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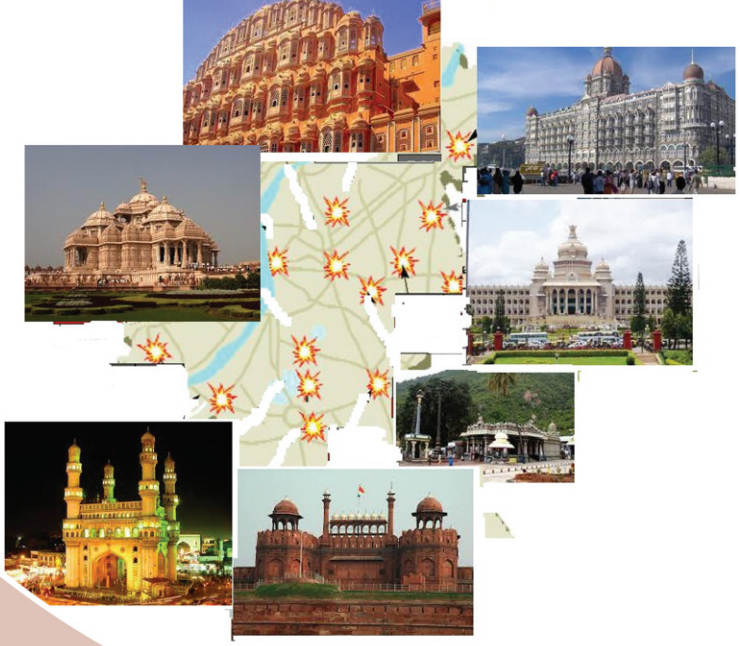

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Patterns in Terror Attacks in Urban and Semi-Urban India – An Empirical Investigation

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International Strategic and Security Studies Programme
National Institute of Advanced Studies
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Published by
National Institute of Advanced Studies
Indian Institute of Science Campus
Bengaluru - 560 012
Tel: 2218 5000, Fax: 2218 5028
E-mail: admin@nias.iisc.ernet.in

NIAS Report: R9-2012

ISBN 978-81-87663-62-1

Typeset & Printed by
Aditi Enterprises
Bengaluru - 560 023
Ph.: 080-2310 7302
E-mail: aditiprints@gmail.com

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Summary

Terrorism and insurgencies in India broadly fall into the following types:

- those relating to the insurgency in Jammu and Kashmir;
- those related to the separatist movements in North Eastern States;
- violence perpetrated by left wing extremist groups;
- terrorist attacks in urban and semi urban areas of India that are not obviously connected with the above three types.

By making a distinction between insurgencies and terrorist attacks this report addresses terrorist incidents in urban and semi urban areas of India. The Mumbai 1993 multiple bomb blast was the first incident of this kind. Since then several incidents have occurred in various parts of the country.

This report describes the efforts taken to build a data base of such incidents. Data for this purpose has been drawn from the English newspapers published in India.

The data base includes:
Name of the incident;
The date of the incident;
Location;
State;
Special events associated with the date if any;
Type of attack;
Number of bombs;
Explosives used in the bomb;
Delivery method;
Number killed;
Number injured.

Currently the incidents that occurred between 1993 and 2010 are included in this data base. There is also a provision to update this database.

Initial analysis of this data provides basic statistics on the terrorism problem. These statistics in conjunction with linked narratives on each of the incidents together provide a more comprehensive picture of how these attacks were planned, organized and executed. Although data on some of the variables is still missing, having a database of this type has many advantages. Using standard clustering algorithms it has been possible to group the incidents into ten clusters. These clusters are differentiated primarily by the bomb materials used, the delivery vehicles and whether the incidents are single or multiple bomb blasts.

The availability of such a database has also enabled us to carry out a spatial analysis of the bomb placements in the case of multiple bomb blast incidents. A preliminary analysis shows that in some of the incidents the bombs were placed randomly showing a lack of sophistication. In some cases the bombs were clustered while in some cases some amount of regularity is observed. This kind of analysis if carried out with complete data will help to classify the perpetrator groups in

terms of their organization capabilities and level of sophistication in carrying out such attacks.

Problems of linking terror attacks to geography and time along with clustering and spatial analysis may permit a more organized way to look for patterns in these attacks.

This is a preliminary report of the study carried out by the International Strategic and Security Studies Programme (ISSSP) of the National Institute of Advanced Studies (NIAS) and brings into focus several questions that need to be addressed in order to understand the problem of terrorism in India.

Background

1.0 Global Developments

Research on terrorism across the world focus on the definitions of terrorism[1], the history and culture of terrorism, trends in terrorism[2], motivations of terrorist groups[3], conflict situations that provoke terrorist acts, vulnerability and risk assessment,[4] psychological and cognitive models to understand the making of a terrorist and measures to counter terrorism [5,6]. India has been a victim of some form of terrorism or the other since independence. It has been reported that for the period 1970 - 2007 India ranks fourth among the most frequently attacked countries and third in terms of fatalities[5]. In spite of this, there has not been any effort to look at the problem quantitatively or make a quantitative assessment of the problem. The effort by Piazza[6] is probably one of the few that has attempted to look at the problem of terrorism in India analytically. He has shown that terrorism is not necessarily due to poor economic development but is an outcome of unresolved and poorly managed political conflicts. Piazza's analysis however, does not distinguish between terrorism and insurgencies.

The Policy Working Group[7] on the United Nations and Terrorism in 2002 stated the following: "Without attempting a comprehensive definition of terrorism, it would be useful to delineate some broad characteristics of the phenomenon. Terrorism is, in most cases, essentially a political act. It is meant to inflict dramatic and deadly injury on civilians and to create an atmosphere of fear, generally for a political or ideological (whether secular or religious) purpose. Terrorism is a criminal act, but it is more than mere criminality. To overcome the problem of terrorism it is necessary to understand its political nature as well as its basic criminality and psychology."

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1 Schmid, A.P., "Frameworks for Conceptualizing Terrorism, Terrorism and Political Violence" Vol.16, No.2, 2004, pp.197- 221

2 Bonnie Cordes, et al., "Trends in International terrorism, 1982 and 1983" RAND Corporation, R-3183-S1, August 1984.

3 Ryan Clarke, "Lashkar-I-Taiba: The Fallacy of Subservient Proxies and the Future of Islamist Terrorism in India" Strategic Studies Institute, March 2010.

4 Brent L. Smith, Kelly R. Damphousse, Paxton Roberts, "Pre-Incident Indicators of Terrorist Incidents: The Identification of Behavioral, Geographic, and Temporal Patterns of Preparatory Conduct" May 2006, University of Arkansas, Document No. 214217.

5 Gary LaFree, "The Global Terrorism Database (GTD): Accomplishments and Challenges, Perspectives on Terrorism" Vol. 4, No. 1, pp 24 -46, March 2010.

6 James A. Piazza, "Economic Development, Poorly Managed Political Conflict and Terrorism in India, Studies in Conflict & Terrorism" 32:406–419, 2009

7 Schmid, A.P. (Guest editor), Forum on Crime and Society, Vol. 4, Nos. 1 & 2, Dec. 2004, UN Office on Drugs and Crime, New York, 2005.

The document also refers to insurgency and points out how the two terms are different. "An insurgency differs from terrorism in the sense it is an organized revolt against the government or State with the purpose of acquiring some territory of land." In many cases an insurgency is also a means to bring the state to the negotiation table.

For our purpose a terrorist incident is a planned and motivated act of violence using weapons of destruction against civilian population resulting in loss of life, damage to property by a person or a group with the intention of creating fear in a population and to 'destabilize the state'. A communal riot which is more common in some parts of India is however not to be confused with a terrorist act. A communal riot is a violent confrontation of two groups belonging to two different religions or communities. This often results in loss of life and property. A communal riot is a spontaneous reaction to a conflict and is not pre- planned.

1.1 India & Terrorism

Unlike many other countries the problem of terrorism in India particularly after independence has several facets and exhibits an ever changing scenario. Some of the major terrorist / insurgency incidents that independent India has had to contend with include:

The Kashmir insurgency;
The Khalisthan movement;
Naxalism and Maoist insurgency;
Insurgency in the North Eastern States of India;
LTTE related incidents in South India.

India has successfully dealt with insurgencies in Punjab, Nagaland, Mizoram and Tripura. It took 19 years to deal with the Naga insurgency and Mizo insurgencies, 14 years to deal with Khalisthan terrorism and 10 years to deal with Al Umma. India has succeeded whenever the terrorism or insurgency was confined to a narrow area.

The International Strategic and Security Studies Programme (ISSSP) of the National Institute of Advanced Studies (NIAS) decided to initiate a study of terrorism following the Mumbai terrorist attack that took place on November 26, 2008. The primary objective was to understand the way the terrorist attacks were planned and executed. Though the attack had all the hallmarks of Pakistan's involvement, it also raised a number of questions related to terrorism in India. Do all terrorist incidents emanate from outside? Are there entities within India also carrying out such acts on their own? Do they get outside support? We also needed to understand whether there was any similarity in the nature of attacks. As we were trying to grapple with these questions, it became evident that we needed a data base of all the incidents that have taken place in India. We also realized that such a data base is not available and has to be built from scratch. The initial focus of the work thus turned towards building such a database.

Currently, terrorism and insurgencies in India fall into four main types:

- Those relating to the insurgency in Jammu and Kashmir;
- Those relating to the separatist movements in North Eastern States;
- Violence perpetrated by left wing extremist groups;
- Terrorist incidents in urban and semi urban India that are not obviously connected with the above three types.

1.2 Scope

This report focuses exclusively on the last category. The incidents that we have covered do not fall into the category of an insurgency nor can they be classified as a communal riot. They are often given a religious overtone by the media. Many of these terrorist acts are also referred to as cross border terrorism since it is believed that these acts have been triggered by agencies outside the country. We have not separated out international terrorist attacks on India from those perpetrated by domestic terror groups, since it is difficult to get data on the terrorist groups located both within and outside the country. Many of the terrorist attacks are still under investigation. It is not the objective of this report to associate a terrorist incident with any specific group.

The Babri Masjid demolition on December 6, 1992 in India was followed by widespread communal riots across the country. It is generally believed that the Mumbai blasts of March 12 1993 were an aftermath of this. Since then several incidents have occurred in the country that have no relation to the insurgencies mentioned earlier.

This report tries to ask a number of questions based on the data base that has been built. As we look at the various terrorist incidents that have taken place in the country, we would like to know if there is any pattern in the "madness". We would like to understand whether there has been any significant change in the targets chosen and in the kind of explosives used. We have tried to summarize some of our findings in this report. More detailed studies however need to be carried out. The report also suggests what could be the future areas of study.

This report does not attempt to draw any major conclusions because many of the data elements are incomplete for quite a few of the incidents. Data on terrorism in the public domain is sparse and agencies that probably have the data are rarely willing to share it with researchers. This has to change in India so that different aspects of the problem can be addressed by academia in the country.

Terrorism Data for Research

2.0 Need for Creating a Data Base

There are not many data bases on terrorism. Even when they do exist they have both spatial and temporal gaps. Since there are differences in the way terrorism is defined, the entries in different data bases on the same incident also differ. These aspects of data bases and the utility of data bases have been examined by Schmid[8] (2005). In recent years the Global Terrorism Data (GTD)[9] maintained by the National Consortium for the Study of Terrorism and Responses to Terrorism (START), a United States Department of Homeland Security Center of Excellence, located at the University of Maryland, has been building and maintaining a database on terrorisms incidents all over the world. However, even this data base on India is not complete. There are gaps on some of the variables of interest. Clearly, if any meaningful study on terrorism in India has to be made, the data base should necessarily be built in India. The authors of this paper realized that a data base of the kind amenable for analysis does not exist and has to be built from scratch from data available in the public domain.

Apart from the Global Terrorism Database (GTD), the South Asian Terrorism Portal (SATP)[10] has a list of terrorist incidents that occurred in India. The data primarily includes the date of the incident, the place where it occurred and the number killed and injured. Since we were interested in building a data base, we looked at the archives of National English Dailies published in India, using the dates of the incidents available in GTD and SATP as a guide for the search. More details about the incidents were thus collected from these newspaper articles and a few magazines such as India Today and Frontline. Even as we were collecting this data, several incidents that were not mentioned in either GTD or SATP surfaced. Some of them were not major incidents, but nevertheless important. Thus over a period of time we were able to list 62 incidents of this kind between March 1993 and December 2010.

Building this data base brought forth several problems. The very nature of terrorism introduces certain biases in reporting both in the print and visual media. In addition, the political aspects and dimensions during the time of the incident also colour the reporting. The location of the incident also has a significant role to play since incidents that occur in small towns may or may not get reported in major newspapers. Local Newspapers in the vernacular languages probably cover many of

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[8] Schmid A P, The Challenge of measuring Trends in Global Terrorism, in Forum on Crime and Society, Vol. 4, Nos. 1 & 2, Dec. 2004, UN Office on Drugs and Crime, New York, 2005.

[9] "Global Terrorism Database, START, accessed on 1, March 2011

[10] The South Asian Terrorism Portal (SATP) – www.satp.org – was launched in 2000 and has data base on extremist events in the region. It is a project of the Institute for Conflict management, New Delhi, India.

the incidents that go unreported in the major English Newspapers.

2.1 Structure of the Data Base

Our database includes items such as the name of the incident, the location, the State, the special events associated with the date if any, the type of attack and so on. The complete list of the fields for the data record is shown in **Table 1**. A comprehensive understanding of terrorism incidents and their inter linkages require descriptions of the actual incidents, the way they occurred etc.

The original document from which the data has been collated is therefore important. In our data base these are hyperlinked to each of the incidents. Thus the data base includes all aspects of an incident. For some of the incidents data on some of the fields are not available. These can be filled out as and when the data becomes available.

