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# Explosive Detection Producing Explosive Controversy

***A proposal by the U.S. Federal Aviation Administration has ignited a firestorm of disagreement over required installation of 10-ton machines costing $1 million each for detection of explosives. One dispute is whether they work; another is whether they're needed.***

*by*
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Few issues are more emotional, technical, political or philosophical than terrorist acts against innocent civilians. These considerations have become interwoven with a U.S. Federal Aviation Administration (FAA) proposal published in the July 10, 1989, *Federal Register* that would require airlines to install thermal neutron analysis (TNA) machines at a number of specified airports beginning later this year.

The 1960s threat to civil aviation represented by a hijacker's pistol soon yielded to the explosives threat, represented by dynamite and its equivalent in the hands of early bombers. Most detectors could find it. Then more sophisticated terrorists began using military explosives and an upgrade in detection ability was required. This cycle has been repeated in many arenas of security, and there is no reason to believe it has stopped with the radio-cassette -recorder bomb.

Technology is often effective, at least psychologically, in restraining terrorism by impressing some terrorists with the obstacles in their path. That value alone perhaps repays a part of the expenditure in tax and passenger dollars, which are the same dollars in most instances. With the TNA advent, the dollars have increased to $1 million per machine. Science Applications International, Inc., the sole manufacturer of these machines at the moment, estimates there may be a need for 1,500 of them. (Other TNA machines are under development in France, England and in the United States by Westinghouse and EG&G Astrophysics Corp.)

It does not take much calculating to arrive at the cost of acquisition alone, to which must be added operating costs, maintenance costs, modification costs to airport structures and the liability costs of taking the TNA route to aviation security.

The proposed security upgrade has aroused some segments of the aviation industry, primarily airports and airlines, to heights of resistance not often seen where security is involved. While the U.S. industry is aroused, many foreign governments are flatly opposed to TNA, and at least three nations have refused to allow the radioactive devices to be installed at their airports.

The FAA initially ordered the machines installed at 15 U.S. and 25 foreign airports handling international traffic with the United States. Later, installation of the detectors may be required at 100 airports, according to U.S. Secretary of Transportation Samuel Skinner.

Arthur Kosatka, chairman of the security committee for the Airport Operators Council International (AOCI), said industry would prefer another approach. He said, “If AOCI had its preference, we would like a threat-driven system using combinations of low-technology detection systems. We have no problem with TNA where it is indicated for really high-threat areas where you might have to check a large number of bags. But you don’t need it everywhere.”

Responding to industry concerns over the FAA proposal, John Battema, director of marketing for Science Applications International, Inc. (SAIC), likened it to an earlier controversy: “Yes, there are a lot of people unhappy about TNA. But if you think back when X-ray equipment first came out, they all screamed, ‘Who’s going to pay for it! People will get X-ray burns! We’ll ruin their film! We’ll kill babies!’ All that sort of thing. I recall a tabloid story with a huge headline that said: ‘Airport X-ray Units Cause Cancer!’

“We’re now twelve years down the line and I suspect that if you announced we’re pulling all X-ray units from airports, there would be a great outcry from the traveling public. They do help people feel more confident about flying. Ten years from now, I think TNA is going to be an accepted fact. If someone comes along with a better mousetrap, it will be that system.”

Former FAA security chief Billie H. Vincent, now affiliated with Aerospace Services International, Inc., says there should be immediate deployment of TNA (for checked baggage) and the Ion Track Instruments (ITI) sniffer system (for boarding passengers). This, he said, “is a near-term solution to explosives detection, with sniffer technology being introduced when detection goals are met.

This article deals with the main issues under dispute, which may be classified at the outset into two basic questions: does TNA do what its developers and the FAA claim; and, does its performance matter when the machine is intended to deal with only one threat?

## The Background

The destruction of Pan Am Flight 103 in December 1988 by a terrorist bomb did not, as many people believe, spur the introduction of TNA technology for explosives detection. In November 1988, five weeks before the Pan Am 103 bombing, the FAA routinely announced through its public affairs office that the agency would propose the imposition of rules requiring TNA machines for international air traffic.

Following the bombing, the U.S. Congress put predictable pressure on the Bush Administration to do something. In April 1989, Transportation Secretary Skinner announced at a press conference that he had ordered the installation of TNA machines in response to the Pan Am 103 disaster. The schedule of acquisition and installation was almost exactly the same as that disclosed by the FAA with neither political pressure nor media fanfare the previous November.

