Chapter VI

TAGGANT UTILITY REVIEW

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Chapter VI

TAGGANT UTILITY REVIEW

INTRODUCTION

Bombings are a particularly heinous crime as they are normally indiscriminate in their choice of victims, often involve innocent people, and have the potential for producing large numbers of casualties and high property damage. Bombings are attractive to the perpetrator as bombs can be placed at the bomber's convenience and set to detonate at a time when the bomber is elsewhere. Bombings are a quite spectacular crime, easily drawing public attention when that is the perpetrator's purpose.

Bombings are particularly difficult crimes for law enforcement agencies to handle as the bomber is not usually near the scene of the crime, the physical evidence is destroyed or damaged by the detonation, and the materials necessary to fabricate even a quite catastrophic bomb are easily obtainable.

It is the purpose of this chapter to review the utility of both identification and detection taggants to law enforcement and security personnel. In order to assess the utility of taggants, it is first necessary to understand the magnitude of the bomber problem, including the types of bombers, the types of targets, the sources of explosives, and current measures to control and combat bombers. This information is reviewed in the next section. The utility of taggants is then discussed, together with possible responses by criminal bombers to a taggant program. The chapter concludes with a short discussion of the experience of selected foreign countries in the control of bombers.

In the analysis it is assumed that the taggants have been demonstrated as safe to add to explosive materials; that the identification taggants survive the detonation of tagged explosives and can be recovered at the scene of the crime, either directly or by laboratory separation of collected debris; and that sensors exist which detect the detection taggant vapor at a parts-per-tril l ion concentration in air, with extremely few false alarms and with no requirement for special maintenance or skilled operators. These assumptions would have to be verified before a taggant program could be implemented.

The analysis is primarily qualitative. Data exist on the numbers and types of criminal bombings which take place, but it is difficult to analyze the data as it is not consistent from one data bank to another and information retrieval in any other than summary form is difficult. Characterization of types of perpetrator, or of motives, is available in only a limited number of bombings; even identification of the explosive filler is not available for a sign if icant fraction of bombings.

No data exist that would allow a quantitative assessment of the numbers of bombers

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who would be deterred, arrested, or convicted as a result of a taggant program, or of the amount of property damage or casualties which would be averted by such a program. An analogy can be drawn between the utility of the current date-shift information contained on explosive cartridge cases and the utility of identification taggants in apprehending and convicting bombers, but the date-shift information utility data base is quite small. Similarly, an analogy can be made between the drop in hijackings that occurred after the introduction of antihijacking procedures and the potential reduction to be expected in the bombings of high-valued, controlled-access buildings protected by detection sensors. Such analogies are discussed in the text. The primary source of data on the current bombings threat, current means of combating that threat, and the utility of taggants to law enforcement personnel, however, comes from the opinion of law enforcement personnel in the field.

In-depth discussions were held with a broad cross section of law enforcement and security personnel, including personnel from the following agencies:

- domestic law enforcement and security personnel. (New York City; San Mateo County, Calif.; Dallas-Fort Worth Airport; Summit County, Ohio; Washington, D.C.);
- foreign law enforcement personnel (West Germany, England, Republic of Ireland, INTER PC) L);
- Federal agencies (Federal Bureau of investigation (FBI), Federal Aviation **Administration** (FAA), Bureau of Mines, Department of Transportation, Corps of Engineers, U.S, Army Criminal **Investigation** Division, U.S. Army Development and Research Command); and
- contractors (Management Sciences Associates (MSA) and Institute for **Defense Analysis).**

A number of discussions were also held, on various subjects, with the Bureau of Alcohol, Tobacco, and Firearms (BATF), the agency charged with explosives control.

Unfortunately, it was not possible, given the time and money constraints of the OTA analysis, to meet with as many law enforcement personnel as would be desirable, particularly given the large variations in types of bombers, types of targets, and local laws and procedures **in the various parts of the country.** To obtain a larger sample of expert opinion, a questionnaire was sent to approximately **950** members of the International Association of Chiefs of police (I AC P), chosen at random from their directory. The IACP was chosen because of the OTA desire to obtain input from a broad cross section of the law enforcement community—geographically, functionally, and by size of community. The results of the in-depth interviews and questionnaire responses are integrated in the discussion in this chapter. A detailed discussion of the questionnaire is given as appendix B. Due to the small response rate (approximately 15 percent) the sample may be biased. However, the bias is probably toward those with knowledge of, and interest in, the subject. An additional possible bias was introduced by an error in the explanatory material accompanyin, the survey, which indicated that the identification taggant trace would identify the last legal purchaser of the explosives, rather than indicating that the trace would produce a list of last legal purchasers.

PROBLEM CHARACTERIZATION

Approximately 3,000 incidents are reported annually in the BATF Explosives *Incidents Report.* The incidents include accidents, threats, recovered explosives, and hoaxes, as we l l as actual explosive and incendiary bombings. The BATF report contains a breakout by target type and explosive filler used, but little information on the various types of perpetra-

tors. The FBI compiles similar bombing statistics at its National Bomb Data Center, which are published quarterly and summarized annually. The bombings are committed by a wide range of perpetrators, who differ in their skills, resources, motivations, and types of targets attacked. Current security measures at most explosive manufacturers, distributors, and users are sufficient to dissuade casual outside theft, but cannot readily protect against thefts that are committed by or assisted by employees, or against a determined outside attempt to steal explosives. Protection of some high-value potential targets against bomber threats is currently adequate but some targets are essentially unprotected against a serious bombing attempt. Finally, current law enforcement efforts to control criminal bombings are not very effective. These topics are discussed briefly below.

The Bombing Threat

Both the FBI and BATF maintain national bombing data information centers which collect statistics on bombings and other explosive incidents. The data are not consistent between the two centers, however, and many bombings are not reported to either center. The formatting of the data, and the lack of updating procedures, make accurate analyses difficult.

The BATF 1978 *Explosives Incidents Report* includes over 3,000 incidents for both 1977 and 1978. The incidents include accidents, threats, seized and recovered explosives, and hoaxes as well as actual explosive and incendiary bombi rigs. Of these incidents, 1,377 represented explosive detonations, accidental detonations by criminals, or recovered bombs which failed to detonate in 1977, with 1,250 the corresponding number for 1978. At least 953 of these in 1977 and 787 in 1978 represent actual detonations of explosive bornbs against substantial targets (mailbox and open-area bombings are not inclided).

During 1977, at least 38 people were killed and 180 wounded by explosive and incendiary bombs, while the numbers in 1978 were 23 and 185, respectively Due to the way initial estimates of property damage are made in the BATF data and the lack of updating, only the crudest property damage estimates can be made. There was at least $10 million in direct property damage due to explosive and incendiary bombs in 1977, and at least $17 million in 1978. Thirty-five of the thirty-eight reported deaths in 1977 and twenty of the twenty-three reported in 1978 were from bombings against vehicles, residences, and commercial establishments. Similarly, about 80 percent of the injuries from bombing of known targets in 1977 and 70 percent in 1978 were caused by bombings of those three types of targets.

The FBI data, as indicated above, are somewhat different, both in number of incidents reported and in the breakout of categories. In 1977, for instance, FBI data show 867 actual explosive bombings and 118 attempted bombings. Similarly, the number of people reported killed that year from both explosive and incendiary bombings was 22, while 162 were reported injured. In 1978 there were 768 explosive bombings and 105 attempted explosive bombings. The pertinent 1977 and 1978 BATF and FBI statistics are summarized in table 54.

Table 54.–Minimum Bombing Incidents Statistics Summary'

	BATF		FBI	
Item	1977	1978	1977	1978
Explosive bombings, number	1,037[b]	896[b]	867	768
Undetonated explosive bombs, number	319	287	118	105
Incendiary bombings, number	339	446	248	349
Unignited incendiary bombs, number	81	71	85	79
Criminal accidents, number [c]	21	67	–	–
Property damage from bombings. millions of dollars[c, d]	$ 10	$ 17	$ 9	$ 9
Injuries [c] ...	180	185	162	135
People killed by bombings [c]	38	23	22	18

[a] BATF repel'fed 3177 total Incidents in 1977 and 3 256 in 1978 Total Incidents include accidents threats seized and recovered explosives and hoaxes as well as actual explosive and incendiary bombings The OTA study was concerned only with explosive bombings
[b] Of these 953 in 1977 and 787 in 1978 were against substantial targets
[c] Includes both explosive and Incendiary bombings OTA was unable to obtain separate figures for number of criminal accidents injuries deaths and property damage caused by explosive and incendiary bombs Incendiary bombs and bombings would not be affected by the proposed taggant program
[d] Actual value probably considerably higher due to lack of data file uPdates

SOURCE *BATF 1978 Explosives Incidents Report FBI Uniform Crime Report Bomb Report 1978* See app F for a discussion of the derivation 01 these figures

An effort was made to resolve the differences in statistics compiled by FBI and BATF; according to the Explosives Enforcement Division of BATF:

- There is no Federal statute or law on the books requiring local police officials to report bombing incidents to either BATF or the FBI.
- Cooperation at the local level has led to an informal procedure on the part of local police to report a bombing incident to either BATF or FBI, who in turn will normally notify each other. (There are obviously some breakdowns in this procedure).
- There is a statute giving BATF the "right of inspect ion" at the site of any explosion; therefore, whether BATF receives word of a bombing from the local police, or whether a local special agent reads of it in the local paper, BATF can by law check it out.
- BATF requires each agent to report *all* bombing incidents to its explosives data center in Washington, irrespective of the theoretical importance, damage, casualties, or jurisdiction since, among other uses, these data are used by the Secret Service in arranging security for the President when he is travel ing.
- There is a question of jurisdiction with reference to investigations. A memo of understanding exists between BATF and the FBI. Generally the FBI covers terrorist acts, attacks on airlines, attacks involving unions, college campus buildings, and Federal buildings other than Treasury and Postal buildings. BATF has primary jurisdiction over criminal bombings related to interstate commerce, firearms violations, and Treasury buildings. Either the FBI or BATF may respond to requests for aid from other jurisdictions. Conflicts are settled by mutual agreement.
- The normally higher number of incidents annually in BATF reports is a direct result of the above.

It is of considerable interest to know whether the statistics for 1977 and 1978 are characteristic of the recent past, or if trends in criminal bombings are apparent. Table 55 shows the bombing trend since 1972, from the FBI data. While the BATF numbers differ, the rough trends are similar. Figure 22 shows the trends graphically, with the total number of incidents depicted in figure 22a, property damage in 22b, injuries in 22c, and deaths **in 22d. The total incident numbers in figure 22a include both successful bombings and attempts; the property damage and casualty figures may include incendiary bombings as well as explosive bombings. No long-term trend is detectable from the data, although an unusually high number of incidents and casualties occurred in 1975. This increase was primarily due to three incidents.**

1. **On January 24 a bombing at the Fraunces** Tavern in New York .City killed **4** people, injured 53 others, and did extensive property damage. Responsibility for the bombing has been claimed by FALN, the Puerto Rican separatist terrorists.
2. A bomb detonated in the baggage claim area at La Guardia Airport, on December 29, killing 11 people with 70 additional serious injuries. No positive identification of the exact type of explosives used has been made for this incident and no attribution has been made.
3. A bomb detonated at a sponge factory **in** Shelton, Corm., in March 1975, killing

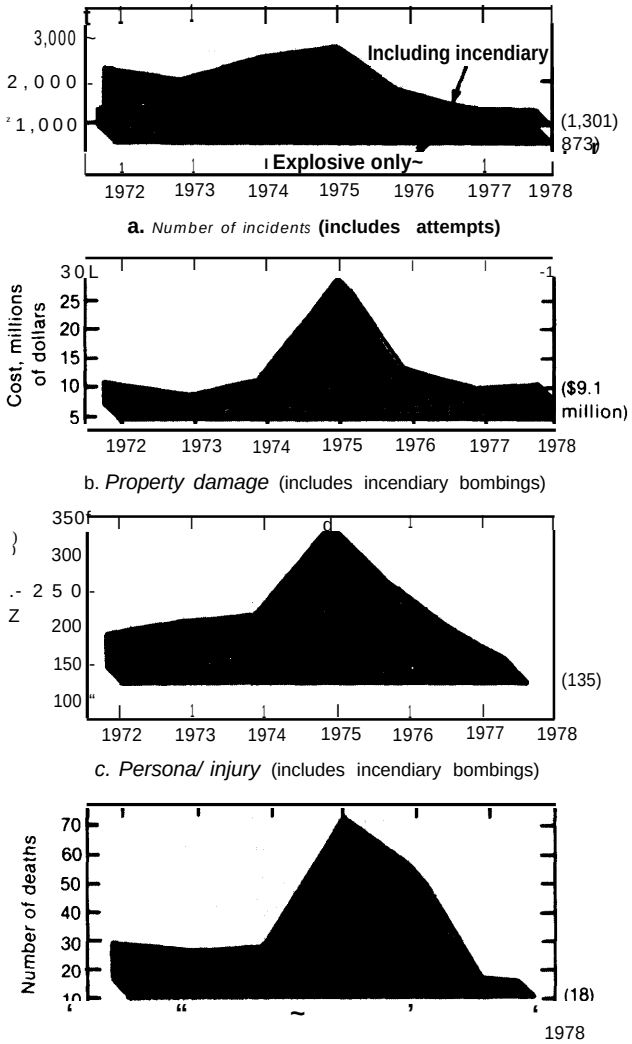
Table 55.–Explosiv e 8 Bombing Incident Trends, 1972-78

Year	Total actual and attempted explosive bombings	Actual	Attempted	Total actual and attempted incendiary bombings	Actual	Attempted	Property damage (dollar value)	Personal injury	Death
1972 .,	951	714	237	1,011	793	218	$ 7,992,000	176	25
1973	995	742	253	960	787	173	7,262,000	187	22
1974. , ...	1,129	893	236	915	758	157	9,887,000	207	24
1975, . . .	1,326	1,088	238	748	613	135	27,004,000a	326'	69a
1976 ..., . . .	1,040	852	188	530	405	125	11,265,000	212	50
1977, ... ,	985	867	118	333	248	85	8,943,000	162	22
1978. , ...	873	768	105	428	349	79	9,161,000	135	18

[a] Includes three major bombing incidents resulting in unusually high personal injuries and deaths and substantial damage to property

SOURCE FBI *Uniform Crime Reports Bomb Summary 1978*

Figure 22.—Annual Bombing Statistics, 1972-77



a. *Number of incidents* **(includes attempts)**

b. *Property damage* (includes incendiary bombings)

c. Persona/ injury (includes incendiary bombings)

d. *Deaths* (includes incendiary bombings)

SOURCE: Drawn by OTA from FBI data

three people and injuring several others. No attribution has been made for this incident.