Table 1: List of the Fields and their types in the Data base

Field	Type	Remarks
Sl. No.	Integer	
Incident ID	Alphanumeric	
Date	DD-MM-YY	
State	Text	
District /Town	Text	
Place	Text	Actual locations
Incident name	Text	Popular name for the incident
No. of Locations	Integer	
Target	Binary	*Temple, Mosque, Train, Bazaar, Public Building, Government Building, Public place, Hospital, Monuments, Others
Day of week	Text	
Special days	Text	Describes if the incident occurred close to some special days
Time	HH:MM	
No. Killed	Integer	
No. Injured	Integer	
Type of Incident	Binary	*Bomb blast, Grenade attack, Rifle attack, Incendiary attack.
No. of bombs	Integer	Range: 0 – total no. of bombs used
Bomb Material	Text	Describes the materials used
Packing	Text	Describes how the bomb was packed
Delivery method	Binary	Planted, Thrown, Stored, Accidental
Delivery Vehicle	Binary	*Bicycle, Two wheeler, Three wheeler, Four wheeler, Bus, Train, Human
Bomb-Trigger	Text	Describes the trigger mechanism used.
Perpetrator	Text	Name of the group claiming responsibility for the incident
Remarks	Text	Any additional data

Note: * For each incident 0 or 1 is assigned against these categories.

It is difficult to validate all the parameters in the data base. We are not aware whether there is any agency in the country that collects and puts together data on the terrorist incidents in this form to facilitate analysis. Nor do we believe that our list is exhaustive because our sources have been primarily from the English media. It is possible that some 'small' incidents could have been given wider coverage in a vernacular medium and we would have missed them.

Data Analysis

3.0 The Big Picture

From March 12, 1993 till the end of 2010, 62 incidents were recorded. A total of 1467 persons were killed and 4497 persons were injured in these incidents. On an average 3.4 incidents of this type have occurred annually in the country resulting in an average of 80 deaths per year. The incidents occurred in the states of Andhra Pradesh (A.P.), Bihar, Goa, Gujarat, Haryana, Karnataka, Jammu & Kashmir, Maharashtra, New Delhi, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh (UP) and West Bengal (WB).[11]

Delhi, Maharashtra and U.P. bore the brunt of the incidents with nearly 70% of the incidents occurring in these states.

The maximum number of incidents (18) occurred in Maharashtra resulting in more than 700 deaths and leaving more than 2300 injured. This constitutes close to 50% of the total number of deaths due to such terrorist incidents in the country.

Uttar Pradesh faced 14 incidents resulting in 100 deaths and 400 injured. New Delhi[12] which had fewer incidents (9) than UP had more casualties than UP.

Figure 1 shows the number of incidents and the fatalities in different states during 1993-2010.

Figure 2 shows the cumulated number of incidents in Delhi, U.P and Maharashtra during the same period.

Although there were only 4 incidents in Gujarat, the casualties were as much as in UP suggesting that these incidents are 'large scale operations'. Maharashtra, UP, New Delhi, Gujarat, AP, and Rajasthan have had the maximum casualties – close to 80% of the total casualties since 1993.

Haryana is not included here because the one incident that occurred in Haryana refers to the Samjauta express train blast. Though this occurred in Haryana the target was not necessarily the Haryana state or its people.

West Bengal had two incidents. The first occurred in Bow Bazaar which did result in massive deaths. However it is doubtful whether this was a pre-planned terrorist incident or not. The other incident on the American centre, Kolkata resulted in 9 deaths.

Figure 3 shows year wise statistics on the number of incidents. The figure shows that the

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[11] Considering the fact that insurgencies are prevalent in the North Eastern States, Bihar, Orissa, Chattisgarh, Jammu & Kashmir and Jharkhand, it is clear that almost all the states of India are victims of terrorism or insurgency

[12] Incidentally there were records of 12 incidents in Delhi in 1997 which was not reported in any of our sources. If these incidents were also included, Delhi would have as many as 21 incidents during the study period, These 12 incidents were however minor in the sense, they together resulted in fewer than 5 deaths. Since no other data was available on these incidents these were not considered for our analysis.

Figure 1 State wise No. of incidents, No. Killed and No. injured (1993 - 2010)

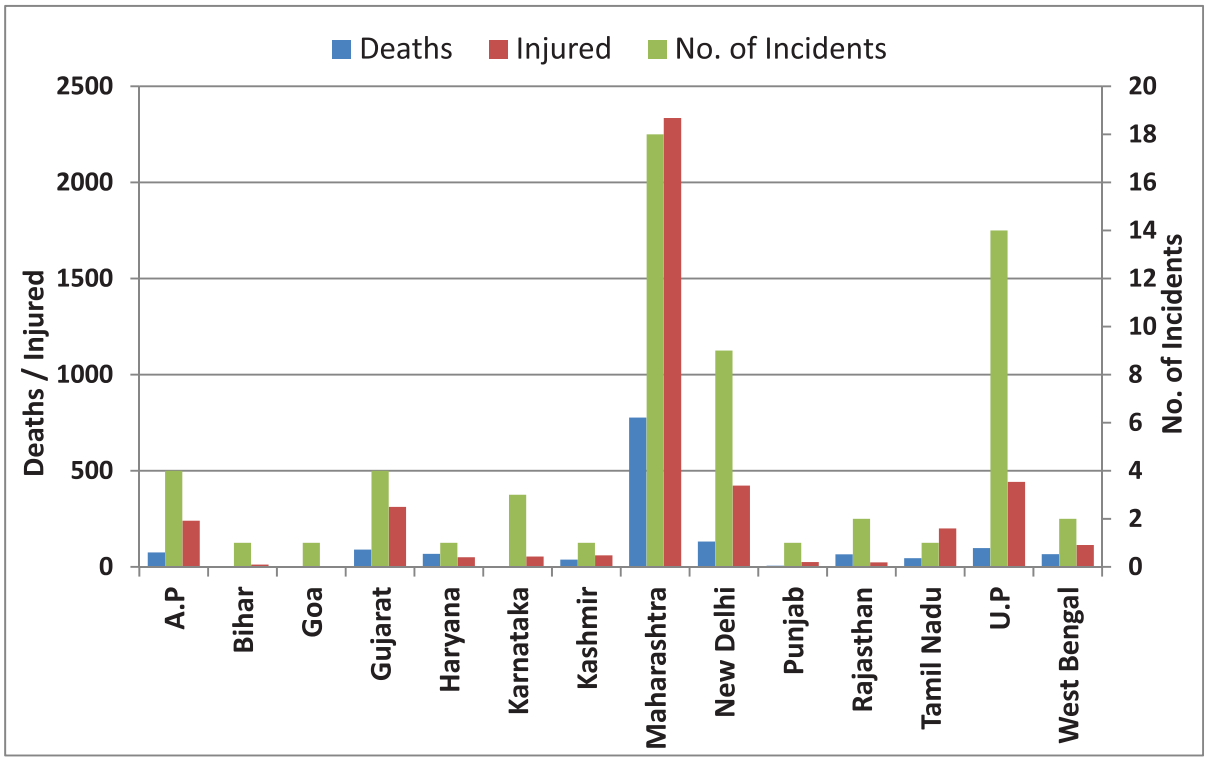


Figure 2 Cumulative Number of incidents in Delhi, Maharashtra and UP

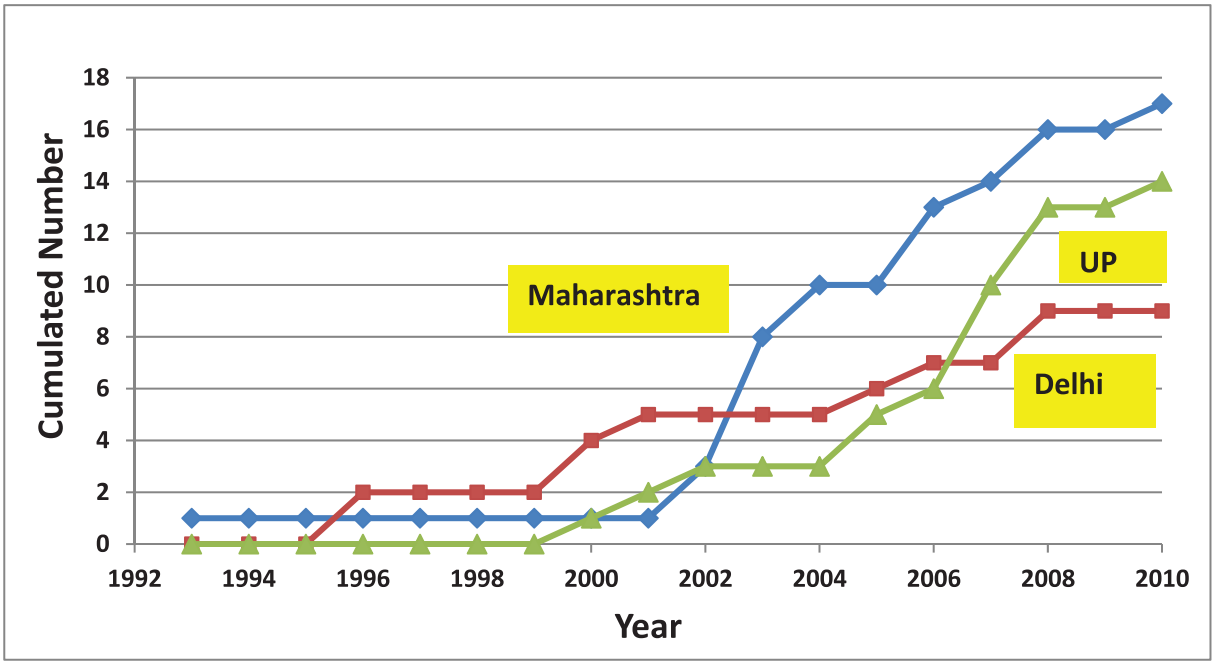
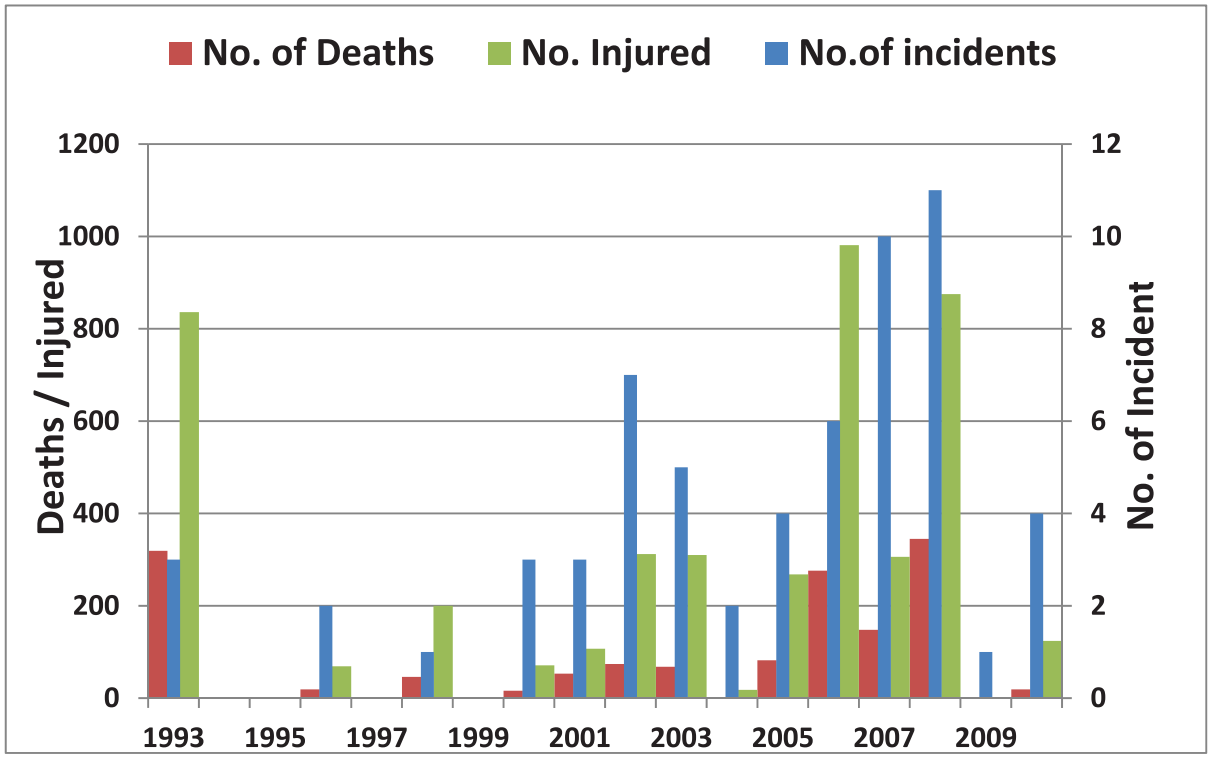


Figure 3 Year wise - Number of Incidents, Number Dead & Number Injured



maximum number of incidents occurred in 2007 and 2008. In all 21 incidents out of a total 62 incidents recorded occurred during this period. There is an increasing trend in the number of incidents.

Figure 4 shows the cumulative number of incidents and fatalities during 1993 – 2010. The maximum number of incidents occurred in 2007 and 2008. There is an increase in the number of incidents from 2000 onwards, the median year being 2005. The median year for the number of fatalities is also 2005. In other words 50% of the incidents and the fatalities occurred in the last five years.

Between 1993 and 2005 the rate of increase in deaths has remained more or less constant. There is an increase in this rate between 2005 and 2008. After 2008, we see that the curve has flattened off again. The cumulative curve for the number injured shows a sudden increase in the numbers in 1998, 2002, 2006 and 2008 from the previous years. The maximum number of injuries occurred in 1993, 2006 and 2008. Since the data on the number injured is the most difficult to verify and validate, it is important to look at the trends rather than the values that are available.

Figure 5 shows the fatalities rate, and the rate of injuries per incident during the same period. The fatality rate ranges from 0 in 2004 to 120 in 1993. The number injured per incident is the highest in 1993 and the lowest in 2009. Although the number of deaths in 2008 is as high as the number of deaths in 1993, the fatality rate does not show this, because there were more terrorist incidents in 2008 as against one incident in 1993.

