4x_{mr} c_r) \leq \sum_{b=1}^B c_b, \forall m \in \bar{M}$
- (4)  $z_m = \sum_{r=1}^R |k_r x_{mr} - (\sum_{i=1}^{k_r} x_{ms_{ir}})|, \forall m \in \bar{M}$

Explanation of the constraints: Constraint (1) ensures that elections in any State are held on any single day. Constraint (2) ensures that  $y_m=1$ , if election in even one State is held on day  $m$ . Constraint (3) ensures that the required police personnel are available at all polling stations in the States where elections are being conducted on day  $m$ . Constraint (3) defines the  $z_m$  variable.

Solving the model, we obtain that election requires to be conducted over the following three phases, each comprising of the following cohorts:

- Cohort 1 comprises the 8 States of Karnataka, Kerala, Madhya Pradesh, Nagaland, Orissa, Tripura, West Bengal and Chattisgarh which have 154 constituencies & 238,308 polling stations
- Cohort 2 comprises the 9 States of Andhra Pradesh, Bihar, Goa, Manipur, Punjab, UttarPradesh, Jharkhand, Dadra&Nagar Haveli and Daman&Diu which have 195 constituencies & 299,555 polling stations
- Cohort 3 comprises the 18 States of Arunachal Pradesh, Assam, Gujarat, Haryana, Himachal Pradesh, Jammu&Kashmir, Maharashtra, Meghalaya, Mizoram, Rajasthan, Sikkim, Tamil Nadu, Uttarkhand, Andaman & Nicobar Islands, Chandigarh, Delhi, Lakshwadeep and Puducherry which have 194 constituencies & 295,838 polling stations

2.3.2 Stage 2: There are three unique combinations of holding elections: (I) Cohort 1 followed by Cohort 2 and Cohort 2 followed by Cohort 3 (II) Cohort 1 followed by Cohort 3 and Cohort 3 followed by Cohort 2 (III) Cohort 2 followed by Cohort 1 and Cohort 1 followed by Cohort 3. Thus in combination I, police move from their respective bases to states where elections are to be conducted in Cohort 1, followed by movement to states where elections are to be conducted in Cohort 2, followed by movement to states where elections are to be conducted in Cohort 3, followed by movement back to their respective bases. We use a transportation model for each combination of phases to determine the police personnel movement with minimum men-miles.

The transportation model used for combination I is given below:

Indices used:

$b$ : index for police bases

$u$ : index for Cohort 1 constituencies

$v$ : index for Cohort 2 constituencies

$w$ : index for Cohort 3 constituencies

Sets used:

$\bar{B}$ : set of police personnel bases

Notation for data elements:

$B$ : total number of police bases

$U$ : total number of Cohort 1 constituencies

$V$ : total number of Cohort 2 constituencies

$W$ : total number of Cohort 3 constituencies

$c_b$ : number of police personnel available at base  $b$

$p_u$ : number of polling stations in Cohort 1 constituency  $u$

$p_v$ : number of polling stations in Cohort 2 constituency  $v$

$p_w$ : number of polling stations in Cohort 3 constituency  $w$

$d_{bu}$ : distance from base  $b$  to constituency  $u$

$d_{uv}$ : distance from constituency  $u$  to constituency  $v$

$d_{vw}$ : distance from constituency  $v$  to constituency  $w$

$d_{wb}$ : distance from constituency  $w$  to base  $b$

Decision variables:

$x_{bu}$ : number of police moving from base  $b$  to constituency  $u$

$x_{uv}$ : number of police moving from constituency  $u$  to constituency  $v$

$x_{vw}$ : number of police moving from constituency  $v$  to constituency  $w$

$x_{wb}$ : number of police moving from constituency  $w$  to base  $b$

The Stage 2 objective is to minimize the total number of men-miles, while transporting police personnel from bases to Cohort 1 constituencies, from Cohort 1 constituencies to Cohort 2 constituencies, from Cohort 2 constituencies to Cohort 3 constituencies and finally back from Cohort 3 constituencies to the respective bases. Thus the objective function is given by:

$$\text{Minimize } \sum_{b=1}^B \sum_{u=1}^U (x_{bu} d_{bu}) + \sum_{u=1}^U \sum_{v=1}^V (x_{uv} d_{uv}) + \sum_{v=1}^V \sum_{w=1}^W (x_{vw} d_{vw}) + \sum_{w=1}^W \sum_{b=1}^B (x_{wb} d_{wb})$$

Subject to the constraints:

- (1)  $\sum_{u=1}^U x_{bu} \leq c_b, \forall b \in B$
- (2)  $\sum_{b=1}^B x_{bu} \geq 4p_u, \forall u \in U$
- (3)  $\sum_{v=1}^V x_{uv} \leq \sum_{b=1}^B x_{bu}, \forall u \in U$
- (4)  $\sum_{u=1}^U x_{uv} \geq 4p_v, \forall v \in V$
- (5)  $\sum_{w=1}^W x_{vw} \leq \sum_{u=1}^U x_{uv}, \forall v \in V$
- (6)  $\sum_{v=1}^V x_{vw} \geq 4p_w, \forall w \in W$
- (7)  $\sum_{b=1}^B x_{wb} \leq \sum_{v=1}^V x_{vw}, \forall w \in W$
- (8)  $\sum_{w=1}^W x_{wb} = \sum_{u=1}^U x_{bu}, \forall b \in B$

Explanation of the constraints: Constraint (1) ensures that the total number of police personnel travelling from each base to Cohort 1 constituencies is actually available at that base. Constraints (2),(4),(6) ensure that the total number of police personnel arriving at any Cohort 1,2,3 constituency will meet the requirement of police personnel at all polling stations of that constituency. Constraint (3) ensures that the total number of police personnel travelling from any Cohort 1 constituency to Cohort 2 constituencies, is  $\leq$  the total number of police personnel that had arrived at that constituency from the bases. Constraint (5)

ensures that the total number of police personnel travelling from any Cohort 2 constituency to Cohort 3 constituencies, is  $\leq$  the total number of police personnel that had arrived at that constituency from the Cohort 1 constituencies. Constraint (7) ensures that the total number of police personnel travelling from any Cohort 3 constituency to bases, is  $\leq$  the total number of police personnel that had arrived at that constituency from the Cohort 2 constituencies. Constraint (8) ensures for each police base, the total number of police personnel that left the police base for Cohort 1 constituencies is the same as the total number of police personnel that have returned back to the police base from the Cohort 3 constituencies.

Solving the model, we obtain a solution of 1.847 million men-miles for combination I. The model takes about 25 seconds for processing and solution using IBM ILOG CPLEX 12.1.0 on a 1.6 GHz computer. Solution of similar models gives 1.787 million men-miles for combination II and 1.712 million men-miles for combination III. Combination III is thus the optimal schedule, wherein the first phase elections are held in the 9 States of Andhra Pradesh, Bihar, Goa, Manipur, Punjab, UttarPradesh, Jharkhand, Dadra&Nagar Haveli and Daman&Diu; followed by second phase elections being held in the 8 States of Karnataka, Kerala, Madhya Pradesh, Nagaland, Orissa, Tripura, West Bengal and Chattisgarh; followed by third phase elections being held in the 18 States of Arunachal Pradesh, Assam, Gujarat, Haryana, Himachal Pradesh, Jammu&Kashmir, Maharashtra, Meghalaya, Mizoram, Rajasthan, Sikkim, Tamil Nadu, Uttarkhand, Andaman & Nicobar Islands, Chandigarh, Delhi, Lakshwadeep and Puducherry.

2.4 The optimal movement of Central Police Force personnel from Agartala base to Phase 1 constituencies and from Phase 1 to Phase 2 constituencies is given in Table 4 as an illustration. The 94,912 Central Police Force personnel from Agartala base are sent to 11 constituencies in Bihar State and 5 constituencies in Jharkhand State for the first phase elections. 6076 personnel land in Bhagalpur constituency, which is the exact requirement for its 1519 polling stations. 604 personnel land in Jamui constituency, which is less than the requirement for its 1556 polling stations; the remaining requirement of 5620 personnel is met by forces arriving from Kolkata base. In the second phase, the 94,912 Central Police Force personnel from Agartala base travel from 16 constituencies in Bihar and Jharkhand State to 16 constituencies in West Bengal State and 9 constituencies in Orissa State. Of the 4924 personnel based in Kishanganj constituency in the first phase, 104 travel to Maldah-Dakshin constituency (West Bengal State), 188 travel to Jangipur constituency (West Bengal State),

4516 travel to Baharampur constituency (West Bengal State) and 116 travel to Birbhum constituency (West Bengal State). Since Maldah-Dakshin constituency has 1320 polling stations, an additional 5176 personnel arrive from Purnia constituency.