Using FBI and BATF data, the trend of both total bombing incidents and catastrophic incidents was analyzed by MSA for the 5-year period from 1972 **through 1976. The data show no significant change in incidents over that period, although 1975 and 1976 had significantly higher injuries and deaths. In contrast** to inferences based on past statistics, many experts believe a significant increase in bombings, particularly catastrophic bombings, can be expected over the next few years. It should be noted that a single incident involving an aircraft exploding in flight could produce more deaths than have occurred in the United States from bombings during this decade. Such incidents have occurred in foreign countries and a near miss occurred recently in New York. On March 25, 1979, a TWA plane bound from New York to Los Angeles was delayed. A bomb planted in the checked baggage exploded while being transported to the aircraft *on* the luggage truck. If the aircraft had taken off on time the bomb might have caused the deaths of most or all of the 166 people aboard.

Explosives Used in Bombs

Data on the types of fillers used in bombs are also not consistent between FBI and BATF data banks. It is instructive to look at two BATF data sources, however, as shown in table **56.** The second column represents **1978 data for the fillers identified in the field** for all explosive bombs that were detonated, bombs recovered undetonated, and criminal accidents. The first column represents 1978 data for only those fillers that were identified in the laboratory from postdetonation analysis. In both cases, black and smokeless powders and cap-sensitive high explosives all occur with high frequency. Table 57 shows a breakout of the estimated number of significant bombing incidents, deaths, injuries, and property damage occurring during 1978 by explosive material filler. The average of the two frequencies columns shown in table **56 was used for the table 57 estimates. (See app. F for the derivation of**

Table 56.–Identified Explosive Fillers Used in Bombs

	Lab identified fillers 1978	All identified fillers 1978	Average
Black powder	13%	21%	17Y0
Smokeless powder	16	19	17.5
Military	2	7	4.5
Cap sensitive	32	30	31
Blasting agents	–	1	.5
Chemicals	–		
Others	36	2:	28:;

See app F for derivation of these numbers
SOURCE BATF data

Table 57.–Bombing Casulties and Damage in 1978 by Type of Bomb

Filler material	Number of bombings against substantial targets	Deaths	Injuries	Property damage $ millions[a]
All fillers.	**1,298**	**23**	185	$17.2
Incendiary . . . . . .,	**428**	**3**	13	3.7
Black powder ., ., ...	**148**	**4**	19	.2
Smokeless powder, .,	**152**	**3**	23	.2
Military explosives.	**39**	**0**	7	—
Cap sensitive.	**270**	**7**	26	**3.3**
Other		**3**	40	**2.4**
Unknown . .		**3**	57	**7,4**
Total for those fillers which would be directly tagged [b],	570	14	68	3 7

[a] Value probably higher due to lack Of data update
[b] Cap-sensitive explosives black Powder, and smokeless powder would be tagged

SOURCE BATF data See app F for a derivation of these figures

these numbers.) The table shows that a large percentage of the total bombings deaths and casualties is caused by black powder, by smokeless powder, and by cap-sensitive high explosives.

Types of Targets Bombed

The types of targets that attract criminal bombers range from attacks on mailboxes and outhouses by vandals and pranksters to attacks on aircraft by terrorists. The targets most frequently attacked on a year-in, year-out basis are private residences, commercial facilities (usually small operations), and vehicles. Table 58 is taken from the BATF 1978 Explosives incidents *Report.* It shows the total number of actual bombings (both explosives and incendiary) for the years **1977 and 1978, the bombing breakout by target type, the number killed and injured, and the estimated property damage, all by target** type. The FBI data are somewhat different, but show the same trends in that the majority of bombings, property damage, and casualties occurs at residences, at commercial facilities, and in vehicles. In table 59, these data are rearranged to explicitly show that most of the bombings and casualties would occur at targets that are not likely to be protected by detection sensors. It is extremely unlikely that such sensors would be placed **in private residences or in vehicles; most commercial establishments** would also not have sensors. If the assumption is made that all of the incidents that happened at commercial facilities occurred at facilities unlikely to be protected by sensors, then **79 percent of the incidents, 89 percent of the injuries, and 94** percent of the deaths from actual explosive and incendiary bombings which happened in 1977 **and 1978 occurred at places unlikely** to be protected by detection taggant sensors.

Data are not available that would allow separation of the explosive and incendiary bombings statistics. It is likely that a larger percentage of the targets of explosive bombings would be of the type protected by a detection sensor, but probably not a large percentage.

Characteristics of Criminal Bombers

Criminal bombings are committed by a wide range of perpetrators, including both individuals and groups. While it is always difficult to place a heterogeneous population into well-defined categories with well-defined characteristics, it is helpful to group criminal bombers into four categories: terrorists, common criminals, mentally disturbed, and vandals and experimenters. These groups vary greatly in motivation, skill, training, resources, and ability to respond to a changing enforcement environment. It is also difficult to determine which group is responsible for a bombing, although "credit" is sometimes claimed, particularly by certain terrorist groups. Of the bombings reported in the BATF 7978 *Explosives Incidents*

Table 58. –Bombings by Specific Targets for 1977-78 (actual detonations or ignitions)

Type target	Total incidents		No. killed		No. injured		Property damagea	
	1977	1978	1977	1978	1977	1978	1977	1978
Residential	352	294	17	7	66	57	$ 1,022.3	$2,982.2
Commercial	367	375	7	6	48	46	6,640.1	8,777.7
Airports/aircraft:	7		I	–	1	—		,2
Police facllltles/vehicle	14	2:	—	—	—	—	5:;	70.4
Educational	106	97	—	—	13	5	43.1	532.3
Government (local)	24	9	—	1	1	4	145.6	70.1
Government (Federal)	26	22	—	—	4	1	2.4	6.6
Military installations	4	3	—	—	—	1	—	0.0
Utdilities.	51	57	I	–	1	2	628.0	1,727.7
Banks	22	18	—	—	—	—	225.2	49.3
Vehicles	216	252	11	7	24	25	363.3	2,119.4
Open areas	36	40	1	2	8	13	.5	4.2
Mailboxes	48	69	—	—	1	2	25.8	2,1
Other	90	137	—	—	8	27	1,206.8	869.9
Unknown[b]	34	2	—	—	5	2	22.6	0.0
Total	1,397	1,409	38	23	180	185	$10,331.7	$17,212.1

[a]Property damage figures are in thousands and are estimated
[b]This category includes those incidents where the type target was either unknown or not reported

SOURCE BATF *1978 Explosives Incidents Report*

Table 59.–Percent of Bomber Targets That Would Be Protected by a Detection Sensor

	Total bombings [a]		Injuries		Deaths	
Average number of bombings of known, substantial targets[b]	1,175		150		29	
Bombings of residences, vehicles	557	(47%)	86	(58%)	21	(72%)
Bombings of commercial establishments	371	(32%)	47	(31%)		(22%)
Total unlikely to have sensors	928	(79%)	133	(89%)	2	(940/0)

[a]Includes both Incendiary and explosive bombings for 1977 and 1978
[b]Open fields and mailboxes are excluded from these data

SOURCE BATF data

Report, a motive was established for only 2 3 percent of the bombings in 1977 and only 38 percent in 1978. Keeping in mind the above caveats, it is nonetheless useful to examine the characteristics of the various groups, which are summarized in table 60 and briefly described below.

Terrorists

The terrorist groups active in the United States vary widely in ability, resources, training, and adaptability. They share the common characteristics, however, of high motivation, action as a part of a group, and a continuing involvement in catastrophic, illegal activities against society. These characteristics make the terrorist particularly dangerous to society and a particularly appropriate target for anti bombing controls. Terrorists can be roughly divided into political, reactionary, and separatist groups. Political groups, such as the Weather Underground, are primarily interested in attracting attention to and sympathy with their cause. For that reason they engage in spectacular events, such as bombings, but generally attempt to avoid or limit injury and death resulting from their bombings. Political terrorists often have considerable resources available to them, due to a significant number of people who support their aim, if not necessarily their means. The leadership of most of these groups are of above-average intelligence, and have either had specialized training or have studied extensively in terrorist activities. They are thus able to adapt to a changing environment, although the range of responses available to them may be limited by their political aims. They may lack mechanical skills, however, and be more likely to be involved in accidental ex-

Table 60.–Attributes of Criminal Bomber Groups

Perpetrator	Experience and training	Resources	Motivation	Individual or group	Reaction capability	Frequency
Criminal						
Unsophisticated	L	L	M	I	M	Multi
Sophisticated	H	M	H	I	H	Multi
Terrorist						
Political	M-H	M-H	M-H	G	M-H	Multi
Separatist	M-H	M	H	G	H	Multi
Reactionary	L	L	H	G	L-M	Multi
Mentally disturbed						
Disenchanted	L	L	L-M	I	L	Single
Vengeful	L	L	M-H	I	L-M	Single
Pathological	L-M	L	H	I	L-M	Varies
Other						
Vandals	L	L	L-M	I	L	Single
Experimenter	M	L	L-M	I	L-M	Single

L-Low, M-Moderate, H-High, I-Indwldual, G. Group
SOURCE Offlce ol Technology Assessment

plosions, either while fabricating bombs or while placing them. Political terrorists have become less visible in the United States in recent years.

Separatist groups, such as FALN, generally hope to gain their aim by generating a reaction to their activities, rather than sympathy for their aims. They are therefore generally less concerned with public revulsion to bombings that cause substantial injury and deaths. Separatist groups have been credited with more than 25 percent of catastrophic bombings—those resulting in major property damage, injuries, and deaths. The resources of domestic separatists vary from group to group, but are generally less than for comparable groups of political terrorists, as only a fraction of the population represents even potential supporters. As an example, few people outside of the Yugoslavian exile community care whether or not the Croatians achieve separation from the Yugoslavian federation; on the other hand, a group like the Weather Underground, that seeks to exploit discontent with the U.S. Government, could seek support from a larger population. Separatist groups are often critically dependent on a small cadre of leaders; loss or incapacitation of those leaders may shatter the group or considerably reduce their effectiveness. As an example, FALN in New York lost their bombmaker over a year ago and have not committed any bombings in New York since that time. Their ability to react to a changing control environment is less than the political terrorist groups, due to more limited resources. If the goal of the separatist group is viewed with sympathy by a large part of the population, as is the case in Northern Ireland, then the group can attract resources, attract recruits, and perfect skills. If, on the other hand, the population is either not in sympathy with the separatists or is not directly affected by the cause of the separatists (as is the case of the Croatians in the United States or the South Moluccans in the Netherlands), then the group will not be able to attract resources or otherwise grow.

Reactionary groups, such as the Ku Klux Klan and the American Nazi Party, would appear to share some of the characteristics of the political terrorists, but generally do not possess the same levels of training, motivation, and resources, and are not as capable of reacting effectively to a changing control environment. They also differ in that their bombings are usually directly targeted at the individual or group they intend to influence, rather than simply at a spectacular target. Generally, their purpose is intimidation; thus, fairly small, contained bombs are used. Even when murder or injury is desired, the results are usually confined to the directly targeted individual. While

the political terrorists are generally younger and well-educated, the reactionary terrorists tend to be less well-educated and somewhat older.

Terrorists, as a group, have been responsible for approximately 12 percent of those bombing incidents in the past 5 years for which the FBI attributed a motive,

Common Criminals

Criminals range from the petty operator who utilizes a bomb for extortion to the professional bombers of organized crime, The petty operator is generally poorly trained, not very motivated, has limited resources, and cannot readily adapt to a changing enforcement environment. The only major characteristics he shares with the professional bomber are that his targets are generally individuals or small commercial establishments, unlikely to be protected by a detection taggant sensor, and that he generally works alone or as part of a small group. The petty operator normally engages in repeated bombings over a number of years.

The professional bomber is highly trained and motivated and generally has considerable resources available to him, either directly or through his "employer." While the professional generally works alone, he may be affiliated with a larger criminal structure, such as the organized crime network in the United States. His target may range from bombs planted as a result of labor problems to murder-for-hire "hits." The professional bomber and the more sophisticated terrorists share many characteristics and are the most difficult to control or contain.

Criminals as a group are responsible for approximately 11 percent of bombing incidents. Most incidents are limited to specific targets and do not generally cause substantial injury or death to innocent bystanders.

Mentally Disturbed

The category of mentally disturbed includes psychopaths, those seeking revenge for a real or imagined wrong, and those who may be temporarily disenchanted with a particular situation. Many of the individuals who become terrorists or criminals could fall into this broad category; the term is limited here to the disturbed persons who act alone and do not act for profit.

The mentally disturbed bomber also differs from terrorists and criminals in that he generally does not engage in multiple bombings, although exceptions such as the Los Angeles "alphabet bomber" certainly exist. He generally is poorly trained, has limited resources, and acts alone. He is often highly motivated, but perhaps only for short periods of time, in direct response to some stimulus. He is extremely limited in his ability to respond to changing control situations, either through lack of care of consequences or belief in his invincibility. As his motives are hard to identify, it is difficult to predict his target.

The mentally disturbed account for approximately 38 percent of al I bombing incidents that can be attributed to a specific type of perpetrator.

Vandals and Experimenters

Vandals and experimenters share the characteristics of poor training, limited motivation, and limited resources. They generally work alone or in small groups, and do not generally intend to harm people or cause extensive damage. Their targets are often of little value, such as mailboxes or outhouses, but some acts of vandalism can cause extensive damage to buildings such as schools. While accounting for 39 percent of the reported bombing incidents, they are responsible for little damage and few casualties.