Globally the average number of victims (this includes both the number dead and injured) per international terrorist attack for the periods

Figure 4 Cumulated Number of Incidents and Deaths (1993 – 2010)

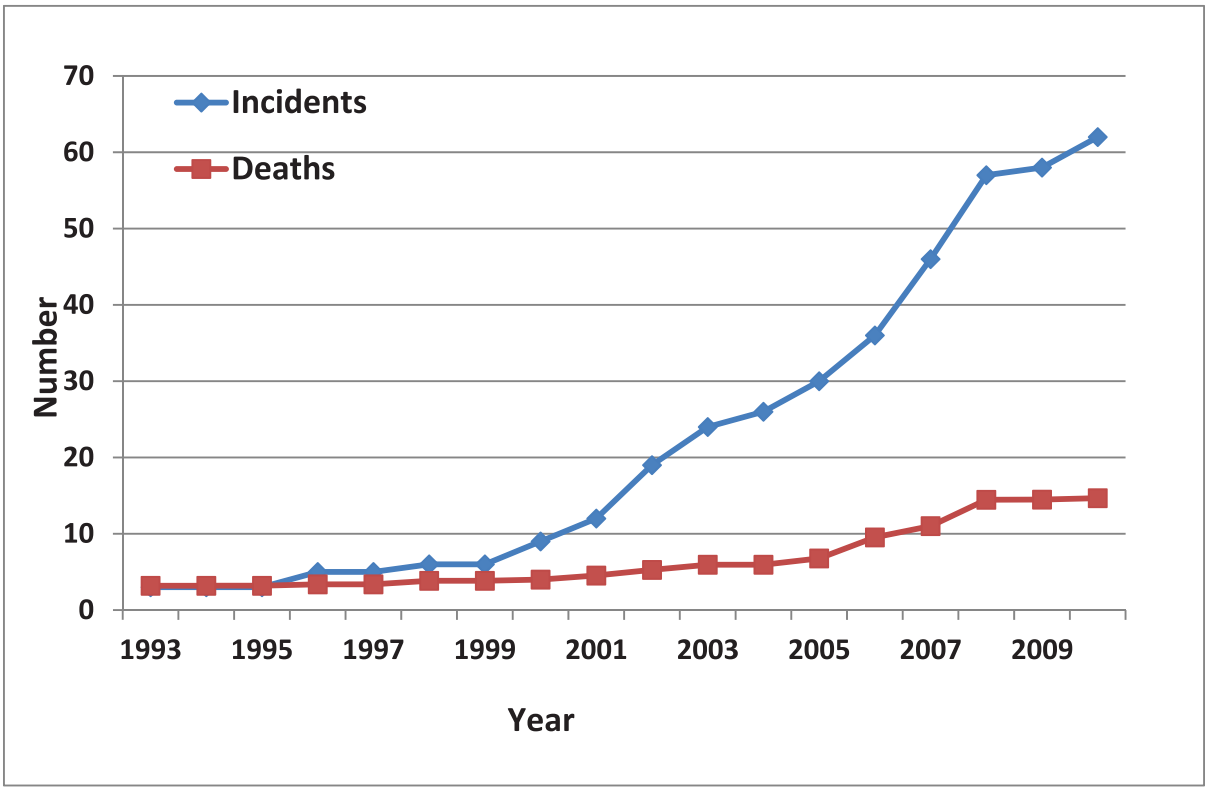
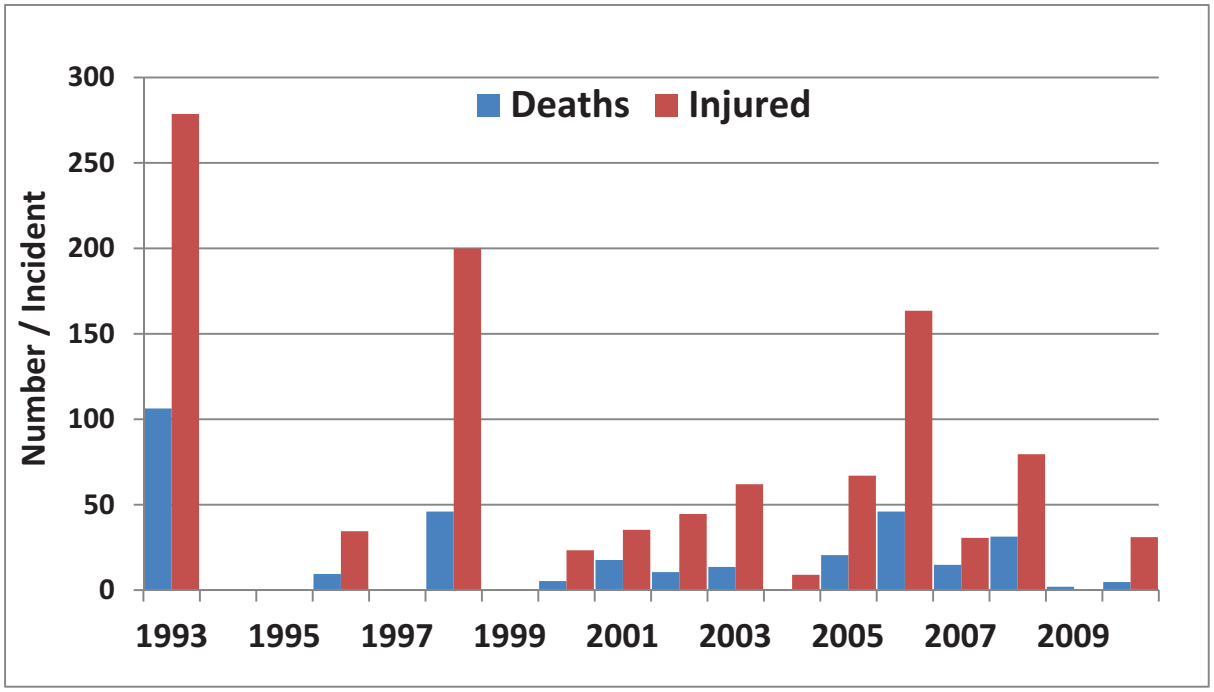


Figure 5 Deaths and Number Injured Per Incident



1990-1999 and 2000-2005 have been quoted to be 10.38 and 10.89[13]. For the same period, in India the numbers are 24.8 and 9.6. From our data we observe that for the period 2006 -2010, this has gone up to 19.2. Of course not all the 62 incidents are international terrorist incidents. It is important to note that these numbers are not small and that the situation in India is both serious and grave.

3.1 Grouping of the Incidents

Not all incidents of terrorism have the same impact in terms of the number of victims and property loss. A careful scrutiny of the incidents shows that there are three types of incidents

- Those which are primarily attacks with rifles or weapons;
- Those which involve IEDs, explosives, bombs etc.;
- Those which involve rifle attacks as well as explosives, bombs etc.

3.1.1 Attacks with Rifles or Weapons

The attacks on Delhi Red Fort (2000), the Kashmir Assembly (2001), Parliament (2001), the American Centre, Kolkata (2001), the Akshardham Temple in Gujarat (2002), the Ram Temple in UP (2005), IISc in Bangalore (2005) and the CRPF camp attack in UP (2008) are all attacks that primarily used rifles or weapons. These constitute 12% of all incidents and resulted in less than 8% of the total casualties. The number injured in this kind of attack is close to 4% of all injured.

A quick glance at these incidents show that the attacks on the Kashmir assembly the attack on Parliament in 2001, the attack on the American Centre again in 2001 and the CRPF camp attacks in UP in 2008 are clearly aimed at government establishments. The two attacks on temples in Gujarat and UP are attacks on religious establishments. The attack on Delhi Red Fort and the one at Indian Institute of Science, Bangalore created more panic and fewer deaths.

Attacks of this kind are much more difficult to organize, because every one of these buildings or establishments is under high security. Persons willing to undertake such missions have to be highly motivated and trained to successfully carry out the attack.

3.1.2 Attacks involving Rifles and Bombs

On 26 November, 2008 there were more than ten attacks involving coordinated shooting and bombing across Mumbai. The attacks began on 26 November 2008 and lasted until 29 November. The terrorists knew the city extremely well and had done a thorough reconnaissance of the area. The organization and planning was very meticulous and the terrorists carried sophisticated weapons and explosives. The skill with which the attack was carried out indicates that they were trained by experts. The terrorists were equipped with enough ammunition to carry out a major attack spanning several days.

The Mumbai 2008 incidents involved bombs, grenades as well as attacks with rifles and belongs

[13] Piazza, J.A., Is Islamist Terrorism More Dangerous?: An Empirical Study of Group Ideology, Organization, and Goal Structure, Terrorism and Political Violence, 21:62–88, 2009. The author used Terrorism Knowledge database (www.tkb.org) to arrive at these figures. MIPT Terrorism knowledge Base was an online portal containing information on terrorist incidents, leaders, groups, and related court cases. The TKB ceased operations on 31 March 2008. The TKB contains two separate terrorist incident databases, the RAND Terrorism Chronology 1968-1997 and the RAND-MIPT Terrorism Incident database (1998–Present). While the former component tracked international incidents, the latter database includes both domestic and international attacks.

to the third category. This incident stands out since it resulted in 175 deaths and left at least 300 injured. This single incident resulted in 12% of the total fatalities. Unlike the other attack incidents this incident was spread out spatially and involved multiple locations and targets.

3.1.3 Attacks involving only Bombs and Grenades

It is obvious that the primary objective of a terrorist group will be to cause maximum damage to the population, property and also create panic. Broadly one can assume the steps involved in planning and executing an attack will be as follows:

1. Select Target(s).
2. Survey around the target(s) to decide on the exact location of attack. This could eventually help the placement of a bomb.
3. Procure equipment, explosive materials.
4. Plan method of attack, Time of attack and Training.
5. Actual attack
6. Escape

Planning a terrorist attack involves decisions on the method of attack - weapons or bombs; explosive materials; making of a bomb with the material – including packing; trigger mechanism; delivery method; planning the locations and time of attack. One or more persons are required to lead and carry out such an operation. The total number of persons required to execute the attack increases with the complexity of operations. The organization and execution of major terrorist operations thus require complex human interactions and involve considerable training in every one of these operations.

Depending on the availability of resources at any point of time, attacks are organized by a group of individuals. The availability of a particular type of explosives; the ability to assemble an explosive device; the choice of trigger mechanisms; the power source to trigger a device; the timing of the explosion are important elements in planning an attack. These elements are thus essentially the signatures of a particular group. Having a data base on all these elements for every incident of terrorism will help to identify these signatures which in turn may help to identify the possible groups.

Of the 62 incidents recorded in our data base, 51 incidents were bomb blasts; some of them single blasts and some were synchronized multiple or serial blasts. There are similarities in the incidents with respect to the type of explosives used, the kind of delivery vehicles employed and other characteristics. The data base per se does not obviously show linkages or connections between incidents. This can be ascertained if we are able to decipher some patterns in the way the attacks have been planned and executed.

There are a number of quantitative models that can be applied to this data base to identify the patterns. Clustering and Spatial Analysis of bomb placements in the case of multiple bomb blast incidents are useful to identify if there are any patterns in the way these attacks are planned and executed. While Clustering groups incidents that are similar, spatial analysis brings out the level of sophistication of the group that carries out multiple blasts. Broadly Clustering can be used to look for patterns in steps 3 and 4 above. Spatial analysis of bomb placement will help bring out the patterns in Step 2 and provide a link to patterns in steps 3 and 4.

We demonstrate the application of both these methods using our data base. The results are discussed in the subsequent sections.

3.2 Variables Used for Clustering the Incidents

Tools such as clustering algorithms could be used to group incidents that are similar and this would perhaps facilitate investigation.[14] The present study demonstrates this using data on incidents of terrorism in India during the period 1993 – 2010. The objective of clustering here is to assign incidents with similar characteristics to the same cluster and also distinguish it from incidents in other clusters. In order to do this we need to define variables that describe a terrorist incident. For the purpose of clustering, we define several variables to describe an incident from the data base that we had generated.

Some of the variables are binary (Yes or No) and some of them are discrete. The variables chosen are:

The type of blast (serial or not);
The number of locations;
The number of bombs;
The explosive material used;
The non-explosive materials used;
The trigger mechanisms employed;
The type of packing;
The delivery vehicles used;
The targets

Variables and their type derived from our data base are shown in **Table 2**.

The blast types could be either a single blast or multiple blasts. This is described in terms of the number of bombs. For instance if the blast is not a serial blast and the number of bombs is more than one, it suggests that several bombs went off at the same location. For our purpose we would consider that bombs placed reasonably close by (say within a distance of a few meters) to be treated as the same location. In the case of multiple serial blasts, the number of locations and the number of bombs will be greater than one.

The explosive materials are many and what we have included in our data base is based on what has been observed in the incidents that occurred in India. In many of the incidents, the materials used are not known from available sources. In some incidents a combination of explosives were used. In other cases some kind of improvised devices were used suggesting a lack of sophistication in the planning of the attack.

The bomb making itself can be a very complex task. Materials like metal pieces, nails, cement chips etc. are packed along with the explosives to create more damage once the bomb goes off. Although this is not a very important signature of a group, the kind of materials used for packing does indicate whether the group is sophisticated or not. Perhaps it is also indicative of the kind of training that has been provided to the bomb maker.

The bombs are usually triggered with a remote device. These can be of different types. Some Improvised Explosive Devices (IED) use electrical firing cable which affords the user complete control over the device right up until the moment of initiation. There are IEDs which are triggered by radio signals. In this device, the receiver is connected to an electrical firing circuit and the transmitter operates from a remote distance. A signal from the transmitter causes the receiver to trigger a switch in the explosive device. This switch fires an initiator in

[14] Chenoweth Erica and Lowham Elizabeth (2007) , On Classifying Terrorism: A Potential Contribution of Cluster Analysis for Academics and Policy makers, Defense & Security Analysis, 23:4, 345 -357.