In 1982, the FAA calculated that the value of a statistical human life was $620,000. A more recent figure calculated by researchers from Harvard and Tufts Universities and the Oak Ridge National Laboratory put the value of a human life at $2 million. Such numbers are used by governments to calculate cost-versus-benefits of proposed regulations. One of the points now annoying the aviation industry is that the FAA seems to have ignored this calculation in proposing the TNA rule, allegedly fearing it would show TNA far too expensive a solution to the problem of bombs aboard airplanes.

“When you do all the statistics involved in this problem,” said Kosatka, “you discover that you come up with the likelihood of one percentage point plus a fraction — I’d be willing to say two percent — against eight Billion, with a B. The FAA’s proposed solution is simply overkill. The FAA’s cost analysis data shown in the Notice of Proposed Rule Making (NPRM) are all assumptions, all guesswork. There is no data in there to back it up. Nowhere do they give the cost-benefit analysis details.”

Congress, being a body of elected legislators, is vulnerable to an emotional component in terrorism which is not present concerning aircraft accidents due to mechanical failure, pilot error, weather and other reasons. Terrorists work to keep it that way, of course. People feel horror in dying from a terrorist act that does not compare with dying in a “routine” accident.

In his current best-selling book Innumeracy, author John Allen Paulos notes: “... seventeen Americans killed by terrorists in 1985 were among the 28 million of us who traveled abroad that year — that’s one chance in 1.6 million of becoming a victim. Compare that with these annual rates in the United States: one chance in 68,000 of choking to death; one chance in 75,000 of dying in a bicycle crash; one chance in 20,000 of drowning; and one chance in only 5,300 of dying in a car crash. Confronted with these large numbers and with the correspondingly small probabilities associated with them, the innumerate will inevitably respond with the non sequitor, ‘Yes, but what if you’re that one,’ and then nod knowingly, as if they’ve demolished your argument with their penetrating insight.”

Responding to this phenomenon, the FAA has for years been pursuing numerous approaches to detection of weapons and explosives. Some experimental detection technology has been discarded because it could injure passengers or their baggage, or it is not sufficiently effective. Systems must meet a minimum level of detection for threats and a maximum level of false alarms, all without mangling luggage, taking too long per container or making the luggage radioactive.

More than any other aspect of civil aviation security, passenger screening (with accompanying baggage) is seen as the critical element because terrorists have often posed as passengers or would-be passengers entering the terminal. There are numerous ways to screen people and objects, all with pros and cons. Some are theoretical techniques that do not work in the real world, others generate a high false-alarm rate or permit too many undetected items of contraband to pass.

## Explosives Detection

Bombs are only the most recently demonstrated threat against world civil aviation, although they may be replaced by others such as missiles, chemical agents or a still-unanticipated weapon. Notable with any new threat is the reaction of passengers, who are very tolerant of security delays in the first weeks or months after an incident; then tolerance falls off as memories fade.

About 500 different types of explosives are manufactured in the U.S. alone, most of these being nitrogen-based. The FAA has spent more money developing explosive detection technologies than almost any other R&D problem since the mid- 1970s, and there is hardly a potential technique which has not been checked out. Aside from the TNA system, there are "sniffers" which detect vapors of explosives. Principal U.S. makers of these devices are Thermedics Inc. and ITI. The FAA deserves great credit for the thoroughness of this R&D effort, partly because the technology has benefits for many other law enforcement fields.

This information is important in aviation operations because security professionals must know what justifies their concern and what is not likely to be encountered. It also matters because FAA officials have complained that manufacturers of detection equipment do not always mention what their equipment *cannot* detect. Security managers, therefore, need to know about these limitations before they buy equipment.

Aside from detection hardware itself, the FAA is concurrently developing or adopting software for signal processing to enhance the results of detection sensors, and is integrating different kinds of sensors to create one machine that will cover all aspects of passenger and carry-on bag screening,

The International Civil Aviation Organization (ICAO) is studying the possibility of an international agreement that identifying taggants be added to all explosives at the point of manufacture. This would allow post-incident investigators to trace the sources of explosives, if those explosives were made in a legal plant. Early tests showed identification of explosives to be quite clear-cut.

A significant irony regarding taggants is that the explosives expert who advised the U.S. government on how to identify illicit explosives later turned out to be involved with renegade CIA agent Edwin Wilson in illegally delivering about 20 tons of C4 plastic explosive to Libya, in addition to unspecified quantities of liquid binary explosives. Binary explosives, as the name suggests, require two principal ingredients, each of which is harmless until mixed with the other. When mixed, one such blend is the most powerful non-nuclear explosive in the world. This material delivered to Syria is believed to have been used in many terrorist bombs. It was a liquid binary explosive which destroyed Korean Air Lines Flight 858 over the Andaman Sea in November 1987, killing 115 people.