The primary danger from this group is that a harmless prank may accidently turn into a major bombing with subsequent significant property loss and casualties. There is also the danger that experimenters will learn their craft and "graduate" to a more dangerous category of criminal bomber.

In summary, table 61 shows the approximate number of significant explosive bombings (excluding mailboxes and detonations in the open) that would be attributable to each type

Table 61 .–Estimated Number of Significant Bombings by Group of Porpotrators (average of years 1974-78)

Perpetrator group	Estimated number of bombings
Terrorists, ., ., ., .,	107
Criminals	98
Mentally disturbed ., ., ..., ., .,	340
Vandals and experimenters. ., ...	348

SOURCE FBI data See app F for a deribation of these figures

of perpetrator, if the same relative distribution by perpetrator held for unattributed bombings as for attributed ones. To obtain these estimates, OTA averaged F B I data from the 5 years 1974-78 (no 1979 data is yet available). Year-to-year numbers vary due to changes in the FBI categories and method for allocating bombings by motive. (See app, F for more detail.)

No detailed data is available concerning the number of deaths and injuries caused by the various bomber groups. However, almost 40 percent of catastrophic bombings (those with casualties or serious property damage) are attributed to separatist terrorists and the more professional criminals.

Sources of Explosives

The explosives used in criminal bombings can come from a variety of sources, including:

- legal purchase,
- illegal purchase,
- theft,
- importation from abroad,
- homemade, and
- theft of some components, fabrication of others.

At present, a determination of the source of explosives can rarely be made except in the case of bombs that have been recovered undetonated. The date-shift code information on the cartridge label allows the source of the recovered explosives to be traced. Such traces can, theoretically, locate the source of essentially all cap-sensitive high explosives recovered in their original cartridges; however, investigative effort is necessary to determine which of the last legal purchasers on the list is the source of the explosives. Such an effort would be expended if the recovered bomb had the potential to cause catastrophic damage, if the target was an important one, or if the pattern of the attempted bombing indicates that useful intelligence information would be gathered by the trace. Devices recovered undetonated, which were small in size or which were to be used against relatively unimportant targets, may well never be reported to the BATF network,

While it is impossible to determine precisely the source of explosives used in most criminal bombings, analysis of the existing data does indicate some trends. Examining table 56, it appears that homemade explosives are used very infrequently in criminal bombings in the United States, although they account for up to 85 to 90 percent of the explosives used in countries such as West Germany and England, where commercial explosives are rigorously controlled. There also appears to be little use of explosives imported from abroad, a judgment supported by discussion with various law enforcement agencies. Both of these sources could become more important, however, if a taggant program were legislated.

I l legal purchases are primarily of stolen explosives, discussed below. That leaves legal purchases and theft as the primary current sources of explosives.

Explosive materials can be purchased legally in each State; the requirements vary from State to State, and they vary for different explosive materials. In every State, gunpowder can be purchased legally; identification may or may not be required for smokeless powders and is required for black powder. In some States, cap-sensitive high explosives can be purchased simply by showing identification and filling out a form. In others, the explosives can only be legally sold to people with State or Federal licenses.

A general rule-of-thumb expressed by most law enforcement personnel was that criminal bombers will use the most easily available source. If explosives can be purchased legally, the bombers will do so; the Weather Underground apparently purchased much of their ex-

plosives legally in New Hampshire. If explosives are easy to steal, then stolen explosives will be used. Explosives are more prevalent and easier to steal in the western States; a large theft from Colorado, for instance, furnished the explosives for a large number of bombings in the Eastern States.

BATF keeps track of stolen explosives, as well as explosives seized, recovered, or found. The data for 1977 and 1978 are summarized in table 62. While no firm conclusions as to outstanding amounts of explosives can be made on the basis of the data, several trends are apparent.

- Little gunpowder is stolen. As gunpowder are easily purchased, there is little need for theft
- Large amounts of blasting agents are stolen, and recovered, each year. According to table 56, however, little of it is used in criminal bombings.
- More military explosives seem to be recovered than stolen. This may be due to the inclusion of "souvenirs" as recovered explosives, or to the reluctance of the military to report thefts. At any rate, the amounts stolen are small. Much of the military explosives used by criminal bombers is material acquired some years ago. For instance, the Cuban exile terrorist groups, such as omega 7, still primarily use C-4 given to them by the Central Intelligence Agency at the time of the Bay of Pigs invasion.
- The amount of cap-sensitive explosives stolen and recovered appears in rough balance. Some of the recovered explosives, however, include abandoned explosives found in old mines and other places. A significant net amount is probably available, and used, for criminal bombings.
- A large net number of blasting caps appears to be stolen each year, and to be available for use in criminal bombings. This is not surprising as caps are generally not as well secured as main charge explosives. If a taggant program is initiated, security of detonators will require upgrading, as detonators are generally needed to initiate explosives and the fabrication of detonators is a much more difficult and dangerous job than fabrication of the main explosive charge.

An additional analysis can be made of the frequency with which explosives are stolen on a State-by-State basis and compared to the frequency of criminal bombings. A high correlation appears between the number of thefts and number of bombings. An even higher correlation appears when the thefts from nearby States are included in the analysis. As an example, both California and New York have more stringent regulations controlling the use and storage of explosives than nearby States such as New Jersey and Washington. Law enforcement officials feel that many of the incidents in New york and California use explosives stolen in New Jersey and Washington.

Table 62.–Stolen and Recovered Explosive Summary

	Amount stolen		Amount recovered	
Tvpe	1977	1978	1977	1978
Blasting agents, pounds	20,834	42,172	21,260	23,623
Black powder, pounds	145	379	277	723
Smokeless powder, pounds	0	163	16	1,361
Boosters, pounds	2,177	9,528	2,804	362
Military explosives, pounds	49	140	640	701
Cap-sensitive high explosive, pounds	36,498	44,316	43,738	41,097
Primer, units	1,300	4,333	2,733	344
Blasting caps, units	61,531	66,614	40,719	44,456
Det. cord/safety fuse/lgnltor cord feet	183,224	113,510	84,554	101,117
Total, explosives, pounds	61,003	101,217	71,470	74,966
Blasting caps, units	61,531	66,614	40,719	44,456
Det cord/safety fuse/igniter cord, feet	183,224	113,510	84,554	101.117

SOURCE BATF 1978 Explosivea incidents Report

Current Security Measures

Sources of Explosives

Current methods of securing explosives vary somewhat from State to State; different types of explosives are also secured in different ways. In general, all cap-sensitive high explosives, including boosters and detonating cord, must be stored in BAT F-approved magazines. The magazines require hardened locks and lock-covers to protect the lock from direct access by hacksaws or from attempts to shoot off the lock. Detonators must be stored separately, in magazines that are not as well protected from theft as the high-explosive magazines. Blasting agents are not as well-regulated; bulk ANFO is often stored in large hoppers for direct loading into trucks. Gunpowder are stored in BATF-approved magazines, at least at the manufacturer and distributor levels. At the retail sales level however, gunpowders are just stacked on the shelves.

The above provisions are for permanent storage; some States allow overnight storage of explosives in temporary magazines; at least one manufacturer keeps less than full-lot amounts of detonators in the detonator assembly area overnight.

The purpose of BATF and other regulations on the storage of explosives is primarily to protect against surreptitious or casual theft by outsiders, in much the same way that locking your car door protects the car from theft. The magazines, however, are fairly flimsy, often simply a correlated frame building with additional plywood or plank walls. Entry can still be gained by cutting or prying off the locks, forcing entry through the door, a window, the roof, or a vent, or by help from an employee. Table 63, from the BATF 1978 Explosives Incidents Report, tabulates the methods used to gain entry to explosives. An average of 48 percent of known entries were by removing the lock, another 16 percent were by forcing entry through the door, wall or vent, while almost 9 percent involved the use of a key or other inside help.

Some magazines are well-protected by their placement in a facility or by guards. At the

Table 63.–Explosivos Thefts by Method of Entry– Number of Incidents and Percentages for 1977-78

	Number		Percentage	
Entry method	1977	1978	1977	1978
Locks cut	59	71	31.1	26.9
Locks pried	36	50	18.9	19.0
Door pried	10	10	5.3	3.9
Key	14	23	7.4	8.8
Window entry	7	3	3.7	1.1
Inside help	3	0	1.6	–
Wall entry	10	16	5.3	6.1
Burning	2	1	1.0	.4
Roof entry	7	3	3.7	1.1
Door blown	1	2	.5	.8
Floor entry	0			.4
Vent entry	1	3	.5	1.1
Other [b]	40	80	21.0	30.4
Unknown	137	99	–	–
Total	327	362	100	100

[a] These percentages do not Include 137 unknown method incidents for 1977 and the 99 Incident for 1978
[b] This figure reflects those incidents where the entry method could not be Placed in the above categories

SOURCE BATF 1978 Explosives incidents Report

Bingham Copper Mine, for instance, the magazine is placed within the interior of the property of the large open pit mine. The mine has a limited number of access points, controlled by guards. As the mine is operated three shifts a day, 7 days a week, it would be difficult for anyone to gain illegal access to the magazine area. A similar situation prevails for at least one manufacturer. The entire property is fenced with cyclone fencing, topped by barbed wire. Inside the perimeter, and placed strategically throughout the complex, is a microwave break-circuit alarm system. These facilities are in sharp contrast to others, in which the magazines are located in areas remote from other operations, and accessible by nearby roads.

Security of explosives on military reservations is stricter, with magazines within a fenced area. Security lighting is provided, the magazines are either directly guarded or protected by an alarm which would bring a response within 15 minutes, security patrol inspections are held at frequent intervals, and access is only through secured access roads.

At present neither commercial nor military installations can guard against theft by insiders. While the theft of case lots would be

quickly discovered by inventory procedures, it would be difficult to detect the theft of small amounts of explosives, whether by military troops or by a miner daily placing a couple of sticks of dynamite in his lunch pail.

Transportation of explosives is another potential point of theft. The primary purpose of regulations concerning the transportation of explosives is to protect those people who live along the route being traversed. For that reason trucks are clearly marked when they carry explosives. Commercial explosives are often transported by a single driver; military explosives normally have two drivers. In neither case is the driver normally armed.

Potential Targets

A previous section discussed the wide variety of targets attacked by criminal bombers. The security measures vary widely for each type, in response to the perceived probability of attack and the perceived consequence of such a bombing. Table 59 indicates that almost half of the bombing incidents (and 60 percent of bombing casualties) result from attacks on private residences and vehicles. Security at these targets is almost nonexistent, unless the individual believes he is likely to be attacked; except in certain cases, such as Government officials or witnesses, it is unlikely that law enforcement officials play much of a security role with regard to those targets.

Another 32 percent of the incidents, and 30 percent of the casualties, occur in commercial establishments. Most of these establishments have no security means at present and it is unlikely that the development of detection taggants and sensors would significantly change that situation. Some large office buildings, with control led access, have provisions for checking people as they enter and leave the building and, in fact, institute checks in off work hours. Given a sufficiently severe bombing threat, it would be possible to protect the larger facilities by a detection sensor, but the difficulties involved, the large number of facilities, and the cost of operators and equipment probably preclude such deployment.

Government buildings, banks, police stations, and military establishments account for less than 10 percent of bombing incidents and just over 3 percent of casualties. Most of these targets have controlled access and maintain some sort of guards. In times of increased bombing threats, as happened in the late 1960's and early 1970's, many of these facilities instituted checks of incoming people and packages. A similar situation exists with respect to high-value manufacturing facilities, utilities, and high-value complexes within educational facilities, such as computer centers. Many of these facilities now require inspection of any parcels (including briefcases and purses) brought into the facility, as well as identification of people entering. Detection sensors could be easily installed in each of these facilities, given sufficient threat.

Airports and aircraft represent another major class of potential targets. While attacks on airports and aircraft represent well under 1 percent of incidents, the catastrophic consequences of an aircraft bombing make it an attractive potential target for criminal bombers and the subject of much current security effort.

Current large aircraft cost in the neighborhood of $2o million to $50 million each, and carry several hundred passengers. A single aircraft bombing could, therefore, cause more property damage and more deaths than the sum of all domestic bombings this decade. Table 64 lists the explosions that have occurred aboard U.S. aircraft from 1949 through 1976. Table 65 lists the location of the explosive devices for the 19 U.S. aircraft listed in table 64 and compares the location with the 63 aircraft bombings worldwide in that time period. Table 66 lists the 26 incidents between 1972 and 1976 in which explosive or incendiary devices were found at U.S. airports. All of the tables are from FAA report FAA-R D-77-28. The tables show that no bomb has caused casualties on a domestic flight since 1962; in fact, since 1962, all but one of the casualties, and all deaths at U.S. airports or on U.S. domestic flights, were caused by bombs placed in lockers.