Table 2 - Variables Defined for Clustering

Characteristic	Variable	Type	Variable	Type
Type of blast	Serial Blast	Yes-1, No-0	No. of Locations	Numeric
	No. of Bombs	Numeric		
Explosive materials Used	RDX / Plastic explosive	Yes-1, No-0	Potassium chlorate	Yes-1, No-0
	$NaNO_3$	Yes-1, No-0	NH_4NO_3 / Neogel / Fuel Oil	Yes-1, No-0
	TNT	Yes-1, No-0	Gelatin/Potassium / Sodium derivatives	Yes-1, No-0
Non-explosive materials	Metal pieces Type1	Yes-1, No-0	Nails / nut & bolts	Yes-1, No-0
	Ball bearings	Yes-1, No-0	Cement chips	Yes-1, No-0
Trigger mechanisms	Pre-set timer	Yes-1, No-0	Timer Remote IED	Yes-1, No-0
	Accident while assembling the bomb	Yes-1, No-0		
	Pipe	Yes-1, No-0	Milk Container	Yes-1, No-0
	Tiffin Box	Yes-1, No-0	Pressure cooker	Yes-1, No-0
	Bags / Briefcase	Yes-1, No-0	Packing Paper	Yes-1, No-0
Delivery Vehicles	Two / Three wheeler	Yes-1, No-0	Car	Yes-1, No-0
	Hand Thrown	Yes-1, No-0	Planted on site	Yes-1, No-0
Targets	Mosque	Yes-1, No-0	Temple	Yes-1, No-0
	Train	Yes-1, No-0	Public Building	Yes-1, No-0
	Government Building	Yes-1, No-0	Monument	Yes-1, No-0
	Public Place / Market	Yes-1, No-0	Private Building	Yes-1, No-0

the device setting off the bomb. The transmitter and receiver operate on a matched coding system which prevents the IED from being initiated by spurious radio frequency signals. Such a device can be triggered using car alarms, cell phones and similar electronic devices. There are also occasions where the bomb went off while it was being assembled and this case is also included under trigger mechanism employed. In our data collection, detailed information on the trigger mechanism employed is not available in most of the cases. Therefore the number of categories is limited to three.

The methods used for packing the explosives are grouped under the category of type of packing. The number of categories we have included for our analysis is mainly based on what our data revealed. This is not an exhaustive list and there could be several other methods. Of these, the pipe bomb has been in wide use globally. A pipe filled with an explosive material tightly sealed on both ends is called a pipe bomb. The containment provided by the pipe allows use of easily available low explosives packed tightly to produce a reasonably large explosion. Pressure cooker bombs have also been found to be used in India, neighbouring countries as well as in Dresden, Germany in 2003. Other packing methods that have been used in India are also included under this category. Obviously, the explosives packed inside determine the lethality of the attack.

Some of the packing methods such as tiffin box, milk container and bags suggest crude planning and involvement of local groups.

The delivery vehicles used in carrying out the operation is a clear signature of the sophistication levels of the group. Here we have not included human bombs or suicide bombers as a category simply because such incidents have not been recorded in our data base.

Target categories are necessarily broad and are sometimes not obvious and have to be surmised based on the location of the bomb.

For the purpose of clustering however, not all these variables were included, because data on many of these variables was sparse. For instance very little data was available on the non-explosive materials and therefore was not included in the analysis. The data on the explosive materials used is not complete and hence some amount of overlap between the variables is bound to be there. In any case since one of the objectives of the paper is to demonstrate the use of clustering methods to bring out similarity between incidents, we have not attempted to refine the definition of variables. Agencies that have complete data on these aspects of terrorist incidents would be able to define the variables more precisely.

3.3 The Clusters

Of the 53 incidents there were two involving the removal of fish plates on rail tracks and do not qualify to be in any of the three categories. The 51 incidents that involved bombs and explosives are grouped using standard clustering algorithms and the variables mentioned in **Table 2**. There are several methods for clustering[15] of which the hierarchical clustering method and the K-means clustering algorithm are well known. Since we did not have any idea about the number of clusters, we applied hierarchical clustering on the data. The process resulted in eight clusters. We then computed correlation matrix for the 51 incidents. Using this as the similarity matrix the incidents were classified into 8 clusters using K-means clustering algorithm. The clusters and the incidents that fall in each of these clusters are shown in **Table 3**. The K-means clustering also provides data on the dominant characteristics of the cluster. This helps in understanding the clusters.

In some of the incidents in cluster 3 the materials used were not known. The common characteristics of cluster 3 were also not immediately apparent and therefore we decided to further cluster these incidents. These are shown as clusters 3/1, 3/2 and 3/3.

Cluster 1 includes incidents where the bombs were packed in pipes and hand thrown. A single bomb was thrown in all these cases. The Bow Bazaar incident in 1993 is slightly different. In this incident a blast occurred inside the basement of an apartment block where these explosives were stored, probably for later use. The Nanded incident also is a kind of an outlier because the blast went off when the bomb was being transported. The fatality rate of this cluster without the Bow Bazaar incident is small at 0.5.

Incidents where RDX / Plastic explosives have been used were grouped into 4 clusters. These are the clusters 2, 3, 4 and 8. RDX was used in 18 of the incidents. The fatality rates of these clusters vary from 7.3 in cluster 8 to 68.0 in cluster 3/3. Obviously the making of the

[15] Gan, Guojun, Chaoqun Ma, and Jianhong Wu, Data Clustering: Theory, Algorithms, and Applications, ASA-SIAM Series on Statistics and Applied Probability, SIAM, Philadelphia, ASA, Alexandria, VA, 2007.

Table 3 - Results of Cluster Analysis

Cluster	Incident names	Common Characteristics	Remarks
1	Bow Bazaar 1993 Parbhani 2003 Jalna 2004 Poorna 2004 Nanded 2006	Single Location Materials no data Hand Thrown Packed in Pipes Mosque attacks.	**5 incidents** Fatality Rate : 0.5 without Bow Bazaar incident
2	Lajpat Nagar 1996 Mumbai BEST 2002 Mumbai local train 2003 Mumbai BEST 2003 Jaunpur Train 2005 (UP) Ahmedabad Station 2006 Pune Bakery 2010 Samjauta Express 2007	Single Location RDX /Amm. nitrate based Planted on site. Pre-set and remote timers used. No data on type of packing.	**8 incidents** Fatality Rate : 16.1
3	**Sub-groups 3.1, 3.2 and 3.3**	**Each sub-group different**	**17 Incidents** **Fatality Rate : 31.0**
3 /1	Bangalore Cricket Stadium 2010 McDonald Mumbai 2002 Hanuman Temple Varanasi 2006 Lumbini Park 2007 Gorakhpur 2007 Varanasi 2010	Single Location. Multiple bombs. Public Places. Planted on site. Ammonium Nitrate Neogel / Fuel Oil	Fatality Rate: 11.8
3 /2	Ahmedabad Serial 2008 Coimbatore 1998 Bangalore serial blasts 2008 Delhi serial blasts 2008	Serial Blasts. Multiple Locations. Multiple bombs. Pre-set / remote timers. Amm. Nitrate / Neogel	Fatality Rate : 16.9
3 /3	Mumbai 1993 serial attack Sadar Bazar Delhi 1996 Red Fort 2000 Vile Parle 2003 Delhi Markets 2005 Gateway of India 2003 Jaipur serial 2008	Multiple Bombs Public Places RDX / Plastic explosives Gelatin, Sodium and Potassium derivatives.	Fatality Rate of 3/3: 68.0

Cluster	Incident names	Common Characteristics	Remarks
4	Lucknow 2007 Varanasi 2007 Faizabad 2007 Jama Masjid Delhi 2006 Margoa 2009 Malegaon 2006	Single Location Multiple bombs RDX / Plastic explosives All used Ammonium Nitrate / Fuel oil Pre-set timer except Malegaon Two and Three wheelers.	**6 Incidents** Fatality Rate : 9.0
5	Kanpur 2008(October) Modasa 2008 (Gujarat) Malegaon 2008 (Maharashtra) Bihar 2010	Single Location Materials no data. Two and Three wheelers Timers/Remote ID Public Places targets.	**4 Incidents** Fatality Rate : 1.5
6	Kanpur 2008 (UP) Saibaba temple 2002(AP) Mehrauli Market Delhi 2008	Single Location; Pre-set timers used. KCLO3 used.	**3 Incidents** Fatality Rate : 2.0
7	Mumbai Trains 1993 (5nos.) Sabarmati Train 2000 Ghaziabad train 2001 Mumbai suburban rail 2006 Nanded 2007	Single Location Several bombs Materials not known Targets Trains.	**5 Incidents** Fatality Rate : 25.0 (based on 9 incidents) Nanded incident is an outlier.
8	Mecca Masjid 2007 Ajmer Dargha 2007 Ludhiana Cinema 2007	Single location Two targets Mosques All RDX and TNT Planted on site; Packed in Tiffin boxes.	**3 Incidents** Fatality Rate : 7.3

bombs itself is different in these cases as also the timing and location of the bombs. Cluster 3/3 includes all the incidents which used multiple bombs in multiple locations. The Jaipur incident was a serial attack. Such incidents require complex planning and organization. They also require more people to carry out the attack. Groups responsible for such attacks also need to have considerable knowledge about the topography of the place and support from the local population.

Cluster 3/2 includes incidents which used explosives based on Ammonium nitrate / Neogel. All the four incidents are serial blasts and used some form of pre-set or remote timers. The fatality rate was 16.9. The Bangalore incident was obviously not well planned and did not result in many casualties. Without this incident

the fatality rate becomes 44.0 for this cluster. This cluster includes attacks which require very complex planning. All the incidents involving serial bombs attacks fall in either cluster 3/2 or 3/3[16]. However the explosive materials used in the two clusters differ. Cluster 3/1 includes some incidents that used Ammonium nitrate / Neogel based explosives. All these incidents are characterized by multiple bombs in single locations. In many of the cases bombs placed on site did not go off, indicating that the planning and execution abilities of the group were not very good. In fact it has been reported that in the case of the Lumbini Park incident, 2 bombs went off killing 41 persons and later 19 bombs were defused around the same place.

In contrast in cluster 8, all the three incidents used RDX, planted in a single location. The impact was therefore less. In cluster 2 although the fatality rate is 16, the major incident is Samjauta Express in 2007. Here, in addition to RDX, some fuel oil was also used. Without this incident, the fatality rate for this cluster works out to be 8.7.

In cluster 4 the characteristic feature is that two and three wheelers were used to plant the bombs. All the attacks used Ammonium Nitrate / Fuel oil based explosives. The incident in Margoa is perhaps an outlier here because the blast occurred when the bomb was being transported by two persons on a two wheeler.

Clusters 1, 5 and 7 include incidents where the bomb materials are not known. Cluster 5 differs from cluster 1 in that some kind of timers was used here. Two and three wheelers were used as delivery vehicles. The fatality rate in these incidents was 1.5.

The fatality rate of the cluster 7 incidents is quite high at 25. All the incidents excepting the Nanded incident targeted trains. Of these, the Mumbai suburban rail incident in 2006 is significant because it was a serial blast. The Mumbai suburban rail incident alone resulted in more than 200 deaths. Without this incident the fatality rate for this cluster becomes 2.0. The high fatality rate can be attributed primarily to the large number of persons travelling in the train at the time of blast. The choice of the trains and the timing clearly indicates that the perpetrators planned the attack so that it will have maximum impact. Targeting a train is easier in India as compared to targeting a plane where generally the security measures are much more stringent.

In the case of cluster 6 the fatality rate is 2.0. Pre-set timers were used and the data available to us indicate that KClO3 was one of the ingredients of the explosives.

Eleven incidents belonging to clusters 1, 5 and 6 are minor incidents.

3.4 Incidents involving Serial Multiple Blasts

A careful scrutiny of the clusters shows that the clusters 2 and 3 include most of the major incidents that occurred in India during the period 1993 – 2010. Cluster 3 includes all the serial blasts that occurred in the country. **Table 4** shows the list of 10 major incidents in the country arranged in descending order of lethality. Except for the Samjauta Express and the Bow Bazaar episodes all other incidents involved multiple serial blasts. In the Ahmedabad incident as many as 21 bombs

[16] The only exception being the Mumbai suburban rail attack in 2006 which falls in cluster 7. This is because for this incident, the material used is not known. Many of the data elements are missing for this incident.

went off at various locations causing close to 60 deaths. The number of bombs used in the 1993 incident in Mumbai was 13, leading to 257 deaths. The materials used in each of these cases obviously determined the lethality and the extent of damage. While in the Ahmedabad case the explosives were mostly Ammonium nitrate based, RDX was used in the 1993 Mumbai incidents. There were two more serial bomb blasts in 2008, one in Delhi and the other in Bangalore.

Materials used in these major incidents include mainly RDX, Ammonium nitrate, Neogel, Fuel oils and Gelatin sticks. Clearly the multiple bomb blasts require elaborate planning and organization. The number of persons that need to be mobilized and trained to carry out such operations will increase with the number of locations and the spacing between them. Obviously such incidents cannot be organized quickly. So these incidents are usually not immediate retaliation to other events. Also, they need not be retaliatory events to incidents happening in the same region, state or city. It is therefore difficult to find linkages in the incidents happening in the vicinity of a terrorist event. In other words, it is not possible to identify triggering events for each of these serial blasts. Nevertheless one hears about a particular terrorist group claiming responsibility for an incident and giving reasons for the attack.