Phase	From↓	State	Personnel	Polling Stns	From↓	State	Personnel	Polling Stns	From↓	State	Personnel	Polling Stns	
BASES TO PHASE 1 CONSTITUENCIES	To→	KISHANGANJ			To→	KATI HAR			To→	PURNIA			
	Agartala	Bihar	4924	1231	Agartala	Bihar	5148	1287	Agartala	Bihar	5176	1294	
	To→	BHAGALPUR			To→	BANKA			To→	SASARAM			
	Agartala	Bihar	6076	1519	Agartala	Bihar	5996	1499	Agartala	Bihar	6348	1587	
	To→	KARAKAT			To→	AURANGABAD			To→	GAYA			
	Agartala	Bihar	6120	1530	Agartala	Bihar	6772	1693	Agartala	Bihar	6208	1552	
	To→	NAWADA			To→	JAMUI			To→	RAJMAHAL			
	Agartala	Bihar	6024	1506	Agartala	Bihar	604	1556	Agartala	Jharkhand	5952	1488	
	To→	GODDA			To→	CHATRA			To→	KODARMA			
	Agartala	Jharkhand	8032	2008	Agartala	Jharkhand	5652	1413	Agartala	Jharkhand	8388	2097	
To→	PALAMAU												
Agartala	Jharkhand	7492	1873										
PHASE 1 TO PHASE 2 CONSTITUENCIES	To→	MALDAHA-DAKSHIN			To→	JANGHPUR			To→	BAHARAMPUR			
	KISHANGANJ	West Bengal	104	1320	KISHANGANJ	West Bengal	188	1334	KISHANGANJ	West Bengal	4516	1458	
	To→	BIRBHUM			To→	JANGHPUR			To→	MALDAHA-DAKSHIN			
	KISHANGANJ	West Bengal	116	1548	KATI HAR	West Bengal	5148	1334	PURNIA	West Bengal	5176	1320	
	To→	BIRBHUM			To→	RAIGANJ			To→	BAHARAMPUR			
	BHAGALPUR	West Bengal	6076	1548	BANKA	West Bengal	5492	1373	BANKA	West Bengal	504	1458	
	To→	RANAGHAT			To→	BARRACKPORE			To→	BOLPUR			
	SASARAM	West Bengal	178	1648	SASARAM	West Bengal	4096	1327	SASARAM	West Bengal	472	1648	
	To→	BOLPUR			To→	MAYURBHANJ			To→	BHUBANESWAR			
	KARAKAT	West Bengal	612	1648	AURANGABAD	Orissa	2020	1622	AURANGABAD	Orissa	4752	1306	
	To→	JAGAT SINGHPUR			To→	KRISHNANAGAR			To→	DHENKANAL			
	GAYA	Orissa	518	1711	GAYA	West Bengal	1020	1523	NAWADA	Orissa	1412	1375	
	To→	KANDHAMAL			To→	DHENKANAL			To→	BURDWAN-DURGAPUR			
	NAWADA	Orissa	461	1288	JAMUI	Orissa	456	1375	JAMUI	West Bengal	5768	1688	
	To→	MURSHIDABAD			To→	MALDAHA-UTTAR			To→	BALURGHAT			
	RAJMAHAL	West Bengal	591	1479	RAJMAHAL	West Bengal	36	1430	GODDA	West Bengal	1536	1271	
	To→	MALDAHA-UTTAR			To→	BAHARAMPUR			To→	MAYURBHANJ			
	GODDA	West Bengal	588	1430	GODDA	West Bengal	812	1458	CHATRA	Orissa	4468	1622	
	To→	HOWRAH			To→	BALASORE			To→	BHADRAK			
	CHATRA	West Bengal	118	1650	KODARMA	Orissa	1000	1464	KODARMA	Orissa	900	1542	
	To→	BISHNUPUR			To→	KENDRAPARA			To→	PURI			
	KODARMA	West Bengal	648	1622	PALAMAU	Orissa	6656	1664	PALAMAU	Orissa	344	1524	
	To→	DIAMOND-HARBOUR											
	PALAMAU	West Bengal	492	1604									

Table 4: Movement of Agartala based Central Police Force personnel in first two phases

### 3. Discussion

The method demonstrated in Section 2, enables (a) scheduling of elections within the minimum number of phases (b) sequencing the phases, such that the movement of Central Police Forces (measured in men-miles) is minimized and (c) sourcing the appropriate number personnel from the most convenient bases.

The method assumes that there is only one set of movements from the bases, which is from the bases to cohort where the first phases of elections are being held. Similarly there is only one set of movements from the cohort where the final phases of elections are being held to the bases. There are no movements between the bases and any cohort, where intermediate phases of elections are in progress. Since the scheduling of elections done in Stage 1 ensures that the requirement of forces is evened out across all election phases, this assumption holds.

The method can be modified to incorporate ground realities. For example, the requirement of polling personnel may vary across constituencies, depending on the perceptions of threat to maintenance of law and order. In that case, suitable data will have to be incorporated in both the Stage 1 and 2 models.

### 4. Conclusion

In this paper, a two-stage methodology is proposed and demonstrated for obtaining the optimal scheduling and logistics planning of the Indian General Elections. The method can be utilized for scheduling and planning any nation-wide event requiring scarce resources.

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