Table 64.–Explosions Aboard U.S. Aircraft

Date	Carrier	Aircraft	Aircraft location	Bomb location	Outcome	Device
1 1/1/55	UAL	UL-6B	11 minutes after TO	Baggage	Airplane disintegrated–44 killed	Dynamite
7/25/57	WA	CY-240	47 minutes after TO	Lavatory	Passenger thrown out of lavatory–hole in aircraft side; plane landed successfully	Dynamite
1/6/60	NA	DC-6B	184 minutes after TO	Under seat passenger compartment	34 killed, airplane disintegrated	Dynamite, dry cells
5/22/62	co	707	39,000 ft	Towel container in rear lavatory	Tail blown off–45 killed	Dynamite
11/12/67	AA	727	102 minutes after TO	Rear baggage compartment	3 bags destroyed; aircraft saved	Black powder (?)
11/ 19/68	co	707	24,000 ft	Lavatory	Fire and explosion in lavatory; extinguished by crew; plane landed safely	—
8/29/69	TW	707	Ground after hijack (Damascus, Syria)	Explosives thrown in cockpit after evacuation	No casualties from explosion	Grenades & canister explosive
9/7/70	PA	747	Ground after hijack (Cairo, Egypt)	—	Demolished after evacuation	—
9/12/70	TW	707	Ground after hijack (Dawson Field, Jordan)	—	Demolished after evacuation	—
12/29/71	—	Turbo Cmdr	In hangar	Seat in cabin	Aircraft destroyed, hangar damaged; no casualties	—
3/8/72	TW	707	Parked on ground	Cockpit	No casualties (plane empty)	c-4
9/21 /73	—	Navion	Parked on ground	Engine manifold	Not known	—
12/17/73	PA	707	On ground, Rome	Attack while loading	Fire damage; 30 killed, many injured	White phosphorous grenades
8/26/74	TW	707	On ground, Rome	Aft baggage compartment	Fire, confined to local area; no casualties	c-4
9/8/74	TW	707	Over Ionian Sea	Aft baggage compartment	High-order explosion; 88 killed, aircraft lost	—
2/3/75	PA	747	In air, Burma	Lavatory (suicidal passenger set fire)	Extinguished by crew; minimum damage	Petrol and butane
12/19/75	—	Alouette Helicopter	On ground	Near fuel tank	**$10,000** damage to aircraft	Blasting caps
7/2/76	EA	Electra	Parked next to fence	External, near right landing gear	Explosion and fire destroyed main fuselage	Dynamite (8-10 sticks)
7/5/76	—	Helicopter	On ground	External, under tail	Extensive damage	Dynamite

SOURCE FAA Civil Avaton Security Service

Table 65.–Location of Explosions Aboard Aircraft, 1949-76

	Worldwide		U.S. aircraft	
Location of explosion	Number	Percent	Number	Percent
Stowed	13	21		21
Baggage	(8)	—		—
Cargo or freight	(5)			
Ground attack	5	8	4	21
External attachment	7	11	3	16
Passenger or crew compartment		52		42
Lavatory		—		—
Passenger compartment	(19)	—	(2)	
Cockpit	(4)	—		
Unknown	5	8		0
Total	63	100	19	100

SOURCE Data supplied by FAA Civil Avation Security Service

Current airport security is based on an attempt to separate the areas of public access from the secure air operations areas. Figure 23, from FAA report FAA-RD-77-28, shows a detailed schematic of the flow of people and material into the airport area.

It is possible that bombs could be introduced through the mail, freight, air courier services, or food services, as well as from checked baggage; or could be carried on by aircraft flight or service personnel or by passengers. Current security procedures assume that personnel screening procedures will be sufficient to eliminate a serious threat from airport or aircraft personnel and that air freight and mail service would not allow a criminal bomber to be sure his bomb would be aboard a particular aircraft. Current aircraft security procedures, therefore, concentrate on passengers, carry-on baggage, and checked baggage. Air courier services, in which a small

Table 66.–Explosions and Device Found at U.S. Airports, 1972-75

Date	Airport	Location	Effects	Comment	Device
3/7/2	Kenneay	Cockpit of TWA B-707	No explosion	Detected by dog	c-4
3/8/72	Seattle	Baggage compartment (UAL flight)	No explosion	Extortion attempt; timer stopped	Gelatin dynamite in aerosol cans, blasting caps
11 /19/72	Denver	Attache case carried by Individual	No explosion	Indvidual stated intent to blow up plane	8 sticks of dynamite
3/24/72	San Carlos, Calif	Hanging from belly of helicopter	Hole in ground at remote location	Removed by police	3 sticks of dynamite, timer and detonators
12/1 /72	Grand Rapids, Mich.	Paper towel container in terminal	No explosion	Device extinguished after emithng smoke	—
12/31 /72	Austin	Concession area	Moderate damage	—	Incendiary (gasoline)
3/20/73	Los Angeles	On runway during approach of Continental Airlines plane	None	Thrown by individual on field	Molotov cocktail
3/29/73	Milwaukee	Locker	1 Injury–moderate damage	Extortion attempt	—
8/9/73	Los Angeles	Locker	Did not detonate	Extortion attempt/located by dogs	—
11/30/73	Nashville	Locker	Did not detonate	Extortion attempt	Smokeless powder, timer, initator
3/1 /74	Kennedy	Locker	3 injured–moderate damage	—	—
7/21 /74	New Orleans	(unknown)	No explosion	Removed by bomb squad	3-m long bamboo with powder and fuse
8/1 /74	Kennedy	Cargo building	No explosion	Removed	Cardboard container with explosive powder, fireworks fuse
8/6/74	Los Angeles	Locker	3 killed, 34 injured	—	—
8/9/74	Johnstown-Camoria, Pa.	Hangar	Hangar and aircraft destroyed	—	Probable incendiary (in 55-gal drum)
8/26/74	O'Hare	Men's room	Commode damaged	—	Probably firecrackers
9/ 16/74	Boston	Airline baggage room	Substantial damage	Bomb was in an unclaimed suitcase destined for Tel Aviv	Incendiary (?)
3/15/75	San Francisco	Near ticket counter	Minor damage	—	Probably firecracker
3/22/75	Honolulu	Lost & found baggage area	Did not detonate	—	Crude pipe bomb
3/27/75	Kingsford, Mich	Storage area	No explosion	Removed	—
7/22/75	Tampa	Baggage cart	1 injured	—	Firecrackers
10/17/75	Miami	Locker	Lockers and ceiling destroyed	—	—
10/20/75	Miami	Dominican Airlines Office	No explosion	Discovered by janitor; disarmed by bomb squad	Time bomb
11/6/75	Buffalo	Baggage claim area (2 bags)	No explosion	Checked bags unclaimed after flight, timers turned off (inadvertently)	Black powder and gasoline
11 /27/75	Miami	Bahamasair aircraft. Behind wall panel in lavatory	No explosion	Removed	—
12/29/75	La Guardia	Locker	11 killed, 70 injured; substantial damage	—	Dynamite and RDXa

a FAA estimate Other agencies diagree with this assessment

SOURCE FAA Civil Aviation Security Service

parcel can be placed aboard a specific aircraft for subsequent pickup, are treated in the same way as freight or mail by most airlines.

As a result of the hijacking threat in the mid-1970's, a set of procedures were developed to deal with passengers, checked baggage, and carry-on baggage. Figure 24 (from FAA report FAA-R D-78-66) shows a schematic of the passenger and carry-on luggage-screening systems. Passengers must pass through a magnetometer, which will trigger an alarm upon detection of a significant metal mass, such as a gun or knife. If the alarm is triggered, the passenger is instructed to remove any metal objects, such as keys, and repass through the magnetometer, If an alarm still rings, he is searched by a hand-held magnetometer and subject to a patdown search if the alarm persists. FAA estimates that the probability of detection of guns or knives by the magnetometer, hand magnetomer, and patdown, are 0.90, 0.95, and 0.95, respectively, adding up to an overall detection probability

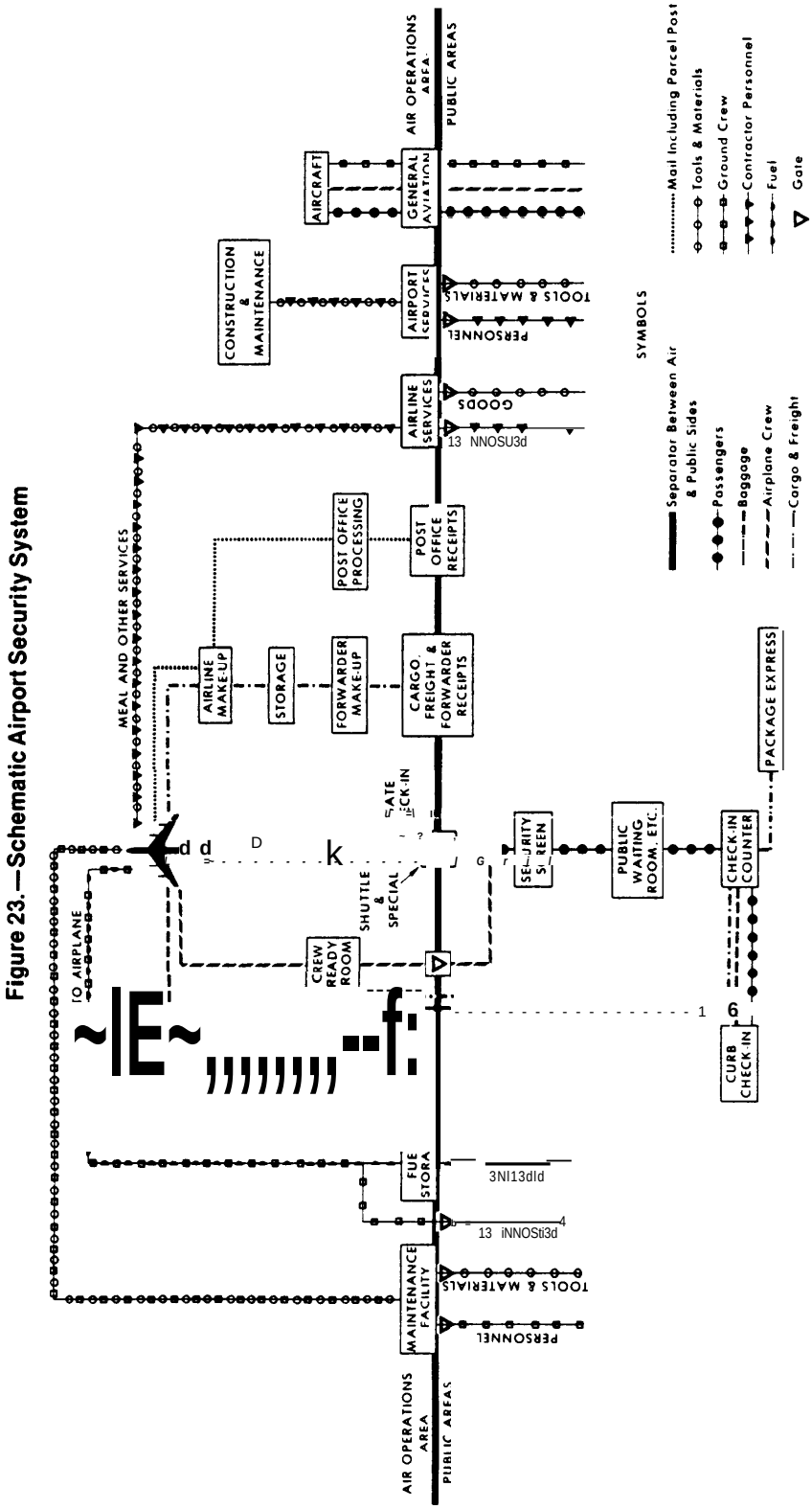
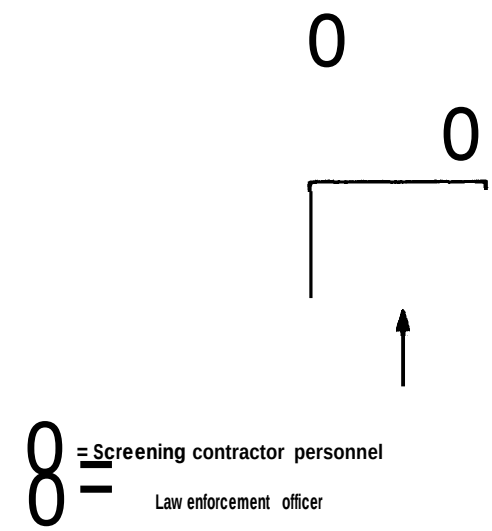


Figure 23.—Schematic Airport Security System

SOURCE: FAA report FAA-RD-77-28.

Figure 24.—Passenger/Hand-Baggage Screening Station



SOURCE: FAA report No. FAA-RD-78-88

of 0.81. * The system is not designed to detect bombs, but FAA estimates that the probability of detecting a bomb is 0.17.

Carry-on baggage is screened, either by an X-ray examination or by visual hand search (only at small airports or when the X-ray machines are nonoperable). FAA estimates that the probability of detecting guns and bombs in carry-on baggage is 0.81 and 0.19, respectively.

FAA estimates are probably high, especially for the X-ray detection of illegal materials in hand baggage. Magnetometers are set to a wide range of sensitivities; one may trigger on a small keyring while another may fail to trigger on a sizable metal mass. X-ray attendants are generally paid at, or near, the minimum wage, have little training, and must deal with the problem of maintaining alertness for long hours while performing an extremely dull job. While an attendant may well recognize a gun, particularly at the start of a shift, it is doubtful that a carefully constructed explosive device would be detected.

Notwithstanding the above limitations, the use of magnetometers and X-ray machines, coupled with a search profile of likely hijackers, has resulted in the recovery of an impressive amount of hardware, and the arrest of substantial numbers of people, as shown in table 67 (from FAA report FAA-R D-77-28), as well as the virtual halt of hijackings of U.S. domestic airlines.

The current procedure for screening checked baggage consists simply of ensuring that baggage can only be checked by a passenger with a valid ticket. When checking baggage at curbside or at the check-in counter, the

● The total probability of detection must be less than the probability of detection by the magnetometer, as no subsequent searches are conducted on those passengers who do not trigger the magnetometer Total detection probability is thus

$$PDT = (P_{D_1})\ (PD,)\ \ (PDN)$$

Table 67.–Results of Civil Aviation Security Program Passenger Screening

	1972	1973	1974	1975
Passengers (millions) ., . . ., . . .,	192	203	201	202
Passengers denied boarding. ., .,	8,265	3,459	2,663	(a)
Referrals to law enforcement . . . ., ...	(a)	(a)	(a)	12,270
Persons arrested. ... ., ., . . .,	3,658	3,156	3,501	2,464
Aviation offenses detected				
Carrying weapons or explosives aboard aircraft	774	736	1,147	1,364
Giving false information ., ., ., ., ...	244	658	1,465	227
Weapons detected				
Firearms. . .	1,313	2,162	2,450	4,783
Explosive devices . . ., ...,	13	3,459	14,928 [b]	158
Ammunition, fireworks, ..., ., ., . .	(a)	(a)	(a)	17,047
Knives	10,316	23,290	21,468	46,318
Other ., ... , ., ., ...	3,203	28,740	28,864	55,830

[a] Data 1101 collected in this form
[b] This figure is a piece count which Includes fireworks and ammunition

SOURCE First Second, and Third Semi-Annual Reports 10 Congress on the Effectiveness of Passenger Screening procedures, FAA Civil Aviation Security Service

passenger must show his ticket. The system can be totally defeated by anyone willing to buy a ticket he does not use, by convincing someone to check a piece of luggage for him, or by a suicidal passenger.