In the following sections we give a brief

Table 4 - Major incidents during 1993 - 2010

Incident Name	No. of Bombs	No. Killed	Type of incident	Material used	Target
Mumbai 1993	13	257	Serial bombs	RDX	Commercial and Infrastructure
Mumbai suburban 2006	7	209	Serial bombs in Trains	RDX and Ammonium Nitrate	Infrastructure
Mumbai 2008	10	175	Serial bombs Attack with grenades and rifles	High grade explosives and RDX	Multiple locations
Samjauta 2001	1	68	Single	IEDs and Inflammable materials	Infrastructure?
Jaipur 2008	9	63	Serial bombs	RDX, Neogel	Market places and temples
Delhi 2005	3	61	Serial bombs	RDX	Markets
Bow Bazaar 1993	1	60	Single	Not Known	Explosives stored
Ahmedabad 2008	21	56	Serial bombs	Ammonium Nitrate	Public places
Mumbai 2003	2	52	Serial bombs	RDX	Public Places
Coimbatore 1998	13	58	Serial Bombs	Gelatin Sticks	Public Places

summary of the serial blast events and in the section following that we describe the spatial distribution of the bomb locations in terms of the Ripley's K function, a very commonly used tool to determine whether the spatial distributions are random or clustered. Since serial blasts require considerable planning and are difficult to execute, most of the time. It is important to understand each of these serial incidents in greater detail.

Understanding Serial Blasts

4.0 Mumbai Serial Blasts 1993

On **12 March 1993** starting from 13.28 hours and lasting for two hours and more, a series of 13 bombs exploded in Mumbai which killed 257 persons and injured 713 people. The attacks were said to be in retaliation for the wide spread Hindu-Muslim riots in Mumbai during December 1992 and January 1993 following the 6th December 1992 demolition of the Babri Masjid in Ayodhya, Uttar Pradesh. RDX was used in bomb making with pencil timers as detonators. Gelatin sticks and grenades were also used. The plan[17] involved planting time bombs at Air India, the Oil Refinery, Share Bazar, Gold Market, 5 Star Hotels, Movie Houses, Sena Bhavan, throwing hand grenades at the airport to destroy airplanes and Machhimar Colony at Mahim and storm the Bombay Muncipal Corporation (BMC) and Mantralaya with AK 56 rifles and shoot down the important leaders. However, the storming of the Mantralaya with the attack weapons was not carried out. The distribution of the bombs is shown in **Figure 6.**

4.1 Coimbatore Serial Blasts 1998

The incident occurred on Saturday, **14 Feb. 1998** from 15.50 to 16.40 hours. Thirteen bombs exploded in 11 places within a 12 km radius. 58 persons were killed and 200 people injured. The blasts are said to be in retaliation

Figure 6 Locations of Bombs in Mumbai 1993 Blast

[17] Black Friday, S Hussain Zaidi, (2003), Penguin Books India

to the November 29 to December 1 1997 clashes between Hindu groups and Fundamental Muslim groups following the murder of a traffic policeman that resulted in the death of 18 Muslims, two Hindus and the destruction of property worth crores of rupees.

The first bomb exploded at 15.50 hours on the Shanmugam Road in R S Puram, 100 metres from the venue of the election meeting that was to be addressed by the BJP President L K Advani. **Figure 7** shows the distribution of these bombs.

Locations where the bombs exploded include:

1. Shanmugam Road, RS Puram
2. Near Central Bus Stand
3. Near Coimbatore Medical College Hospital
4. Gani Rauther Street, Ukkadam area
5. Vehicle parking lot at the Coimbatore Junction Railway Station
6. Commercial complex near the Main bus stand at Gandhipuram
7. A Travel Agency (owned by a local BJP leader) on V K K Menon Road
8. Textile showroom on Big Bazaar Street
9. Sambandhapuram Junction
10. A Jewellery showroom on Oppanakara Street

The explosives used in the blasts were gelatin sticks activated by timer devices. Bombs were concealed in Cars, Motorcycles, Bicycles,

Figure 7 The Distribution of Bombs in the Coimbatore 1996 Incident

the side boxes of two wheelers, denim and rexin bags and in one case a cart loaded in pineapples. Several bombs that failed to detonate were defused. A car laden with 70 kg of explosives discovered on East Lokamanya Street behind the famous Annapoorna Hotel in R S Puram close to the BJP meeting venue was defused.

Large quantities of gelatin sticks, petrol bombs, pipe bombs, detonators, knives, swords, pick axes and sickles, apart from batteries and wires were seized by police.

4.2 New Delhi Blasts 2005

A major bomb blast took place in New Delhi on Saturday, **29 October, 2005**. The **first blast** took place at 17.38 hours in the main bazaar of Paharganj near the Delhi Railway Station. 18 people died and 60 were injured in the blast. The **second blast** took place at 18.00 hours inside a DTC bus in Govindpuri in the southern part of the city. **The third blast** took place at 18.05 hours in South Delhi's busy Sarojini Nagar market. RDX was used in all the blasts.

In the first blast the bomb was planted in a two wheeler. When the bomb exploded, it ripped apart a shop outside which the two-wheeler was parked. A large number of people were assembled in the bazaar area resulting in the high number of deaths.

In the second blast the conductor of the bus spotted a suspicious plastic bag which none of the passenger claimed. The driver and conductor of the bus quickly alerted the passengers and asked them to quickly get down the bus and thus minimised the damage. When the bomb was thrown out of the window of the bus and it exploded. 4 people were injured. The bomb was operated by an electronic device.

In the third blast a bomb exploded in a very crowded corner of the busy Sarojini market. The bomb was placed in a white Maruti van. The bomb went off near a vendor using a gas cylinder, which exploded, triggering multiple explosions leading to an outbreak of fire in a row of shops. 43 people died and 28 were injured.

4.3 Mumbai Suburban Rail Serial Blasts 2006

7 blasts rocked suburban trains in Mumbai during after work rush hour on Tuesday, the **11 July 2006** between 18.24 and 18.35 hours. The locations are shown in **Figure** 8.

4.4 Jaipur Blasts 2008

A series of bomb blasts took place in Jaipur on Tuesday, **13 May 2008**. Eight explosions occurred in quick succession from 7.25 p.m. to 7.45 p.m. All the bombs were placed in bicycles parked at the sites.

The distribution of the bombs is shown **in Figure 9.** The bombs went off in the crowded market districts of Tripolia Bazar, Johari Bazar, Manas Chowk, Badi Choupat and Choti Choupat. Two of the blasts occurred outside Hindu temples at Sanganeri Gate and Chandpole. Another took place in the vicinity of the renowned Hawa Mahal, a popular tourist attraction. 75 persons were killed from the bombings and over 150 were injured. RDX and Ammonium nitrate were used to make the bombs. The bombs were packed with metal splinters or ball bearings to maximize damage in crowded areas.

4.5 Bangalore Serial Blast 2008

The Bangalore incident occurred on Friday the **25th July 2008**. A series of low intensity blasts rocked the southern and central parts of Bangalore. One person was killed and seven were injured in the eight explosions. It started

Figure 8 Locations of Bomb Blasts in the Mumbai Suburban Rail 2006

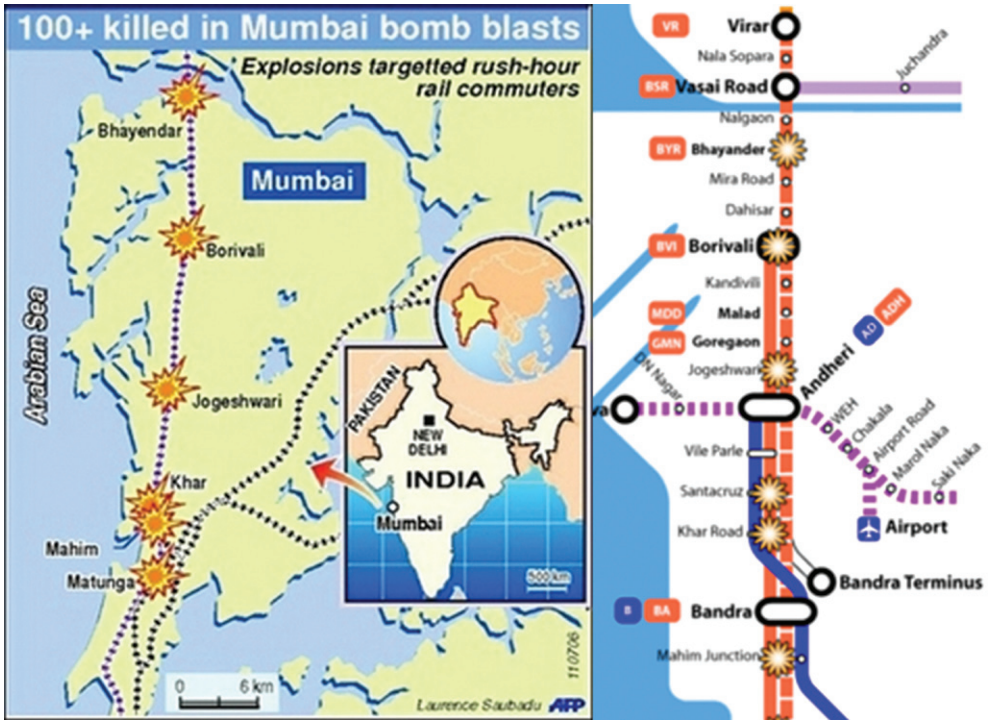
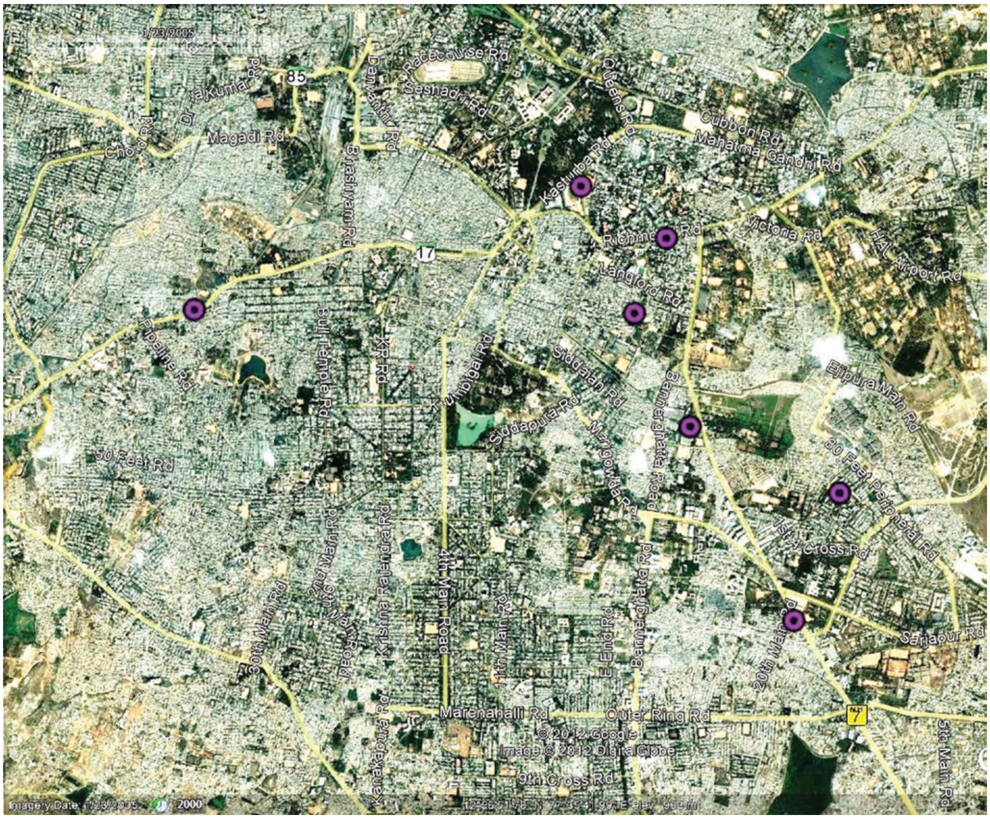


Figure 9 The Distribution of Bombs in the Jaipur 2008 Incident

Figure 10 Locations of Bomb Sites in the Bangalore 2008 Incident



at 13.15 hours and lasted for a period of 45 minutes.

The timeline of the blast sequence and their location is provided below.

Improvised Explosive Devices fitted to timer devices were used in the explosions. Ammonium nitrate, bolts and nuts and cement chips were packed into the device. Embedded chips were used as a timer to trigger the explosions. The sequence of the blasts were as follows :

- 1st blast: 1.20 pm, Madiwala bus depot.
- 2nd blast: 1.25 pm, Mysore road, under a power transformer near a mall, one near a storm water drain and third near a car showroom next to the RTO.
- 3rd blast: 1.40 pm, Adugudi, behind a telephone junction box near a commercial complex.
- 4th blast: 2.10 pm, Koramangala.
- 5th blast: 2.25 pm, Vittal Mallya Road.
- 6th blast: 2.35 pm, Langford Town.
- 7th blast: Richmond Town.

There was another Bomb found on the 26th July 2008 in Bangalore near Koramangala Forum Mall which was defused successfully by the Bomb Detection Squad.

4.6 Ahmedabad Serial Blasts 2008

The Ahmedabad bomb blast occurred on Saturday, the **26 July 2008.** A day after blasts in Bangalore, 21 bomb blasts took place within a span of 70 minutes which killed 56 persons and injured 200 persons.

The first blast took place at 18.45 hours in 13 places. 12 minutes later at 18.57 hours blasts occurred at eight other places. The blasts were of low intensity and similar to Bangalore blasts.

Bombs were planted in tiffin carriers on bicycles, a pattern similar to 13 May 2008 Jaipur blasts. Many blasts targeted the city bus service and ripped apart the vehicles.

2 bombs inside the premises of two hospitals, 1 bomb from Hatkeswar area, and 2 bombs from Maninagar (Chief Minister Narendra Modi's constituency) were found and defused.

Following are the places where the blasts took place:

1. Maninagar
2. Hathkeshwar
3. Bapunagar
4. Amraiwadi
5. Govindwadi
6. Sarangpur
7. Jawaharchowk
8. Narol
9. Ishanpur
10. Saraspur
11. Raipur
12. Sarkhej
13. Juhapura
14. Civil Hospital
15. L. G. Hospital

2 cars, both stolen were found in Surat. One of the cars had four live bombs which were defused. In addition, a wooden box with white powder, wires, a battery and shrapnel were found near Nupur hospital. The cars were stolen from Navi Mumbai and subsequently filled with explosives at Vadodara.