EL AL does hand search each piece of checked baggage before it is boarded, as do the British and French for Concorde flights. Spot checks are made at most airports, particularly if the passenger is identified as matching the hijacker profile, or in times of high perceived bombing threat.

In recognition of the fact that all but one casualty in recent years in domestic airlines or at domestic airports have been due to bombs placed in lockers, most airports have either removed the lockers entirely or placed them behind the security inspection gate.

In summary, most bombings take place at targets that have no means of detecting bombs. Some high-value targets check incoming parcels and require identification. Airport procedures are quite effective in finding guns in carry-on luggage or on the person of a passenger, but much less effective in finding bombs. The probability of finding a bomb in checked baggage is low and essentially nil for courier service, mail, or freight.

Current Anti bomber Procedures

The predetonation anti bomber procedures followed by security personnel at airports are typical of the entire security industry. Effort is primarily directed at prevention — the best procedure is to not allow bombs to reach the secured areas of the airport or the aircraft.

The anti bomber procedures of most law enforcement personnel are primarily aimed at the apprehension and conviction of criminal bombers normally starting after a criminal bombing has occurred. The actual range and intensity of the effort will vary with the severity of the bombing and will be somewhat different for different parts of the country.

The first step in the postdetonation investigation is to secure the area of the bombing, both to ensure that no further danger exists from unexploded material and to preserve whatever clues remain in the area.

After the area is secured, a search is made for physical evidence. This search has two objectives —evidence of the presence of the perpetrator and evidence of the bomb. Traces of the perpetrator include small pieces of clothing, hair, fingerprints, footprints, and possible tire tracks. Fingerprints, in the rare cases they are found, provide a clue to the identity of the perpetrator; the other evidence would be primarily used to tie the suspect to the crime after he has been apprehended by other means. Evidence from the bomb includes undetonated explosives and parts of the container, the detonator, and the timing system. Debris from the explosive is also collected for laboratory analysis.

If the bomb does not fully detonate, the date-shift code information may be recoverable, providing a clue to the source of explosives and a list of the last legal purchasers. If the device fully detonates, the parts of the timer and container can provide some information to start an investigation, but the leads so generated are quite indirect. The debris is more likely to furnish intelligence information, such as connecting a particular bombing with similar bombings.

The next step in the investigation is a laboratory analysis of the debris, and a followup investigation to attempt to trace the perpetrator from whatever clues are available. The laboratory attempts to characterize the physical evidence obtained, including an attempt to determine the type of explosive used. The laboratory evidence could provide clues in the search for the perpetrator, but more likely provides confirmatory evidence and inteliigence. Armed with the data provided by the search of the bomb scene and laboratory analysis, the investigator attempts to trace and apprehend the perpetrator.

In addition to physical evidence, law enforcement agencies question witnesses, attempt to get information from informers, and exercise the resources brought to bear to solve any major crime.

The amount of time spent by law enforcement investigators at the bomb scene, in the laboratory, and working in the investigation depends on the seriousness of the bombing, the workload, and to some extent, the location. A bombing homicide would command considerably more resources than a vandal blowing up a mailbox.

In addition to the postdetonation investigations described above, law enforcement agencies engage in undercover infiltration of bomber groups, undercover contracting for the services of bombers, surveillance of expected targets, and gathering of intelligence concerning expected perpetrators or groups of perpetrators. Sometimes an informant volunteers valuable information. Clues from collateral crimes, such as theft of explosives or buying timers with a bad check, sometimes provide additional clues. Perpetrators are even occasionally apprehended in the act of placing a bomb by routine law enforcement patrol of the area.

A further mechanism which tends to facilitate law enforcement efforts is the occurrence of accidental detonations while bombs are being fabricated or placed, Table 68, taken from FBI data, shows the number of premature detonations and the casualties caused by those detonations for the period 1974 through 1977. During that period, approximately 23 percent of al I deaths by bombings and 14 percent of al I injuries were to perpetrators as a result of premature detonations. A premature detonation often provides considerably more evidence than a bombing, as the explosion often takes place in the residence or vehicle of the perpetrator and with the perpetrator present. This information can lead to the arrest of other members of the perpetrator group.

Table 68.- Premature Detonation Statistics

Year	Incidents	Injuries	Deaths
1974	29	31	11
1975	37	53	2
1976	42	42	11
1977	29	34	2
1978	33	43	5

SOURCE FBI data

Given the paucity of clues to work with, law enforcement personnel are not able to effectively combat criminal bombers. Perpetrators of fewer than 10 percent of all bombings are brought to trial. Considerably fewer than half of those tried are convicted, resulting in a rate of only a few percent for the successful solving of criminal bombings.

DISCUSSION OF TAGGANT UTILITY

Given that identification taggants are able to survive the detonation and be recovered, that detection sensors can be developed which will detect taggant vapors in the parts-per-trillion concentration regime, and that taggants can be safely added to explosives, what would be the utility to law enforcement and security personnel of the taggant program? Possible utility attributes would include increased intelligence information, methods to decrease the theft of explosives, increased rates of apprehension and conviction of criminal bombers, deterrence of potential bombers, and an increased rate of detection of bombs at potential target sites. These issues are discussed in this section; the discussion is primarily qualitative, as little quantitative data is available.

In the initial discussion, the assumption is made that perpetrators make no response to a taggant program. The range of responses available to perpetrators, their likelihood of use, and their effects on a taggant program are discussed in the following section.

Deterrence

Supporters of a taggant program believe that both identification and detection taggants can cause some portion of the criminal bomber population to reconsider a planned incident and decide to either abandon the plan or modify it in a way beneficial to society. The deterrent effect of the identification and detection taggants is quite different, and should

be considered separately. The deterrent effect that an identification taggant may have on a criminal bomber would be to lead him to perceive an increased likelihood of his postdetonation arrest and conviction. This differs significantly from the deterrent effect of the detection taggants, in which the bomber perceives a decreased likelihood of a successful completion of the criminal bombing as well as an increased arrest probability.

A good deal of study has been conducted on the general subject of the efficacy of punishment on behavior modification, and on the deterrent value of prison sentences (or death) on criminals. The results are not clearcut, however, and it is not possible to make a quantitative estimate of the percentage of bombers who would be deterred by knowledge that commercial explosives contain identification taggants. It seems reasonable to expect some deterrence, however, a point made by most of the law enforcement personnel contacted, either personally or by questionnaire. Most law enforcement personnel felt the effect would be small or moderate, although approximately 30 percent predicted a substantial deterrent effect (over 25 percent of bombers would be deterred). The deterrence effect was felt to be most effective in preventing revenge bombings (almost 50 percent of the law enforcement personnel estimated a substantial effect) and crime-of-passion bombings (40 percent) and least effective in preventing bombings by terrorists, criminals, and psychopaths (approximately 25 percent of the respondents felt a substantial deterrent effect would be present for these bombers from identification taggants). These results are shown in more detail in appendix B.

A dedicated terrorist is primarily interested in attracting attention to his cause (and less so in self-protection); a professional criminal recognizes the risk of arrest as a cost of doing business; a psychopath may either feel invincible or doesn't care about the personal aftermath of his crime. These criminal bombers may not be greatly deterred by the increased probability of arrest that identification taggants would provide; however, they may well modify their bombing plans if detection taggants significantly decrease the probability that they will succeed in their bombing mission. Whether the bombers would be deterred from committing a crime, or would modify the type of crime, is uncertain, and would depend, to some extent, on the type of bomber, as well as the target type.

Many targets, such as residences, vehicles, and commercial establishments, would not be protected by detection taggant sensors (about 80 percent of bombings in 1977 and 1978 were of this type); the deterrence effect of detection taggants for bombers who plan to attack that class of target would therefore be small. For bombings which currently are planned against the remaining targets, the presence of detection taggants in commercial explosives and deployed sensors could modify the plan in several ways. Fear of detection taggants could lead bombers to shift to unprotected targets, or a less vulnerable, more accessible portion of the target complex (a bomb could be planted against an outside wall, rather than within a Government building, for instance). Alternatively, fear of detection taggants could lead to one of the countermeasure responses described in the next section.

Some guidance on the deterrent effect that a program of detection taggants and sensors could provide to high-valued targets can be gained by analogy to the effectiveness of the current anti hijacking procedures at airports. Hijacking statistics are summarized in table 69. Between 20 and 30 commercial airliners originating from domestic airports were hijacked each year between 1969 and 1972. In 1973, a series of antihijacking measures became fully implemented in the United States, which included 100-percent passenger screening by magnetometers, X-ray examination of carry-on luggage, and development of a hijacker personality profile. The number of hijackings dropped dramatically — to a single incident in 1973 and an average of 4.5 per year s i rice.

Some foreign countries have instituted antihijacking procedures as well, although not as

Table 69.–Comm8rcial Airliner Hijacking Statistics by Year

Year	Hijackings U.S. origin	Hijackings foreign origin
1949 -67,	9	45
1968	15	14
1969	36	48
1970	20	50
1971	24	29
1972...	27	29
1973a.	1	17
1974	3	17
1975	6	11
1976,	4	15
1977,	5[b]	NA[c]
1978	8[b]	NA

a U.S antijacking measures became fully effective
b U.S airlines irrespective of point of origin
'Not avadable

SOURCE FAA report No FAA.RD-77-66

uniformly as has the United States. As a result, the foreign hijackings declined approximately 60 percent when the 1969-72 period is compared with the 1972-77 period, while hijackings from domestic airports declined almost90 percent in that same period.

While part of this drop may have been due to additional measures such as the use of armed sky marshals for a period on the most vulnerable routes and the gradual erosion of a friendly welcome for hijackers at some foreign countries, a good deal of it is probably due to the deterrent effect of a visible screening system In fact, large numbers of weapons have been reported recovered from trash containers, potted plants, and other hiding places, as a result of the weapon carrier being confronted with an operating screening system. That the deterrent is not 100-percent effective is clearly shown by the number of weapons currently confiscated by the screening process, as shown in table 67.

In summary, it is not possible to quantify the number or percentage of bombers who would be deterred by a taggant program. identification and detection taggants will probably deter some bombers, particularly revenge bombers and those committing crimes of passion. Detection taggants will deter bombers from attacking protected targets, perhaps at the expense of more frequent attacks on unprotected targets. Law enforcement personnel indicated that, overall, about the same magnitude of deterrence would be expected for each type of taggant, perhaps reflecting the larger value of detection taggants for those targets protected by detection sensors, and the total lack of deterrent for those not visibly protected.

Bomb Detection—Target Protection

Detection taggants should greatly increase the probability of detecting explosives containing the taggants and thus increase the protection of the targets at which detection sensors would be deployed, either permanently or in response to a heightened perceived threat. Again, no data exists that would allow quantitative estimates of the detection effectiveness. As indicated in the previous section, FAA esti-

Photo credit U.S. Department of Transportation

Typical airline passenger screening point

mates that the current passenger and carry-on baggage scanning systems at airports have an overall probability of detecting guns or knives of over 80 percent, while they estimate less than a 20-percent detection probability for explosives. If the assumption is made that a detection sensor would have the same effectiveness in detecting bombs that the current systems have for detecting guns, a fourfold increase in effectiveness would be expected. If the Aerospace Corp. prototype specification of 0.9999 probability of detection is met by the fielded system, then essentially full protection would be available to those targets protected by a detection taggant sensor, The term full protection must be qualified– it refers to bombs that are fabricated from tagged commercial explosives and do not have a sufficient seal to prevent escape of the taggant molecule. No protection is offered for bombs fabricated from untagged explosives (homemade, taggant removed, foreign supply, explosives fabricated prior to the taggant program) or from explosives with a sufficient seal.

It is unlikely that a detection taggant program would result in a significant increase in the number of bombs detected, as few of the current bombings are directed at the type of high-value, limited-access targets at which detection sensors would be located. The utility of the detection taggant system would be in eliminating, or greatly decreasing, the low number of bombings which occur at these targets, each of which can cause catastrophic damage and casualties.

The above discussion addressed the utility of fixed detection taggant sensors. Portable sensors have an additional function — locating a bomb whose approximate location is known or suspected. Law enforcement and security personnel are often notified of a bomb threat, through tips, calls claiming credit for planting a bomb, and extortion. Current procedure is to evacuate the premises and then conduct a time-consuming search, using personnel and perhaps trained dogs, in an attempt to locate the bomb. The disruption caused by a bomb threat can be quite costly; a recent evacuation of the World Trade Center in New York is estimated to have cost several million dollars in lost time. The use of a portable sensor could significantly cut down on the time for a search and increase the probability of finding a bomb. It is possible that the existence and deployment of portable detection sensors would deter some bombers from planting bombs, particularly as an extortion device, as well as act to deter bomb hoaxes. BATF reported 105 hoax device incidents in 1977 and 47 in 1978, so reducing the number, or reducing the time lost from each, could have a significant economic impact.

The additional utility of portable detection sensors was noted by law enforcement personnel returning the questionnaire. Approximately 65 percent felt that a portable sensor, needing no skilled operator, would have a high utility (deter over 25 percent of bombers), while less than 50 percent felt that a stationary sensor would have high utility. Similarly the respondents felt that portable units were superior to nonportable units for each type of target suggested. The differences were small for targets such as airports, large Government buildings, and nuclear power stations, but ranged up to more than 5 to 1 for targets such as schools and bus and train depots.

An important limitation to the detection of explosives by any means should be noted. It is possible to defeat any type of detector. Therefore, failure to detect a bomb cannot be taken as proof that no bomb exists. The easier it is to defeat the sensor, the greater the limitations to the utility of the system. A system that detected 50 percent of the bombs would therefore be useful only as a screen. A system that detected 99.9 percent of the bombs would not only screen out twice as many bombs, but could be used to give a high probability that no bombs were present, significantly decreasing search time for bombs, more easily detecting hoaxes, and giving more useful decision data for dealing with threats or extortion attempts.

Bomber Apprehension

The current procedure for the apprehension of criminal bombers consists of three phases:

1. the postdetonation search of the area for physical evidence and subsequent laboratory analysis;
2. the investigation, based on the results of the analysis of the physical evidence; and
3. intelligence gathering, used as an input to the investigation or to direct surveillance of suspected perpetrators or expected targets.

A great deal of effort is currently spent on the postdetonation search and analysis of physical evidence from a criminal bombing. The purpose of this search is to attempt to generate leads to help in the apprehension and conviction of criminal bombers, either directly from clues found in the debris or as a result of intelligence information gathered from a number of bombings.

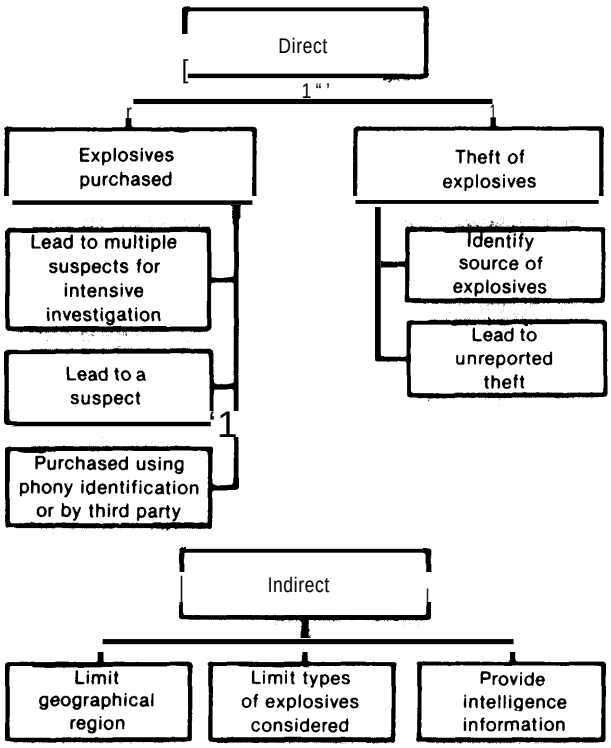
The search for evidence phase includes a detailed analysis to try and determine the type of explosive used and to find and examine any parts of the bomb, such as elements of the timing device, which may have survived the detonation. This evidence, together with any evidence of the presence of the perpetrator (such as hair or footprints) serves as the starting point for the investigative phase. Laboratory analysis is currently successful in determining the type of explosive used approximately 50 percent of the time, but experts indicate that the manufacturer can be identified in less than 10 percent of current cases undergoing intensive analysis. Parts of the detonator and timing device usually survive the detonation, and in many cases, currently provide the best initial leads from which to launch an investigation.

The investigative phase consists primarily of trying to generate some type of lead to the perpetrators from the physical evidence gathered, as well as tracking leads provided by informants or witnesses and attempts to correlate the characteristics of the bombing with similar instances. A great deal of effort may be expended, for instance, in investigating the sources of a common clock used as the timing mechanism.

The addition of identification taggants to explosives would aid the investigatory efforts of law enforcement personnel in a number of ways, provided that the taggants survive the detonation and are recoverable from the explosive debris. In order for the taggant information to be useful, however, the bombing must be of sufficient importance (in terms of property damage, notoriety generated, or casualties produced) to warrant a thorough investigation. In such cases, identification taggants will provide much more definitive information at much less effort by the investigating team. Equally important, the information can be made available quickly— in a matter of hours, if necessary, rather than the days or weeks it may take to generate whatever data can be generated by conventional means. The taggants provide a good starting point for an investigation as they directly indicate the type of explosive used, manufacturer, and time of manufacture, and provide a list of the last legal purchasers. This information may lead directly to a bomber who purchased the explosives legally, provide a limited number of suspects for intensive investigation, tie reported thefts of explosives to bombings, provide leads to an unreported theft of explosives, or provide indirect information to limit the scope of an investigation, such as to a specific geographical region of the country. Some of the ways in which identification taggants can contribute to an investigation are shown schematically in figure 25.

There will be some cases in which the perpetrator legally buys the explosive, and subsequently uses it to commit a criminal bombing. In some of these cases, the bomber would not otherwise be identified with the bombing; in

Figure 25.—Schematic Illustration of Identification Taggant Utility in Criminal Investigation



SOURCE: Office of Technology Assessment.

others, the taggants add a strong I ink in a chain of evidence, which may help to obtain a conviction. A chain-of-evidence example recently occurred at Sparrow's Point, Md., where a bomb, planted in a pickup truck, killed the driver. A search was made of the bomb scene and the physical evidence subsequently examined in the BATF national laboratory. The laboratory analysis indicated that the explosive used in the incident had been tagged as part of the pilot-plant taggant program. The list of legal purchasers of that lot of explosives included James McFillin, one of the prime suspects in the bombing. McFillin was found guilty on December 19, 1979.

Even in those cases where the list of last legal purchasers does not contain an obvious suspect, it provides a means of identifying a limited number of people for a subsequent thorough investigation.

In some cases, explosives will be legally purchased, but with phony identification or by a third party not directly involved in the commission of the bombing. When phony identification is used, an intensive investigation could still provide a viable lead to the purchaser. Although the purchaser's real name and address would not be directly provided by the list of purchasers, a location, a time of purchase, and a witness to the purchase would have been provided. Similarly, for the cases involving a third-party purchase, that intermediary might be identifiable, providing a good lead to the perpetrator. It may also be helpful to know the time frame when explosives used in a crime were obtained.

Some of the explosives used in criminal bombings are currently stolen, and it may be that a taggant program would increase the incidence of explosive theft, as discussed in the next section. Identification taggants would provide information of considerable utility to an investigation of a criminal bombing, even for explosives that turn out to have been stolen. The list of last legal purchasers should provide information as to the source from which the explosives were stolen. In some cases the theft of explosives will have been reported. Identification of the source of the explosives provides intelligence information on the sources and disposition of explosives for criminal bombings. It may also provide a lead directly to the perpetrators of a bombing, by establishing a connection between specific thefts and specific bombings. It may be difficult to establish a motive or any other useful lead for an isolated theft, but tying it in with specific bombings may provide that lead, particularly if the explosives are stolen with the help of an employee.

In some cases, the explosive theft may not be reported, perhaps due to the surreptitious theft by an employee of small amounts of explosives over a period of time. Identifying a source by the use of taggants could result in leads to the explosives thief, and through him, perhaps to the criminal bomber.

While not directly related to an investigation of a criminal bombing, identification of a

particular facility as the source of stolen explosives would help pinpoint those facilities, or types of facilities, that are in need of increased security for their explosives.

The value of the list of last legal purchasers will depend somewhat on the length of the list. A trace which indicates that the full taggant-batch of explosives was sold directly to a mine by the explosives manufacturer obviously provides a more immediately useful lead than a trace which shows thousands of purchasers of a lot of smokeless powder. Even the list with thousands of legal purchasers would provide a better starting place for an investigation than the types of information generally available with present methods. For example, investigators attempt to trace timing mechanisms even though thousands of people may have purchased the model of clock that was used, and there are no records available that would turn up their names.

It is rather unlikely that the trace would turn up a list of thousands of names as likely perpetrators of a significant or catastrophic bombing, even if black or smokeless powder was used as the filler. The types of bombings likely to warrant a detailed investigation are unlikely to be caused by 1 lb of gunpowder, which would eliminate most of the people on the list either by narrowing the list to those purchasing more than 1 lb of the same lot, or by providing multiple traces of the multiple lots used in the filler. When effects such as the geographical distribution of the tagged gunpowder lot are also taken into consideration, the list of viable names is likely to be much smaller than would appear to be the case on the surface.

BATF traced the number of entities that were involved in the manufacture, distribution, and ultimate end use of the unique taggant lots produced during the pilot test program; the number ranged between 2 and 68. The size of the uniquely tagged batch varied from 12,000 to 26,000 lb, with the number of entities directly, but weakly, related to the taggant batch size. The batch involving the most entities (68) included the manufacturer, 3 primary distributors, and 21 secondary and 43 tertiary distribution points.

The above discussion is pertinent when the taggant trace produces information directly indicating a suspect, a group of suspects, or a source of explosive theft. In some instances it may not be possible to directly narrow the list of possible suspects. Examples would include unobserved theft with no inside help, purchases from which no obvious leads turned up, or traces in which the list of last legal purchasers was too large to provide a reasonable starting point for investigations of all of the individuals involved. In these cases, the identification taggant traces, including the manufacturer, time of manufacture, specific product, and list of distributors and ultimate purchasers would still provide indirect information of use to the investigation. Examples of indirect information might be data that limit the investigation to a small geographic region of the country, identification of the type and manufacturer of the explosives, and an indication of when the explosives were acquired by the bomber. Even the indirect information provides more data to the law enforcement investigators than currently available, after extensive laboratory and field investigation of post-detonation debris.

In addition to providing both direct and indirect leads to the investigation of criminal bombings, taggants can contribute considerable intelligence information.

Intelligence Concerning Criminal Bomber Activities

The gathering and integrating of intelligence concerning the activity of criminal bombers and groups of bombers is a time-consuming process which is a necessary activity of control by law enforcement agencies. Identification taggants would greatly facilitate law enforcement intelligence activities, particularly in monitoring the range of activities of bomber groups, the theft and disposition of explosives, cooperation between various bomber groups and between domestic bomber groups and foreign organizations, and keeping track of current sources of explosives for criminal bombers. Intelligence information is particularly

useful in combating the repeat bomber, and may provide the only effective method to generate leads to the most sophisticated bombers — professional criminals and terrorists.

Strategic data banks, receiving information from a variety of domestic and foreign sources, have successfully identified patterns and trends that have led to a better understanding, and arrests and convictions, of members of international narcotics rings, high-finance swindlers, and terrorists. Taggants could enhance the utility of such data banks to facilitate identification of terrorist objectives, leading toward arrests and convictions of terrorist bombers. Taggants, by identifying known sources of terrorist bombs, and bombs used by other criminal organizations as well, would help intelligence analysts differentiate among several groups which may claim, or which may seem to be responsible for a particular bombing incident, separating out the group directly responsible. The British taggant system, which apparently consists of identifier threads dispersed in the explosives, is used primarily as an apparatus for gathering intelligence about criminal bombers. A few specific examples of how intelligence information could be used for bomber control are instructive.

Some criminal bombers operate in a single location, with no activities beyond that area. Others range over a fairly wide geographic area. If taggants recovered from a bombing indicate that the explosives were purchased in the area of the bombing, then a local group or individual is probably responsible. On the other hand, if the explosives were stolen or purchased in one part of the country, and used in another, that would indicate that either a group with a considerable geographic span of activity was involved, or that there was cooperation between various groups of criminal bombers.

BATF currently keeps a record of the amount of explosives stolen, recovered, and expended in bombings. While it is possible to trace and allocate cap-sensitive high explosives that are recovered in their original cartridges (by the date-shift code stamped on the cartridge), it is extremely difficult to identify the source of explosives that have been detonated. Recovery of taggants would allow a much more accurate record to be kept of the use to which stolen explosives are put.

At present there appears to be little cooperation among domestic groups responsible for criminal bombings (terrorists and professional criminals, in particular) or between these groups and foreign organizations. That is not the case, however, for foreign groups that engage in bombings or other terrorist activities abroad. Some terrorist activities abroad have involved groups from two or even three different countries, separated widely in geography. Intelligence analysts predict that coordinated activity of that sort may soon be seen in the United States. Taggants could help to identify cases of intergroup activity. As an example, explosives may be stolen, and the modus operandi of the theft or a claim of credit for theft indicates that one group was responsible. If the taggants recovered from the debris of a criminal bombing (identified as having been caused by a different perpetrator) indicate the use of those explosives, then a link may be postulated to exist.

A final example illustrates the predictive value of bombing intelligence that would be available from a taggant program. Analysis of the explosives used in a series of bombings could indicate they were all from the same taggant lot. Analysis of the pattern of the bombing could be useful in predicting a geographic area for a subsequent bombing, or in predicting a time for a bombing by the group involved, allowing increased surveillance of individuals in the group (if identified) or of potential targets.

Prosecution of Criminal Bombers

There is rarely a single piece of evidence that so clearly ties a perpetrator to a criminal bombing that additional evidence would not enhance the case for the prosecution. A limited amount of data on the use of the date-shift code indicates that taggants may forge an important I ink in the chain of evidence against a criminal bomber, resulting in a higher rate of

convictions than would be possible without that link. For undetonated bombs the date-shift code provides the same information as identification taggants would provide for the postdetonation case. No total review of the cases involving explosives recovered from malfunctioning bombs has been conducted. However, a limited set of 55 cases was examined by BATF. In that sample, six cases were forwarded for prosecution (10.9 percent). That is twice the percent forwarded in cases that did not include date-shift code data. Similar results were obtained by MSA during a review of BATF data. Of the 10 bombing attempts they reviewed, the date-shift code proved useful in 40 percent of the cases, was not useful in 50 percent of the cases, and was of questionable utility in 10 percent. While the results were positive in both cases, the extremely small sample size makes it impossible to draw significant conclusions. The Institute of Makers of Explosives (I ME) has informed OTA that testimony from manufacturers to establish the source of explosives with a given date-shift code is occasionally requested in criminal prosecutions, but that such requests are very infrequent. I ME estimates that less than 1 percent of al I traces lead to a prosecution.

As one specific example, the prosecution in the McFill in case believes that taggants were a key piece of evidence in that case, and that the taggant evidence was valuable in court.

Taggant Utility by Type of Perpetrator

Taggants may well be more effective in contributing to the direct arrest and conviction of certain types of criminal bombers than of others, due to the varying ability of different types of perpetrators to develop effective countermeasure responses to taggant programs, as well as to the nature of the bombings and targets. These countermeasures and their effects in limiting taggant utility are discussed in detail in the next section.