Just days after the Ahmedabad blasts, another bomb was found near an electricity transmitter and contained a packet of 700-800 grams of Ammonium Nitrate, a packet of shrapnel, 2 detonators, one battery and a circuit.

On 29 July 2008, 18 bombs were found in Surat in the diamond processing residential areas within a span of just 4 hours and 23 bombs were found in Surat in three days. Forensic investigations revealed that the bombs did not

Figure 11 Locations of Bombs in the Ahmedabad 2008 blasts

explode because the circuits had been wrongly assembled.

4.7 New Delhi Serial Blasts 2008

A series of five blasts exploded in the busy market places of **New Delhi** within a span of few minutes from 18.10 to 18.40 hours, in which 20 were killed and 100 injured. The incident occurred on Saturday the **13 Sept. 2008.** The first explosion took place at Karol Bagh, two were triggered at Connaught place and two more in the bustling M-Block market of Greater Kailash. The initial investigations have revealed that IED's were configured with Ammonium nitrate and timer devices were used for timing the explosions. One live bomb was found at Connaught place, and two more at Central Park and at India Gate.

- The first blast took place at 18.10 hours at Gaffar Market area of Karol Bagh. The bomb was kept in or near a three wheeler (autorickshaw).
- A bomb was kept in a dustbin near Gate No.1 of the Barakambha Road Metro station in Connaught Place which went off at 18.35 hours.
- A bomb was kept in a bin in Central Park and exploded at 18.40 hours.
- Two low intensity bombs planted in a dustbin and on a cycle in the busy M – Block market of Greater Kailash. They went off at 18.30 and 18.40 hours.
- A bomb was found in a dustbin outside Regal Cinema in Connaught Place and was defused.

The IED's used in the Delhi blast were similar to those used in the recent explosions in Jaipur, Bangalore and Ahmedabad. Readily available clocks were used to set the time for the blasts.

4.8 Mumbai serial attack 2008

On **November 26, 2008**, attacks were carried out by multiple teams on locations where the citizens of Mumbai as well as foreign nationals move around or stay. The attacks were launched through the indiscriminate and random firing from AK-47 assault rifles and lobbing lethal hand grenades. RDX based IED's were planted in 2 taxis in which the terrorists travelled and others in the places of attack. The heavily armed terrorists took over buildings as hostages, indulged in drive-by shootings in sequential and simultaneous attacks. It is believed that ten perpetrators were involved divided into 5 batches of two each. Each of them had one 8 - 10 kg RDX laden IED and grenades and AK-47 assault rifles. In all ten bombs went off at various places. These were accompanied by attacks with grenades and AK 47 rifles at various places.

Figure 12 provides the locations of the attacks carried out in 2008. The attacks were conducted with military precision and commando like action with detailed and meticulous planning. The perpetrators had familiarity and dexterity in the handling of sophisticated weapons and electronic equipment. This shows that they were professionally trained. They were trained for physical fitness, swimming, weapon handling, tradecraft, battle inoculation, guerilla warfare, firing sophisticated assault weapons, use of hand grenades and rocket launchers, handing of GPS and satellite phone, map reading etc.

Figure 13 compares the locations of the bombs in the 1993 and 2008 attacks. It is interesting to trace the way the serial blasts have been organized since 1993 to understand whether there has been any major changes in the materials used, actual planting of the bombs, selection of the locations etc. The data

Figure 12 Locations of Bombs in Mumbai 2008 Attack

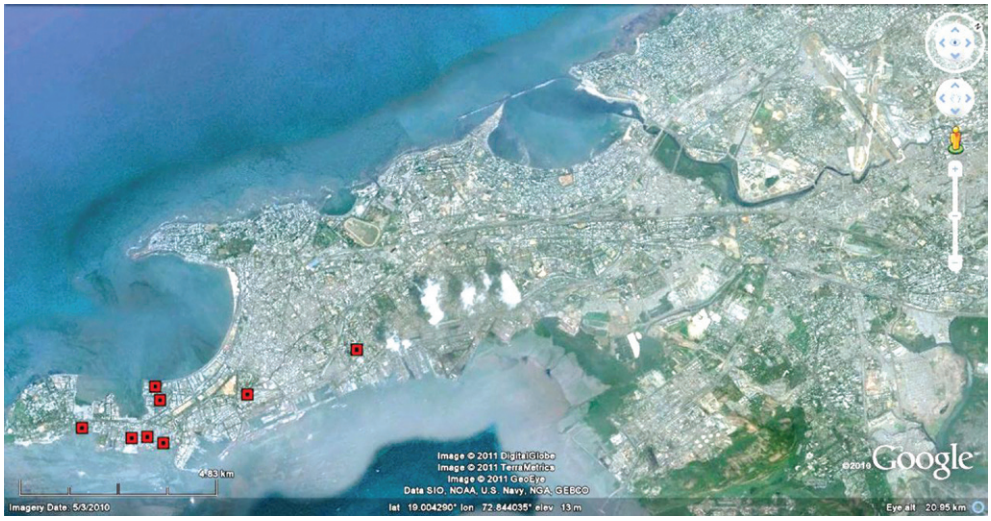
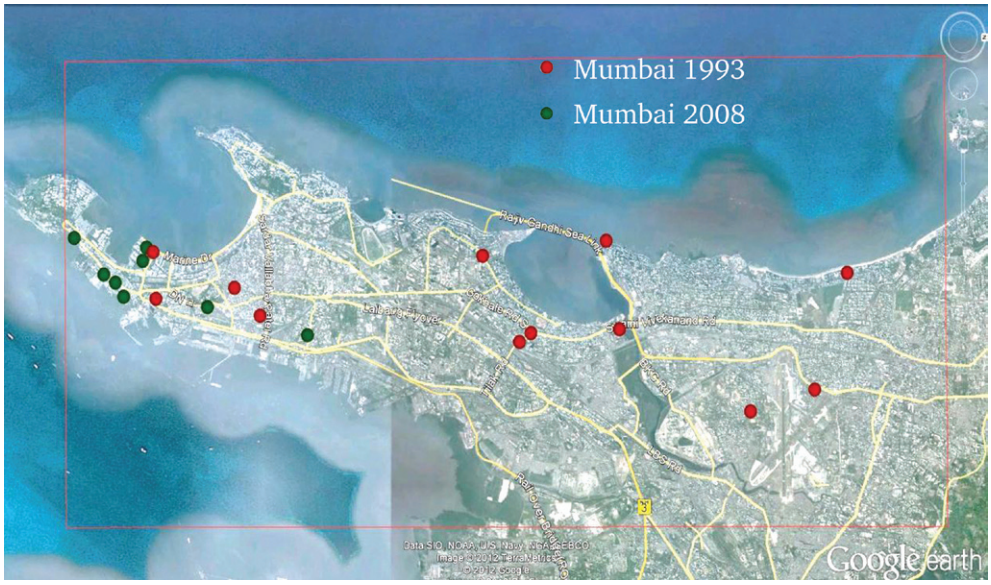


Figure 13 Locations of bombs in Mumbai 1993 and Mumbai 2008 Blasts



on the materials used is not complete but it reveals some interesting facts. The explosives used in most of the incidents were either RDX or Ammonium Nitrate. In the Mumbai blast of 1993 RDX was used. After that incident, RDX came into use in 1996 and then in 2001. Since 2001 RDX has been used in as many as 19 incidents. It is also interesting to note that ammonium nitrate was used for the first time in 2003. Since then this has been used in 17 incidents. What is interesting to observe is the fact that while RDX is a difficult material to procure and Ammonium nitrate is probably the easiest to get, both these materials have been used as explosive material by the terrorist groups. In many cases ammonium nitrate is used together with other materials such as potassium chlorate and TNT. In the year 2007, there were 6 incidents that used RDX and 5 that used Ammonium nitrate.

Spatial Analysis of Serial Bomb Blasts

5.0 Can Spatial Analysis Help?

A terrorist group capable of carrying out multiple serial blasts definitely displays a higher level of organizing capability than a group that carries out a single bomb blast. The financial and human resources available to the former group are also high. In our analysis we have seen that as many as eight incidents were multiple bomb blasts. The materials used in these incidents were different, the impact was different and the motivations for carrying out such attacks are also not obviously evident.

If one looks at the way the bombs were dispersed in the area of attack, we see different patterns. A simple visual analysis seems to suggest that the locations have been chosen after a lot of thought. Is it really the case? Are these locations associated with proximity to other specific features of interest, such as transport arteries, monuments, commercial establishments etc.? Even before we try to answer such questions, we need to determine whether the bombs are located randomly in the area or not.

Data in the form of a set of points, irregularly distributed within a region of space, arise in many different contexts; examples include locations of trees in a forest, of nests of birds. We call any such data-set a spatial point pattern and refer to the locations as events. Point pattern analysis looks for patterns in the spatial location of events.

Spatial point pattern analysis based on functions such as Ripley's K function allows us to answer questions such as – Are the distribution of the location of bombs random in the sense of completely spatial random[18] (CSR)? If they are not random, are they regular or clustered?

Understanding this pattern helps us to assess the capability of the group. A sophisticated group would not place the bombs randomly. Placing the bombs regularly implies either the group knows the locality well and finds it advantageous to place them in that fashion. Depending on the chosen area bombs may be placed at regular intervals. In most of the multiple bomb blast cases, it can be expected that the bombs will be located at strategic locations where it will cause maximum damage or impact. One could also expect some form of clustering or aggregation in this case.

Predominantly spatial point pattern analysis has been carried out to understand naturally occurring phenomenon such as plant species distribution or earth quake epicentres. There have been a few studies where the patterns of industrial clusters in an urban environment

[18] Complete spatial randomness (CSR) describes a point process whereby point events occur within a given study area in a completely random fashion. This is also called a spatial Poisson process. The hypothesis of complete spatial randomness for a spatial point pattern asserts that: the number of events in any region follows a Poisson distribution with given mean count per uniform subdivision..

have also been studied[19],[20]. Spatial analysis of crimes[21] and their locations is commonly used to identify 'Hot spots' of crimes. This kind of analysis is easier with the availability of software such as Crimestat[22].

The effect of the serial bomb blasts have not been the same across the country. Apart from the materials used, the way the bombs are packed, the locations and the distribution of the bombs also indicate the nature of planning and the organization ability of the terrorist group. We note that the distributions of the bomb locations are not similar in these multiple blast incidents. This is also evident in the differential impact of these incidents. For instance, in the Bangalore incident of 2008, although bombs were placed in 7 locations, it did not have serious impact as compared to the Coimbatore incident of 1998.

Spatial distribution of the bomb locations determines the intensity of the terrorist attack. In a multiple bomb blast, the choice of locations will indicate whether they are well planned or not. In a well-planned attack for instance, the perpetrator would have studied the impact area carefully and also worked out the placement of the bombs. In other words, the bombs will not be placed haphazardly. In this case the persons employed to place the bombs will not have much freedom. He or she is employed only to place it at a pre-determined place. This also means that the number of persons involved in such an operation will increase with the number of bombs and the number of locations. On the other hand in operations that are not so well-planned, the placement of the bombs would be haphazard. We demonstrate the use of spatial point pattern analysis for the four incidents – Mumbai 1993, Jaipur 2008, Bangalore 2008 and Ahmedabad 2008.

The Cluster analysis discussed earlier was able to group incidents which are similar in terms of the type of materials used, number of bombs, and other factors. In fact all the multiple bomb blast incidents fell into the same cluster. Even among these multiple incidents which are in cluster 3 the differing fatality rate indicates that there are differences in the organization and planning process of the incidents. It is in this context that the spatial analysis of the bomb placements becomes relevant.

5.1 Choosing the Incidents for Spatial Analysis

We have selected four incidents to illustrate the method of spatial analysis. Table 5 provides the basic data for comparing these incidents.

There are apparent differences in these incidents. For example, the Mumbai blast in 1993 and the Ahmedabad blast in 2008 involved multiple blasts. Though the areas of operation in both the incidents were of the same order, the number of bombs was larger in the case of Ahmedabad **(Table 5).** The incident lasted for as much as 2 hours in the Mumbai case

[19] Joseph Wartman and Nicholas E. Malasavage, Spatial Analysis for Identifying Concentrations of Urban Damage, Ch. 7 in Methods and Techniques in Urban Engineering, Armando Carlos de Pina Filho and Aloisio Carlos de Pina (Ed.), InTech publisherers, 2010

[20] Barff R.A. Industrial clustering and the Organization of Production: A Point pattern analysis of manufacturing in Cincinnati, Ohio, Annals of the Association of American Geographers, 77 (1), pp 89 – 103, 1987.

[21] Anselin L, Cohen J, Cook D, Gorr W, and Tita G, Spatial Analyses of Crime, in Criminal justice 2000, Vol. 4, pp. 213-262.

[22] See the link http://www.icpsr.umich.edu/CrimeStat/ for more details. This software was developed by Ned Levine and associates.

Table 5 - Characteristics of the Four Multiple Blast Incidents

Incident Name	No. of Bombs (Duration Minutes)	No. of Locations (Area Sq. Km.)	Cluster (Fatalities)
Ahmedabad 2008	21 (10)	15 (301)	3 / 2 (57)
Mumbai 1993	13 (122)	13 (290)	3 / 3 (257)
Jaipur 2008	9 (20)	7 (4)	3 / 3 (63)
Bangalore 2008	9 (20)	7 (48)	3 / 2 (2)

while it lasted for only 10 minutes in the case of Ahmedabad. It appears that the Ahmedabad incident is more sophisticated in operation and must have required greater planning effort, simply because of the number of people involved. Note however, that the number killed were not as many as in the Mumbai case. Two main reasons could be attributed to this: (i) the bomb materials were different (ii) the location of bombs.

Similar comparisons can be made between the Bangalore 2008 serial blast and the Jaipur 2008 serial blast. Both lasted for more or less the same duration and again the bomb material used and the location of the bombs made all the difference in the number of fatalities.