Vandals are not likely to be greatly affected, as their bombings generally cause little damage, and would not normally initiate the field, laboratory, and investigative procedures necessary to utilize the information available from identification taggants. On the other hand, bombings by professional criminals often involve homicide and bombings by terrorists generate considerable public attention, both of which are likely to initiate extensive investigations. To the extent that the more sophisticated of these groups make use of countermeasures, an operational taggant program may not add much to the likelihood of their arrest and conviction. Psychopaths are likely to engage in bombings that initiate a thorough investigation, may well attack targets protected by detection sensors, and are unlikely to have the resources to generate effective countermeasures. Taggants should be particularly effective in their control.

The law enforcement respondents to the questionnaire indicated a differing utility for taggants against the various bomber categories. As an example, almost 60 percent estimated that identification taggants would result in a significantly higher arrest rate for revenge bombings, and over 40 percent estimated significantly higher arrests for crime-of-passion bombings by psychopaths, while less than 25 percent estimated a significantly higher arrest rate for bombings by terrorists and organized crime. A significantly higher rate means an increase in the arrest rate by more than 25 percent. Similar estimates were made for the use of detection taggants.

Utility of Taggants to Update the Taggant Program

BATF plans to implement the taggant program only for those explosive materials that have been identified as being used extensively by criminal bombers. If analysis of bombing debris shows that tagged explosives are not used in a large number of cases, then the BATF plan would need modification. Similarly, if some explosives that are tagged are not identified as being used in bombings, then those explosive materials should be considered as candidates for exclusion from the program.

Nonbomber Control Utility of Taggants

The Bureau of Mines is very interested in the use of identification taggants to determine the types of explosives used when an accident occurs in a mine. Some mine operators are suspected of using nonpermissible explosives in underground coal mines. Permissible explosives have been specifically tested for low flame emission and certified for use in underground coal mines— other explosives may not be used. If nonpermissibles are identified as being used illegally, the appropriate action can be taken.

Similarly, taggants could be used to identify the cause of an explosion. If an explosion were to occur at a natural gas plant, for instance, then it might be difficult to determine if the explosion were an accident or caused by a bomb. The resolution of cause is important both to law enforcement personnel and to the insurance industry. A similar resolution of cause could be of interest in investigating possible insurance fraud cases.

POSSIBLE BOMBER COUNTERMEASURES IN RESPONSE TO A TAGGANT PROGRAM

The above discussion assumes that criminal bombers do not respond to the introduction of a taggant program. There are a number of countermeasures the bomber can take, however, which may decrease the utility of a taggant program. Only a limited subset of bombers would respond to the taggant program, and those criminal bombers who seek to evade the effects of a taggant program are likely to encounter additional risks or require substantial training and technical knowledge.

Among the possible responses of a criminal bomber to an identification taggant program are:

- removal of the taggant,
- fabrication of homemade explosives,
- switch to incendiary devices,
- use of blasting agents, if they are not tagged,
- theft of explosives,
- black-market purchase of explosives,
- use of explosives manufactured before the taggant program is implemented, and
- resorting to another type of unlawful activity, such as assassination or kidnapping.

In addition to the above responses, the effectiveness of detection taggants can be defeated by providing a seal between the explosives and the detection taggant sensors. It is also possible that the detection taggant sensors could be purposely triggered, or "spooked," by placing detection taggant materials, or chemicals which the detection taggant sensor could not distinguish from detection taggants, in or on nonexplosive material.

The appropriateness and effectiveness of the various responses, in terms of possible limitation to the utility of a taggant program, are a function of the resources, motivation, and aim of the various types of criminal bombers. Table 70 briefly summarizes the likely response countermeasures of each type of bombers, and how effective those responses are likely to be. Effectiveness in this sense includes both the likelihood of successfully accomplishing the response and the appropriateness of the action in fulfilling the primary aim of the criminal bomber. It is interesting to note that approximately half of the law enforcement respondents to the questionnaire estimated that the less sophisticated bombers would initiate no response to an identification taggant program, while almost 40 percent felt that even the most sophisticated bombers would not initiate response countermeasures. Each of the response countermeasures is briefly discussed below.

The baseline 3M identification taggants contain both a magnetic layer and a fluorescent layer to aid in recovery after a detonation. The taggants could therefore be removed from

Table 70.–Possible Perpetrator Response Counter mesuresasuros to Taggant Program

	Criminal		Terrorist			Mentally disturbed			Other	
Countermeasures	Unsophis-ticated	Sophis-ticated	Political	Separatist	Reactionary	Disen-chanted	Vengeful	Pathological	Vandals	Experimenters
Taggant removal	—[a]	M[b]	M	H	L-M	—	—	—		L-M
Fabrication of explosives.	L	H	H	M	M	L	L	L	L	L-M
Incendiary devices.	H	—	L	L	M	M	M	M	M-H	L-M
Use of blasting agents if untagged. . . .	L	H	H	M	M	L	L	L	L	M
Theft, commercial	M	H	M-H	M-H	L-M	L-M	L-M	L-M		M
Theft, military	L	—	L	L	L	—	—	L		—
Illegal sources. . . .	L	H	H	H	—	—	—	—		—
Use of exploswes manufactured before implementation of tagging	L	H	M	L	—	—	—	—		—
Vapor seals.	—	L-M	L-M	—	L	—	—	L		—
Other tactics ., ...	—	L-M	H	H	H	—	L-M	M		—

[a]Unlikely to be attempted
[b] Letters indicate possibility of succes in the attempted countermeasure L = low, Medium medium, H = high

SOURCE Off Ice of Technology Assessment

powdery explosives by using a magnet; the process would be both easy and safe, and would require less than an hour for a typical bomb. In order to hinder this countermeasure, taggants have been manufactured without a magnetic layer. If a powdery explosive were tagged with a mixture of magnetic and nonmagnetic taggants, then the use of a magnet would enable a criminal to remove only a portion of the taggants; the remainder would be present after an explosion, although they would be somewhat more cliff icult to recover than the baseline taggant. If the criminal were deterred from attempting magnetic removal by the knowledge that about half the taggants were nonmagnetic, then postdetonation recovery would be only marginally more dif - ficult than the baseline case.

Another possible technique for removing taggants from an explosive is to use a black light to identify the taggants by their fluorescence, and then remove them with a tweezer. This process is safe, but more difficult than magnetic separation, and would probably require many hours of painstaking effort for a typical bomb. Unlike magnetic separation, it could be used to remove taggants from explosives that are tacky rather than powdery. It has been proposed that the encapsulation of the taggants be made opaque, and matched to the color of the explosive, in order to render such removal impossible. Since the encapsulant would be melted by the heat of a detonation, postdetonation recovery would not be affected. Although it should not be difficult to develop an opaque encapsulant, this has not yet been done. Opaque encapsulation would make quality control, both of manufacturing taggants and of mixing them with explosives, more difficult, and its cost impact has not been evaluated.

The explosives could be acetone dissolved, the taggants and other solid materials removed by filtering, and the explosive reconstituted, but that complex operation would be within the capabilities of only the professional terrorists and criminals and would be roughly equivalent in danger and difficulty to fabrication of explosives from raw materials. It was the near unanimous opinion of law enforcement personnel that criminal bombers would not attempt this complex removal/reconstitution process. Reconstituted explosives would also be less reliable (less likely to detonate) than the original explosives. If detonators were tagged, some taggants would still be present after the detonation of bombs using reconstituted or homemade explosives, unless the even more difficult task of fabricating detonators was attempted.

Removing taggants from some gunpowders is considerably simpler than removal from explosives. Many gunpowder grains are consider-

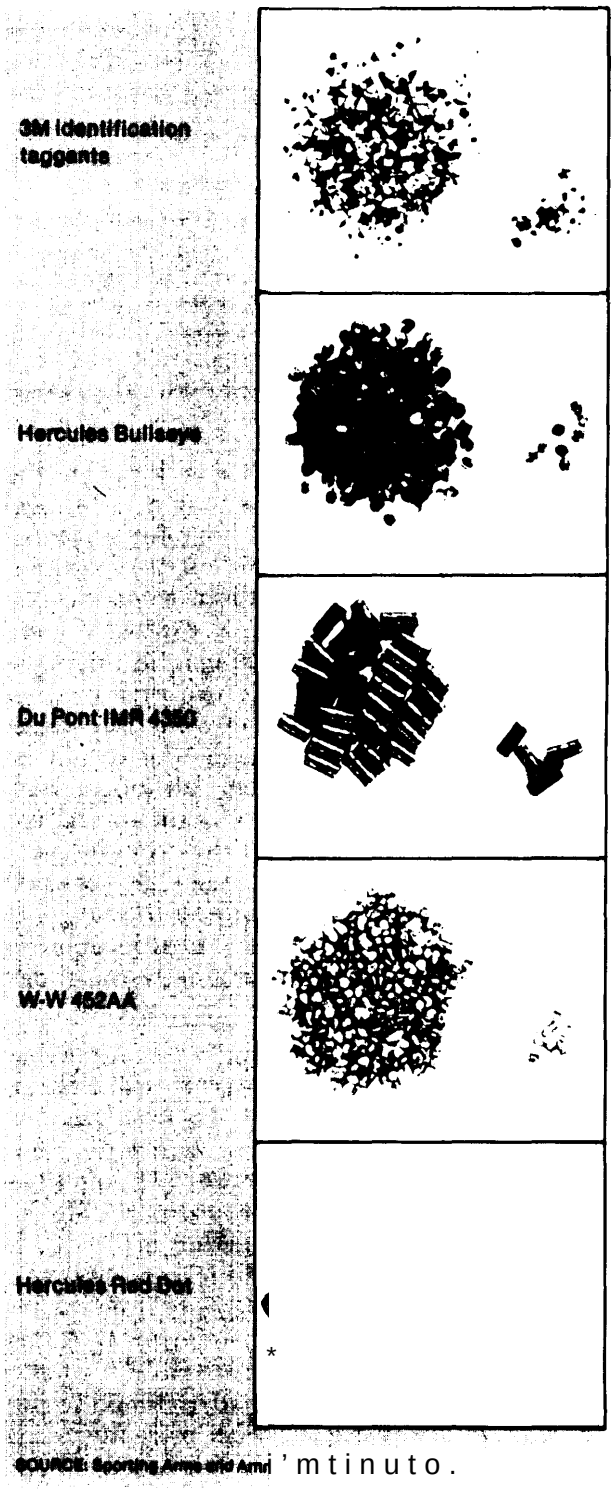
ably larger than the identification taggants, as shown in figure 26. Separation may therefore be accomplished simply by screening, although the manufacturing process may preclude that approach in some cases. Alternatively, it may be possible to agglomerate the taggants into clumps whose size roughly matches the specific grain size. However, the cost impact of such a solution was not addressed during this study.

The detection taggant vapors are microencapsulated into extremely small spheres, which form powder with fineness approaching that of talcum powder. Removal of these taggants from tacky or powdery explosives is clearly impractical and most likely impossible. There is some evidence that the taggant grains tend to adhere to gunpowder grains. The tenacity of adhesion (response to attempts to dislodge the taggants) has not been tested. It is probable, however, that the extremely small taggant powder cannot be simply separated by physical means; similar materials, such as graphite, do not respond. Attempts to "wash" the grains off with a solvent are likely to affect the properties of the smokeless powder.

The only viable removal technique, therefore, appears to be removal of individual identification taggants from gunpowders. As was shown in table 70, the more sophisticated criminals and terrorists could accomplish the removal with moderate to high success, while the less sophisticated terrorists and experimenters would have a somewhat lower success rate. One result of the greater practicability of removing taggants from gun powders may be to produce a shift in explosive materials used in criminal bombs by sophisticated bombers from high explosives to gunpowders. As gunpowder are significantly less energetic than cap-sensitive high explosives, such a shift could result in a significant loss of efficiency for the bombers.

In summary, taggant removal would tend to somewhat decrease the effectiveness of a taggant program in the control of the most sophisticated bombers, attacking targets not protected by a detection sensor, but at some loss in efficiency by the criminal bomber. It is

Figure 26.—Size Comparison of the 3M identification Taggant and Some Smokeiess Powders



SOURCE: Sporting Arms and Ammunition Manufacturers' Institute.

possible to make identification taggant clumps which simulate the grain size of the larger powder grains, thus making taggant removal an ineffective countermeasure, but the cost of doing so has not been calculated. Aternatively, taggants could be incorporated in the grain of some, but not all powders.

Fabrication of Homemade Explosives

As noted in table 70, only the most sophisticated bombers would have a significant success in fabricating explosives. Even to these criminal bombers, the fabrication of homemade explosives would involve a somewhat higher danger of premature detonation than with commercial explosives. It is true that a number of "cookbooks" are available that describe methods of making explosives from uncontrolled materials, but many of these texts list the ingredients without describing a safe and effective fabrication process, or contain errors that could result in a high accident rate or unreliable detonation. The present incidence of premature detonations with commercial explosives, while fabricating and placing bombs, is high, accounting for almost 25 percent of all deaths and 15 percent of injuries from bombings. If homemade explosives are used, the number of deaths and injuries to perpetrators of bombings may climb substantially—acting as an effective bomber control mechanism.

Fabrication of detonators is a much more complex and dangerous activity than fabrication of explosive materials, and could probably be accomplished only in a well-equipped central facility. The widespread use of homemade detonators would, therefore, require the development of a central illegal manufacturing and distribution network, implying a degree of cooperation among perpetrator groups that does not currently exist.

It was the opinion of law enforcement officials contacted that the establishment of a taggant program would tend to drive the more sophisticated criminal bombers toward the use of homemade explosives. The example provided by criminal bombers in Europe, particularly Britain and West Germany, is illustrative. Approximately 85 percent of criminal bombings in West Germany and a majority of the bombings in Britain and Ireland use homemade fillers. As the bombing statistics include both explosive and incendiary devices, the percentage of explosive bombs using homemade explosives may be somewhat less, but may still constitute a majority in all three countries. It is interesting to note that most bombs, including those with homemade explosives, use commercial detonators.