While the clustering discussed earlier did bring out the difference in the materials used and other aspects, it did not take into account the spatial distribution of the bombs. At one level the complexity of operations are brought out by the different clusters. Another way to look at the sophistication involved in planning and executing these incidents would be to look at the placement of bombs. It is for this reason that the spatial analysis becomes important.

5.2 Ripley K Approach to Spatial Pattern Analysis

Annexure 1 provides a brief introduction to the Ripley K approach to spatial pattern analysis. For our purpose, the locations of the bombs in a multiple serial bomb incident constitute a spatial point pattern. In our analysis, we treat the study area as a plane (although we do know that the earth is not a plane) since the area of interest is not very large. The precise locations of the bombs are not known to us, but we do know the general location.

We had earlier mapped these locations on to a Google earth image of the relevant area. **Figures 6, 9, 10 and 11 illustrate this**.

The analysis involves calculation of K (r) or L(r)[23] and comparing it with πr^2 for various values of r.

If the events are Completely Spatially Random (CSR) Ripley's K function K (r) = πr^2

If the events are regularly spaced Ripley's K function K (r) will be less than πr^2 and

If the events are clustered or aggregated Ripley's K function K (r) will be greater than πr^2

[23] Ripley's K function analyses the spatial distribution of points or events in space in terms of the distance between the points or distances in an area A. Crudely put, the function K (r) is a measure of the average number of events within a distance r normalized by λ, the number of events per unit area. If there are n events distributed in area A, then $\lambda = n/A$. Usually L(r) which is a transformation of K (r) is computed and plotted against the distance r for ease of interpretation.

If we use L (r) instead of K (r) as we have done the conditions are as follows:

If L (r) = 0, the points are CSR;

If L (r) > 0, the points are said to be clustered or aggregated

If L(r) < 0, the distribution of points are regular.

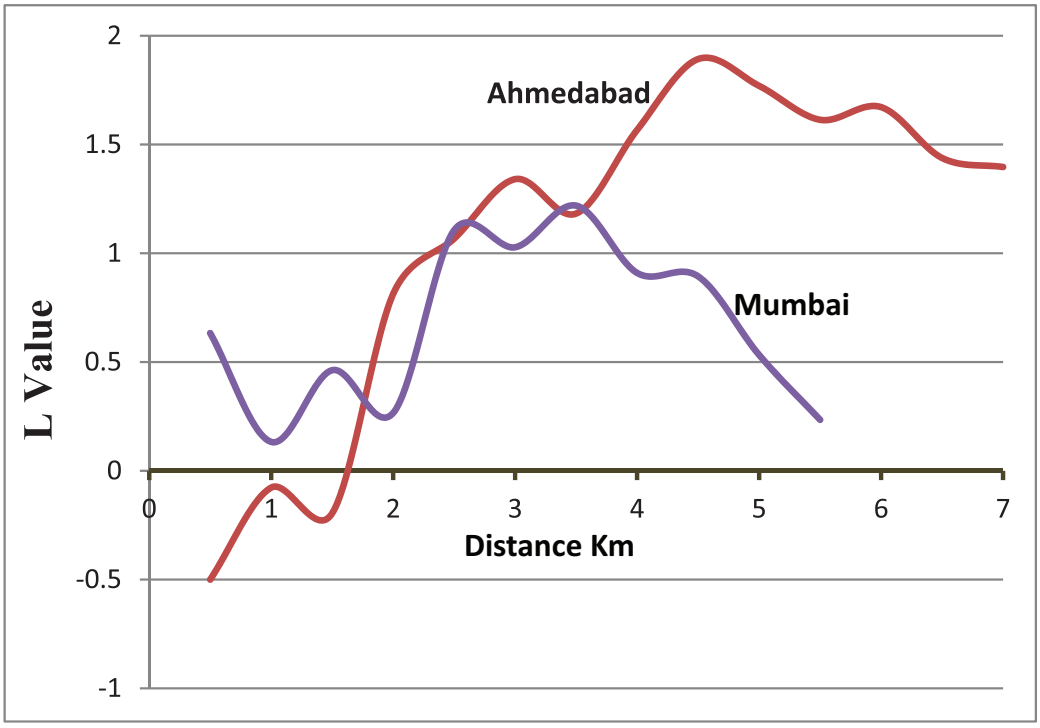
In some of the cases the number of bombs is greater than the number of locations. For instance, in the case of Ahmedabad 21 bombs went off in 15 locations. We have the data on the 15 locations but we do not know where multiple bombs were placed. Hence our spatial data shows only the fifteen locations. Similar is the case in Jaipur. With the exact data on all the bomb locations, analysis of this kind will be more meaningful.

The L functions for the Mumbai 1993 and the Ahmedabad 2008 incidents are shown in **Figure 14.**

In the case of Mumbai the study area is linear over a distance of 12 Kms. The spatial distribution of the bomb locations in this case appears to be clustered at a scale of 1 Km and above. It also appears that there are probably 2 to 3 clusters since there are that many peaks. In the image showing the locations we see that there are clearly three clusters. Two of the clusters have points that are 1 Km. apart and in the other cluster the points are more closely placed. One can associate these clusters with Commercial, Political and Infrastructure activity.

In the case of Ahmedabad incident, some amount of regularity is indicated at smaller distances (< 2 Km) and clustering at higher scales. If we look carefully, we see two peaks suggesting two clusters. The spatial distribution of the points in the case of Ahmedabad (**See Figure 11**) suggests this. There is regularity within each cluster – the clusters separated by a

Figure 14 L Function for Mumbai 1993 and Ahmedabad 2008 Serial blasts

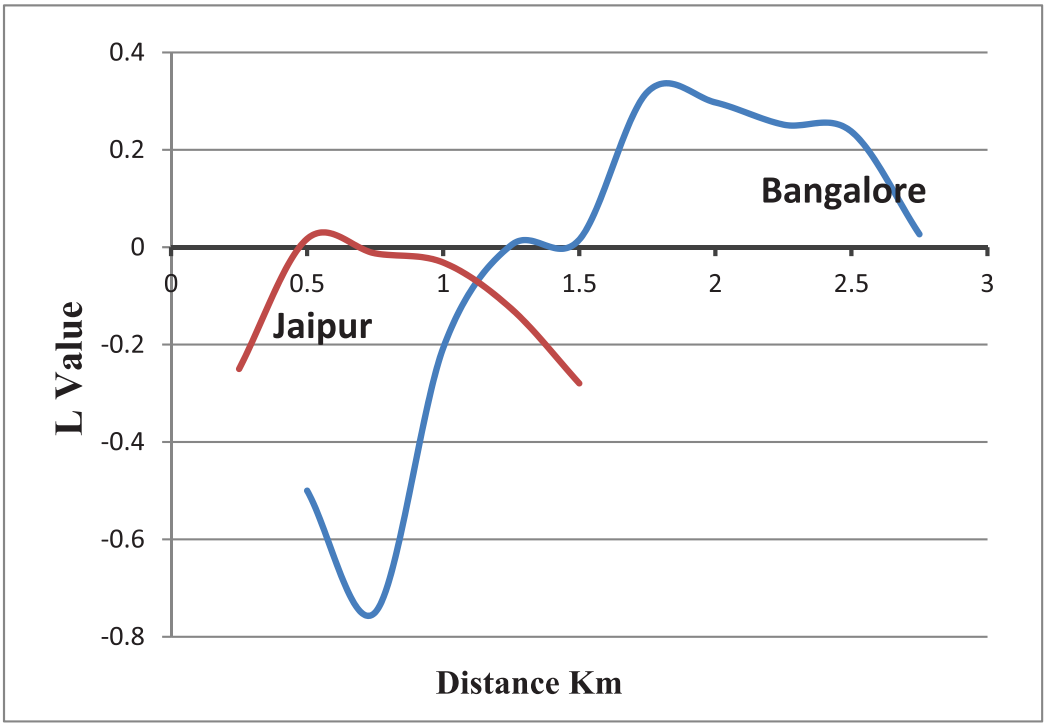


river. The points are on either side of the river. In the case of the Ahmedabad 2008 incident, which occurred the day after the Bangalore incident as many as 21 bomb blasts occurred within a span of 15 minutes at 15 different locations. Some of them are believed to be simultaneous although it is not known in what sequence the blasts occurred. At the outset, it appears that there are four clusters. But, if we look carefully, there are only two clusters. In fact if one looks at the distribution of the bombs, most of them were concentrated in the Mani Nagar area which is one of the developed localities in Ahmedabad and is also believed to have a cosmopolitan population. Since as many as 21 bombs were placed, the number of persons involved was at least twice this number, just for bomb placements. If the number of bombs that did not go off was added to this we have to conclude that a terrorist group carrying out such an operation has to be well organized in order to be successful.

However, in this case, the number of deaths was not as large as compared to the Mumbai 1993 blasts. This may be attributed partly to the materials used. It also suggests that maybe the planning was not very good in this case. It is also possible that the persons involved in placing the bombs were not adequately trained. Obviously a serial bomb blast involving as many as 20 or more bombs requires a lot of planning and organization in order to have the required impact. This requires considerable amount of training in bomb making and also knowledge of the city where the attack is planned. In fact support from the local population is very essential for this. The Ahmedabad incident seems to suggest that either this local knowledge was lacking in the terrorist group or that the attack had to be organized and executed in a hurry.

Figure 15 shows the L function for Jaipur and Bangalore 2008. In the case of Jaipur,

Figure 15 L Function for Jaipur 2008 and Bangalore 2008 Serial Blasts



regularity is obvious. In fact if we look at the image, we observe that the bombs were placed linearly along the road at regular intervals. There is no clustering in the placement of bombs. The broad area of operation was probably decided first and within that area they were probably dispersed according to convenience. The total area of operation was little more than 4.0 Sq. Km.

In the case of Bangalore, the picture is different. We see regularity at small scales up to 1.5 Km, and clustering at higher scales. The analysis for the Bangalore 2008 incident brings out a different result. The total area of operation was large, as much as 50 Sq. Km. Some of the points are clustered at distances of 1.75 Km to 2.75 Km. There is also a suggestion of regularity at distances of 0.75 Km as shown by the troughs below the X axis. However, the operation itself was not very successful primarily because of the way the bombs were distributed. In that sense it was not a very well planned attack. This is however, different from the Ahmedabad case. The area of operation in the case of Bangalore is smaller than that of Ahmedabad.

If we consider the loss of lives as a measure of impact and the level of sophistication, we observe that Mumbai 1993 incident has been the most devastating. As the L function indicates there are three clusters which are spatially separated. In the case of Jaipur, the loss is more than that of Ahmedabad even though fewer bombs were used in Jaipur - nine in Jaipur as against 21 in Ahmedabad. The spatial distribution of the bombs is regular in Jaipur. The area of operation is densely populated in Jaipur at the time of the blast. Added to this is the use of RDX for the purpose. All these suggest that the group responsible for this act must have been quite familiar with Jaipur.

In the case of Ahmedabad, the spatial distribution is clustered and regular within the cluster. However, considering the fact that 21 bombs were used, the impact was not significant. This could also be attributed to the material used. It is believed that the explosives were Ammonium nitrate based. We also need to keep in mind here that as many as 9 bombs were defused in Ahmedabad the following day. Since we do not have the data on the location of these bombs, they were not considered for the spatial analysis. Ideally these locations should also be included for getting the correct picture.

We note that the Bangalore 2008 incident resulted in the loss of one life. The spatial distribution of the bombs does not show any sophistication. The timings of the bomb blast also indicated a lack of planning.

Spatial analysis of this kind would be useful to ascertain whether there is a similar pattern in the bomb distribution. Of course the distribution of the bombs will have to be different in different cities. It will depend on the distribution of population, the kind of targets chosen and the materials available for making the bombs. The spatial distribution also motivates us to ask the question why these bombs were placed in a particular manner. Would the impact be different if the distribution was modified? Is it possible to do this kind of analysis? More importantly, if the bombs were placed randomly what would have been the impact? For the investigator of these incidents a spatial analysis is worthwhile at least to see whether the bombs were placed randomly or in a planned way.

The four cases discussed above show that the spatial distributions are different in each of the cases. It also shows that the organization methods are different even though all of them

are multiple blasts. In the Mumbai 1993 and the Jaipur incidents RDX was primarily used, while in the Ahmedabad 2008 and Bangalore 2008 incidents the explosives were based on Ammonium nitrate. Explosives based on Ammonium nitrate are relatively easy to obtain and could have been procured locally suggesting the involvement of internal terrorist groups. However, the knowledge of the group about Ahmedabad was obviously limited thus resulting in fewer fatalities. In the case of Jaipur the area of operation was small and even though the bomb placement does not appear to be very carefully planned, the impact was significant since the material used was lethal, and the area chosen was a densely populated area, particularly at the time of attack. It is well known that the Mumbai 1993 attack was well planned in terms of the explosives used, and the locations of the bombs.

Discussions - A Research Agenda

A data base on terrorism incidents in India that occurred between 1993 and 2010 has been built with the idea that this will enable academic researchers to understand the problem of terrorism in India holistically. The data has been collected from open sources primarily from English media sources. The database includes date and time of the incident, the locations, numbers of persons killed and injured, the targets chosen, the presumed perpetrators, whether a single bomb or multiple bombs were used, the explosives used, the packing method, the delivery method, delivery vehicle and the trigger mechanism used to set off the bomb. Every incident is hyperlinked to the source document containing the details of the incident. A summary of each of the incidents is also available.

Of the 63 incidents that have been analysed, there were nine incidents involving only attack with weapons. These resulted in less than 8 % of the total casualties. The Mumbai 2008 incident involved rifle attacks, bombs and grenades. This single incident resulted in 12 % of the total fatalities. Close to 18 % of the fatalities occurred in the Mumbai 1993 serial bomb blast.

There are 51 incidents that used only bombs. Some of them were serial blasts at multiple locations and some were multiple blasts in a single location. Many of the incidents are single bomb blasts.

Two types of statistical analysis are demonstrated using the data base. The first one is clustering of the 51 incidents based on the explosive materials used, number of bombs, number of locations, method of packing, delivery method and vehicles used, and the targets. Ten clusters are identified. The clusters are differentiated primarily by the bomb materials used, the delivery vehicles used and whether the incidents are single or multiple bomb blasts.

The second type of analysis is the spatial analysis of the distribution of bombs in multiple bomb blast incidents. The location of bombs in such incidents is critical and indicative of the sophistication and organization ability of the groups that carry out such acts. This type of analysis is demonstrated for four incidents – Mumbai 1993, Jaipur 2008, Bangalore 2008, and Ahmedabad 2008. Based on this analysis, it is possible to determine whether the bombs are placed randomly, regularly or in clusters. The results suggest that in the case of Jaipur, the bombs are placed at regular intervals; in the case of Mumbai and Ahmedabad they are clustered. The clustering of bombs is an indicator of the planning involved in the choice of the locations. The Bangalore incident shows both regularity and clustering. This kind of spatial analysis together with the kind of economic activities and demographic profile around the bomb location will throw light on why a particular location was chosen for the placement of the bombs.

Several questions have emerged from an initial analysis of this data:

- Why is it that half the incidents have occurred after 2005? Could this be attributed to the political situation in Pakistan? Is there a correlation between the political situation in Pakistan and the number of incidents in India?
- Why has Maharashtra been the most preferred target during this period?
- Have the targets of attack changed with time? Are there any preferred targets? If so, can we secure them?
- What kind of explosives is preferred by the terrorists? Has there been a technological change in the way the bombs are made and used?
- Can we assess terrorist groups and their preferred method of attack?
- What are the different trigger mechanisms that have been employed to set off the bomb thus far? Is there a trend?
- Are there similarities in operation between the various Mumbai incidents and other multiple bomb blasts in India? Are the Mumbai attacks similar to other major international incidents?
- What are the trigger events that lead to terrorist incidents in India?

Further in-depth analysis of each of the incidents together with other collateral data on the political, socio economic, demographic profile of the affected region will hopefully throw more light on this type of terrorism in India.

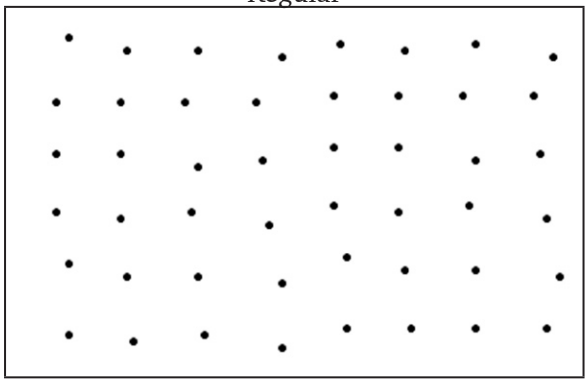
Annexure 1

Method of Calculating Ripley's K(r) function

A spatial point pattern is a set of locations within a region of interest. For our purpose, the locations of the bombs in a multiple serial bomb incident constitute a spatial point pattern. In our analysis, we treat the study area as a plane (although we do know that the earth is not a plane) since the area of interest is not very large. Points can be distributed in regular pattern, randomly or in an aggregated or clustered. This is illustrated below.

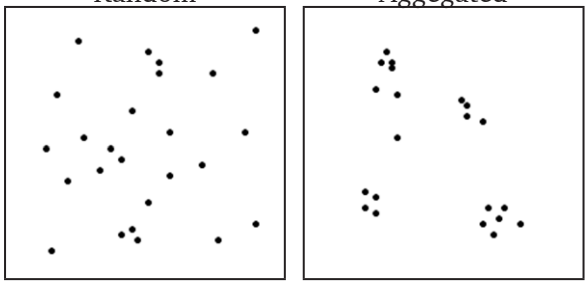
Spatial point pattern

Regular



Spatial point pattern

Random Aggegated



A completely spatial random distribution of points in space means that given an area A, events occur anywhere in this area with equal probability and are also independent in the sense that they do not interact with each other. There are basically two methods to describe a spatial pattern. One is in terms of the number of events in a pre-defined quadrat. Here we statistically analyse the distribution of number of events in the quadrats. This is suitable when we have a large number of events in the study area. This method is usually referred to as first order analysis.

The second method is based on the distance between events or points in the area A. Ripley's K function belongs to this category[24]. This is referred to as the second order analysis. Ripley's K function hereinafter referred to as K function is defined as:

K (r) = (Expected no. of other events within distance "r" of an arbitrary event) / λ,

where λ is the intensity or density of events (i.e. number of events per unit area). Thus, if there are "n" bombs distributed in area A, λ = n/A.

This can be expressed in the form –

$$K(r) = A/n \; \Sigma\Sigma I(dij \leq r)/n \quad A/n \; \Sigma\Sigma I(dij \leq r)/n,$$

[24] For a theoretical development of this function see Ripley, B.D., Spatial Statistics, Wiley Interscience, 1981, Ch. 8 Pages 167-170, 1981.

Where I (.) is an indicator function. d_{ij} $(i \neq j)$ is the distance between point i and point j.

I (.) = 1 if the distance between the points i and j is less than or equal to r

I (.) = 0 if the distance is greater than r.

I (.) is a count of the number of points that fall within a circle of radius r centered at point i.

The double summation ensures that the process is repeated for every point in the study area.

Since the study area is often arbitrarily decided, corrections for edge effects have to be made.

The edge effects[25],[26] arise because a circle of radius r may not lie entirely inside the study area. This is corrected by using Ripley's weighted edge correction that calculates K (r) as,

$$K(r) = A/n \sum\sum I(d \leq r)/n * w(r)$$
$$A/n \sum\sum I(d \leq r)/n * w(r),$$

Where $w(r) = 1 - \pi^{-1} \cos^{-1}(b_i/r)$,

Where b_i is the shortest distance between the centre and the boundary. We have chosen to define the study area as a rectangle.

W(r) takes the value 1 if the circle of radius r centered at point i is completely inside the study area. This kind of weighting actually takes the proportion of the circumference of the circle with radius r and centered at point i as the weight.

Once the K(r) values are computed for various intervals of r, we plot K(r) versus r and compare this curve with curve of π r^2 for the same range of values of r.

If the events are Completely Spatially Random (CSR) Ripley's K function K (r) = πr^2

If the events are regularly spaced Ripley's K function K (r) will be less than πr^2 and

If the events are clustered or aggregated Ripley's K function K (r) will be greater than πr^2

In actual application, a transformation of K(r) is usually employed called the L function[27],[28] which is defined as

$L(r) = \sqrt{(k(r)/\pi)} - r$

L (r) is a linear function and has an expected value of 0.

In this case conditions for CSR is made easier.

If L (r) = 0, the points are CSR;

if L (r) > 0, the points are said to be clustered or aggregated

if L(r) < 0, the distribution of points are regular.

In our analysis we plot the L function after edge correction for each of the incidents.

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[25] The need for edge correction and how to implement it is described in Haase Peter, Spatial pattern analysis in ecology based on Ripley's K-function: Introduction and methods of edge correction, Journal of vegetation science 6: 575-582, 1995.

[26] A demonstaration of the above is available in F. Li and L. Zhang, Comparison of point pattern analysis methods for classifying the spatial distributions of spruce-fir stands in the north-east USA, Forestry, Vol. 80, No.3, 337-349, 2007.

[27] Ripley, B.D., Modelling Spatial point patterns, Journal of the Royal Statistical Society. Series B (Methodological), Vol. 39, No. 2(1977), pp. 172-212

[28] Besag, in the discussion of Ripley (1977), suggested the use of a square-root scale to linearize the plot of k(r) vs. r

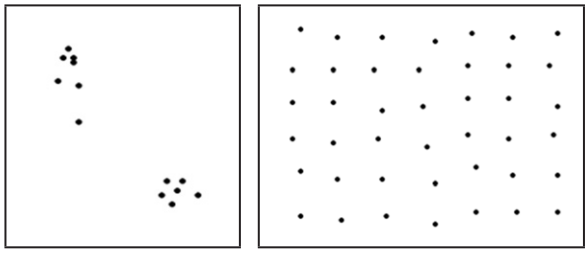
The analysis involves calculation of K (r) and comparing it with πr^2 for various values of r. A circle of radius r is centered at each location or point and the number of points within the circle is counted. By incrementing the radius r, concentric circles are drawn and for each r and for a given point the number of points inside the circle is counted. This is then repeated for all the points or locations in the study area. This is illustrated in the **Figure 16** below. Draw concentric circles with one of the locations as centre. In the figure Worli is taken as the centre. Count the number of points falling within each circle.

This method can be used to study the spatial distribution of the terror events and could form the basis for comparing different terror attacks from the viewpoint of the organizational elements that go into the planning and execution of an attack.

The change in the L function under different spatial patterns of terrorist events can best be understood through some examples.

Figure 17 provides two cases of how terrorist events can be spatially distributed.

Figure 17 Example of Clustered points (Left) and Regular points (Right)



We calculated the L function for a test data of 300 Sq. Km where 16 points are regularly distributed. The L function is plotted for different distances r ranging from 1 Km to 10 Km. **Figure 18** shows the L function when the points are regularly spaced. Observe that the L values are all below zero.

Figure 16 Illustration of computation of K function

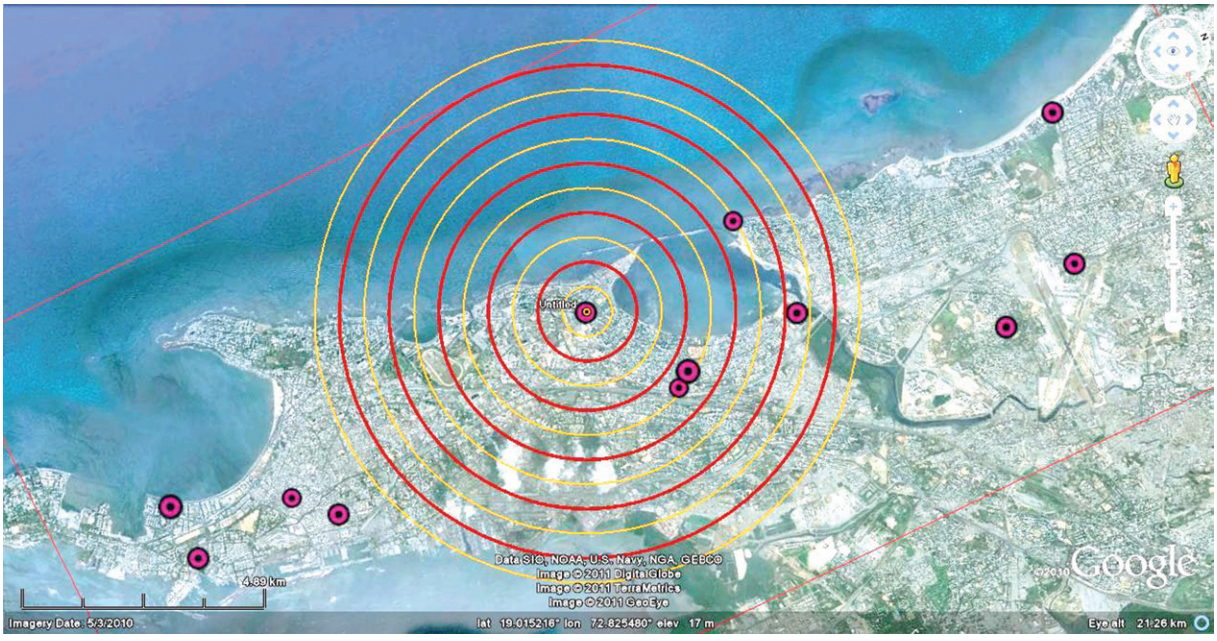


Figure 18 L function for hypothetical Regular Data Points

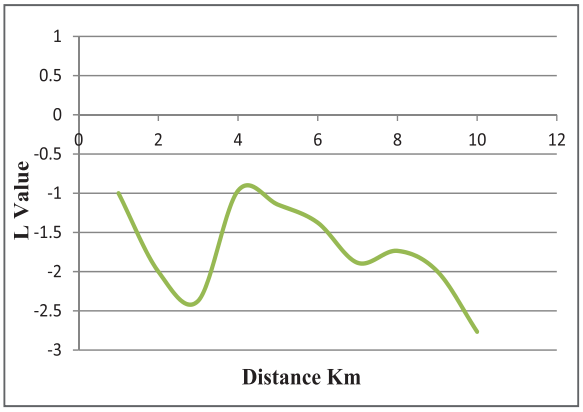
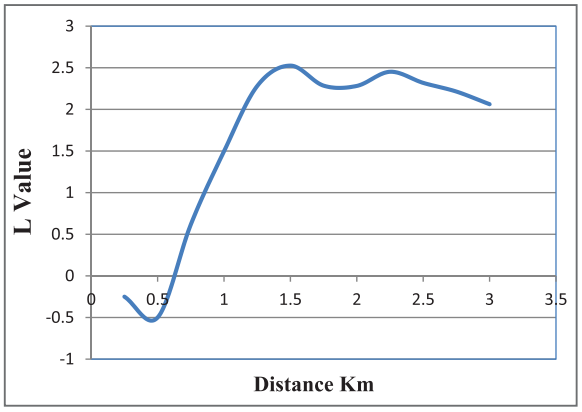


Figure 19 L function for hypothetical Clustered Data



Contrast this with case when the data set consists of 9 points distributed as two clusters in an area of 160 Sq. Km. The L function shown in **Figure 19** for this data set is distinctly different. It shows regularity at small distances up to 0.7 Km and then displays clustering (L(r) > 0).

These are shown just to indicate the nature of the curve describing regular distribution of points and clustered distribution of points. Normally, in the point pattern analysis of natural phenomenon, upper and lower confidence intervals are drawn for the L function and the calculated L curve is compared with these intervals. So long as the curve falls inside the confidence intervals, the points are said to be randomly distributed. In our study we did not attempt this because we do not have large number of points in the study area.