I n summary, the more sophisticated criminal bombers would tend to use homemade explosives more frequently in response to the introduction of a tagging program. Such use would tend to have some detrimental effect on the utility of a taggant program although the effect would be limited by the increased risk of premature detonation, and the reduced reliability and effectiveness of bombs fabricated from homemade explosives. Commercial detonators would still be needed, further limiting the effectiveness of this response countermeasure, as would the elimination of some types of targets. The main threat is that over a period of time, the criminal bombers might become increasingly sophisticated in the fabrication of explosives and even of detonators, and that a degree of cooperation and coordination could develop between the various terrorist and professional criminal groups. The British indicated that they face just that problem —the coordinated IRA improves its tactics and ability to fabricate explosives almost in step with the development of law enforcement control mechanisms.

Use of Incendiary Bombs

A substantial number of current bombing incidents use incendiary materials for bomb filler. Tagging of incendiary materials is not practicable, so legislation of a taggant program may cause a shift toward the greater use of incendiaries in place of explosives. However, incendiary bombs cannot be relied on to cause catastrophic damage or casualties, and are therefore an appropriate filler only for

some types of perpetrators and against some types of targets. It may also be harder to fabricate a reliable delay fuze for incendiary bombs.

Use of Blasting Agents

BATF has indicated that it does not plan to directly tag blasting agents such as ANFO. There are several reasons for their position, In the first place, very few criminal bombings are currently committed using blasting agents as the explosive filler. In addition, tagging the blasting caps, boosters, and detonating cord generally used to initiate the blasting agents would still ensure that taggants were present at blasting-agent bombings, unless homemade detonators and boosters were used. Finally, as blasting agents represent over 80 percent of the commercial explosives currently used in the United States, directly tagging the biasting agents would have a very large cost impact. Some shift to the use of blasting agents might therefore occur if a taggant program were implemented. However, there are a few drawbacks to the use of blasting agents. As detailed in appendix E, the blasting agents are not normally cap sensitive and wou ld therefore require a booster of some sort. Commercial boosters, very large detonators, at least one type of rocket motor used by hobbyists, or several large cherry bombs used together would be sufficient boosters. The fabrication of a bomb using a blasting agent would therefore require the acquisition and assembly of more components than would a bomb using cap-sensitive explosives or gunpowders. The assembly process would not prove a large obstacle to the more sophisticated bombers, but might well prove one to the other types of bombers. Similarly, the increased risk associated with blasting-agent bombs would depend on the knowledge and patience of the bomber.

Blasting-agent bombs would be useful against targets where the blast was the primary damage mechanism, but somewhat less useful than cap-sensitive explosives against targets in which fragment damage was the primary threat. More blast and better fragmentation would be expected from blasting-agent pipe bombs than from gunpowder pipe bombs, but the assembly process would be more complex.

Blasting agents have a density of approximately one-half that of cap-sensitive explosives; approximately twice the volume would therefore be needed, a possible limitation in some circumstances.

Theft of Explosives

Explosives can be stolen, either from the military or from sources of commercial explosives. Some of the explosives used in criminal bombings are currently stolen and more may well be stolen if a taggant program is initiated. Theft of explosives would mean that the perpetrator would be required to commit a collateral crime, increasing the chance for error, the number of leads generated, and the ultimate chance of capture. As detailed previously, the use of taggants should contribute significantly to the rate of solution of explosive thefts, increasing the chance of capture above the current rate.

In addition, protection of explosives from theft could be improved, and may well have to be, to prevent a wholesale shift to theft as a source of explosive material if a taggant program is instituted. Security procedures for explosives storage, transportation, and use are primarily geared to prevent casual or surreptitious theft. Storage magazines have double locks and other features which would require some limited amounts of time and skill to defeat. Inventory controls currently would uncover thefts of large amounts of explosives (case lots). Transportation regulations are primarily to protect the people living along the travel route from accidental detonation. All of these could be altered to decrease the probability of explosive theft. Magazines could be made quite difficult to enter, all explosive material could be required to be stored overnight in a secure magazine (some construction sites use quite flimsy magazines, some manufacturers store sublet amounts of detonators in the assembly building overnight), and transportation of explosives could require armed

guards. Tighter inventory controls, including accountability for each stick of explosive at the blaster level, could also be required. All of these controls, however, have cost impact; it would require investigation to determine whether their cost would be justified by their marginal utility in the face of the current, and predicted, bomber threat. Possible costs for increased security of explosives were not included in the OTA study. As noted above, a benefit of identification taggants is that they would help to pinpoint the places from which explosives used in crimes are stolen, and thus serve as a guide to where security most needs to be tightened.

As noted earlier, military explosives are more securely guarded than commercial explosives, so criminal bombers may be expected to more frequently attempt to steal commercial explosives. As noted in table 70, the more sophisticated bombers are likely to have moderate to high success in stealing commercial explosives (although at increased risk) while the less sophisticated bombers can expect low to moderate success. No group would be expected to have significant success in stealin, military explosives, an indication of the success likely for theft of commercial explosives if increased explosive security measures are implemented.

Illegal Sources

Explosives could be purchased on the black market or illegally imported from abroad. Both courses of action subject the bomber to increased risk of capture, from informants or undercover agents in the former case and as a result of smuggling, in the latter. Only terrorists or professional criminals with substantial resources and the ability to plan in advance are likely to be able to import explosives from abroad, or likely to make the proper black-market connections.

The term black market, in this context, does not refer to a sophisticated nationwide network but to a local array of entrepreneurs who deal in an illicit product for profit. This criminal element exists in nearly every major American city, and when asked could provide stolen commercial explosives or explosive materials as quickly as they could provide stolen drugs, jewelry, or television sets. A taggant program, it is believed by analysts and law enforcement experts, would increase the demand for stolen explosives, thus increasing the local market. However, experts of the two major metropolitan police agencies and two Federal law enforcement organizations with whom detailed discussions on this subject were held agree that initial increases in the black-market demand would be low, as the sophisticated bombers are more likely to turn to one of the other countermeasures as a source of explosives. Moreover, taggants could help in tracing any black marketeer who dealt in stolen, but tagged, explosives.

Use of Explosives Manufactured Before a Taggant Requirement

One further countermeasure is possible, at least initially— the use of explosives manufactured prior to implementation of a taggant program. This response requires planning well ahead and storage of the explosives for a period of time. Storage would increase the risk of accidental detonation (particularly if the explosives had to be moved several times) and of the explosives being found. In addition, most commercial explosives have a limited useful lifetime. Gels, slurries, and emulsions have a limited useful life on the order of 6 months, while dynamites have a lifetime of a few years [more for the lower power dynamites). Gunpowder, boosters, detonators, and detonating cord have a useful life of tens of years.

Detection Taggant Seal

Detection taggants emit a vapor; their efficacy depends on its being able to permeate the container in which they are placed and be detected in the free air stream. It is possible to create a seal around the explosives, thus defeating the detection taggant system, but the construction of such a seal is difficult, cannot be accomplished without specific technical knowledge and equipment, and cannot be ac-

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complished without the time and resources to construct such a seal. Ordinary sealing mechanisms, such as placing the explosive in a paint can, using baggies, home sealing units, or using activated charcoal apparently will not work, even if several are used in conjunction, as the taggants were specifically chosen for their ability to penetrate the microencapsulated membrane and the sensors are able to detect taggants at a parts-per-trillion concentration level. It should be noted, however, that tests under field conditions to confirm these laboratory results have not yet been conducted.

Only the more sophisticated of the criminal bombers are even likely to attempt to achieve vapor seals, and they stand only a low to moderate chance of succeeding. One of the problems faced in trying to construct a seal is the lack of feedback – without a taggant vapor detector, or other sophisticated laboratory instrument, the bomber will not be able to tell if his seal is sufficient.

"Spooking" of Detection Taggant Sensors

Detection taggant sensors could be purposely triggered or "spooked" by placing detection taggants, or other materials so similar chemically to the detection taggant that the sensor could not make the distinction, in nonexplosive materials. If several suitcases or packages within a short period of time triggered the detection taggant sensor for no apparent reason, those operating the sensor might well conclude that it was malfunctioning, and disconnect it. Large amounts of taggant material might also be used to "saturate," and at least temporarily disable, the sensor. It would then be possible to introduce tagged explosives into the protected area. This countermeasure would require that the bomber obtain a supply of the detection taggant material; access to detection taggants can and should be made cliff icult.

Shift to Other Unlawful Activity

Finally, bombers can turn to other crimes, such as murder, assassination, or kidnapping. These crimes, however, are often not as spectacular as bombings and all involve a higher risk to the perpetrators than do bombings. In addition, a direct action against a visible target requires more motivation and a different temperment than does an indirect crime such as a bombing. The switch to other tactics is an appropriate response only for a subset of criminal bombers; only some of the types of bombers who would attempt to switch tactics in response to a taggant program would be successful. The small-scale criminal, the experimenter, and the disenchanted would be unlikely to turn to the other crimes. Some of the mentally disturbed would, with low to moderate success. The professional criminal can be considered a craftsman at his trade; he may not be able, either physically or emotionally, to adjust to other methods of attaining his ends. Terrorists are the most likely to switch tactics, based on foreign experience, and would probably be moderately to highly successful, although at greatly increased risk.

Summary

There are a variety of response countermeasures which the criminal bomber can attempt in an attempt to decrease the utility of the identification and detection taggants programs, The amount of success expected for each response varies with the skill, resources, and aim of the different types of criminal bombers. Most of the countermeasure responses carry with them an increased risk of capture, increased probability of an unreliable or premature detonation, or decreased effectiveness of the explosive. The effect of the added risk should not be underestimated — bombing is an attractive crime because of the low risks currently associated with it. if those risks escalate, then the attractiveness decreases, probably resulting in significantly reduced numbers of bombings and significantly reduced severity of the bombings. Domestic and foreign law enforcement officials were emphatic in their opinions that increasing bomber risk was a realistic and important control mechanism.

In a similar vein, the importance of reducing the effectiveness of bombs should not be overlooked. Taggants have their optimum effectiveness in the protection of high-value targets and the investigation of significant bombings. It is in just those types of situations that reducing the effectiveness of bombs will have the most payoff.

Nevertheless effective countermeasures are possible. Bombers with sufficient skill and training can completely overcome the effects of a taggant program if they have adequate time and resources. The greater the sophistication of the bomber, the smaller the risks and the smaller the loss of effectiveness resulting from countermeasures.

However, it should be recognized that while the countermeasure responses are entirely possible, it is by no means certain that significant numbers of bombers will actually use them.

OTA consulted numerous explosives experts, all of whom agreed that countermeasures such as those described were possible, at least for some of the types of criminal bombers. However, the law enforcement experts and experts on terrorism which OTA consulted also unanimously agreed that most criminal bombers, including terrorists, would fail to make use of the countermeasures. This assessment appears to be based on an assessment of the type of personality that is generally involved in bombings, as well as the general level of skill of the bombers. An instructive analogy is aircraft hijacking. It is possible to smuggle a weapon on an aircraft by a number of means, but, in fact, since the antihijacking program started there have been thousands of weapons found annually by the screening process, hundreds of weapons found abandoned near the controlled boarding gates, but essentially no cases of aircraft hijacked with the use of smuggled weapons.

FOREIGN EXPERIENCE IN CONTROL OF BOMBERS

Discussions were held with British, West German, and Irish law enforcement officials in an attempt to gain insight into the methods used to combat and control criminal bombings in those countries. The bombing problem in those countries, and most of the rest of Europe, is considerably different than the domestic problem; it is appropriate that the control methods also differ.

Essentially all bombings committed in the three countries are carried out by terrorists; in Britain and Ireland the bombings are almost entirely by one group of separatist terrorists — the IRA.

Commercial explosives are rigidly controlled in all three countries. In West Germany this control is primarily administrative— permits are needed for the transportation, storage, and use of explosives. In addition, a much more intensive surveillance of suspected criminals is practiced, together with a very intensive intelligence operation and a relatively strict border inspection procedure. As a result, almost all explosives used in bombings are homemade (85 percent), although some military and commercial explosives are used. The military explosives are stolen from military bases or recovered from maneuver areas, while the commercial explosives and detonators appear to come primarily from Eastern Europe.

In Ireland and Britain the controls are more direct. Commercial explosives are stored, transported, and maintained by the army or police, who personally supervise the detonators and check to ensure that no undetonated explosive remains in the area. The army or police accountability for the explosives extends to the individual detonators and sticks of explosive. As a result, almost all criminal bombings use homemade explosives.

The number of bombing incidents per year in West Germany is about one-fourth of the number of domestic bombings reported *to the* FBI or BATF data banks, which results in about the same bombing rate on a population basis, but a far higher rate per unit area, since West

Germany is about the size of Oregon. This geographic concentration, the single class of bombers, the almost universal use of homemade explosives and an effective centralized criminal control authority have allowed the West Germans to develop field and laboratory investigative techniques that apparently result in higher arrest and conviction rates than is the case in the United States.

The number of bombings in the Republic of Ireland is quite low; no data was available concerning numbers of bombings in Britain or arrest and conviction rates in either country.

The British use a tagging system that apparently consists of different colored threads interspersed in the explosive The threads do not survive the detonation, but the system cannot be defeated by simply discarding the cartridge, as can the current U.S. date-shift code. The West Germans use a system similar to the date-shift code, while the Irish dye their explosives (from the single plant) to indicate a destination.

The experience of these three countries offers some insight into the problem of control of domestic bombers and to potential bomber countermeasures.

As a result of law enforcement efforts to control the source of commercial explosives and to institute other efforts to combat bombers, there are essentially no bombers other than terrorists in any of the three countries. Given the different conditions in the United States, it is improbable that all other bombers would be eliminated, but their relative numbers could be expected to decline dramatically, if a taggant progam were implemented.

As a result of the control of commercial explosives, bombers in the three countries rely largely on homemade explosives. As noted earlier, this countermeasure is likely to be seen in the United States, as well, if a taggant program is initiated. The result of this shift in explosives will eliminate some bombers, make some targets difficult to attack, due to decreased effectiveness of the explosives, and significantly increase the risk of an accident to the perpetrator.

Finally, a possible long-term effect of the taggant program, as is the case in Europe due to explosive controls, may be the development of a highly skilled group of bombers, as well as more coordination and cooperation between bomber groups.