A major difficulty with taggants is that stolen explosive or foreign -supplied explosives without taggants would most likely become the material of choice for the professional terrorist. Amateurs using homemade explosives or tagged explosives are not trivial, but would not be nearly so serious a threat.

Explosives have distinctive characteristics, some easily detectable, some not so detectable. Besides being nitrogen-rich, explosive molecules have low vapor pressure, are electrically negative, sticky and thermally unstable. Some sniffer equipment has encountered difficulty detecting explosives with the lowest vapor pressure such as PETN and RDX.

Of the numerous theoretical ways to detect explosives, research has come down to fewer than half a dozen workable techniques that meet all necessary criteria.

Frank J. Conrad, a scientist at Sandia National Laboratories, Albuquerque, New Mexico, categorizes explosives in order of lower vapor pressures (and more difficult detectability). He says that the principal nitrogen-based explosives are: EGDN (ethyleneglycol dinitrate), NG (nitroglycerine), DNT (dinitrotoluene), TNT (trinitrotoluene), RDX (Cyclonite) and PETN (pentaerythritol tetranitrate).

The now-notorious Serntex plastic explosive used to destroy Pan Am 103 is a combination of RDX and PETN, which the previous listing indicates is one of the harder combinations to detect. There is, however, a wrinkle in the picture. Most explosives are manufactured in facilities which also make dynamite, or are stored near dynamite, which is one of the easiest to detect because of its EGDN content.

## Dangerous Combinations

This is a random sampling of a few common materials to illustrate the problem of preventing dangerous substances from being placed aboard aircraft. Some combinations are hypergolic; that is, they ignite spontaneously when mixed. No matter how unfamiliar a chemical name may be, thousands are used around the world in standard industrial processes. The U.S. National Fire Protection Association (NFPA) lists more than 4,000 spontaneous violent chemical combinations. Of course, conditions must be right for an explosion to occur, but arranging the required conditions is often no more difficult than making a bomb.

| *These common substances* | *Explode or Ignite Violently with* |
|---|---|
| **Borax, carbon tetrachloride** | **Zirconium** |
| **Fluorine** | **Almost anything, including nylon, teflon, etc.** |
| **Hydrazines** | **Nitric acid, hydrogen peroxide, many others** |
| **Acetone, other organics** | **Organic peroxide, nitric acid** |
| **Alcohol** | **Sulfuric acid, chlorine** |
| **Aluminum powder** | **Carbon tetrachloride, chlorine, iodine, etc.** |
| **Permanganate** | **Glycerine, acetic acid (vinegar),** |
| **Calcium hypochlorite (bleach)** | **Turpentine, sulfur, brake fluid, others** |
| **Butyllithium** | **Fiberglass** |
| **Cadmium** | **Hydrozoic acid (30 minute delay)** |
| **Calcium** | **Many acids, water, moist oxygen** |
| **Calcium carbide** | **Water (generates acetylene gas)** |
| **Wax** | **Carbon tetrachloride** |
| **Ammonia** | **Iodine** |
| **Magnesium powder** | **Chloroform, nitric acid** |
| **Phosphorous** | **Many, including chlorine** |
| **Polypropylene, glycerine** | **Liquid chlorine** |
| **Potassium** | **Many metallic halides & other substances** |
| **Silver Nitrate** | **Plastics** |

EGDN insidiously contaminates those other explosives during manufacture, creating a much better situation for security. Semtex itself requires that a detector identify one part in 10 trillion parts of air. Because EGDN contaminates Semtex, however, the job is easier. Some manufacturers have claimed for a long time that their equipment can detect Semtex, neglecting to point out that it is the EGDN contaminant they are detecting. This is an academic point until uncontaminated Semtex arrives in terrorist hands and security officials discover the equipment they bought with confidence cannot detect it.

There are other detection techniques in the experimental stage, ranging from microorganisms which react to explosive vapors, to gamma ray absorption techniques, millimeter wave inspection, bottle-content methods for methyl nitrate liquid explosives, such as those used on KAL 858 and advanced X-ray enhancement which checks the high and low Z (atomic number) of materials.

Cost of explosive-detection R&D is expected to be about $43.2 million more than currently appropriated for the next three years.

## Thermal Neutron Analysis

Thermal neutron analysis (initially called thermal neutron activation) bombards a suitcase or container with a stream of low energy neutrons. The neutrons excite nitrogen molecules which are abundant in most current explosives, and this generates gamma radiation which is easily detected by sensors surrounding the inspection chamber. Initial TNA prototypes took 26 seconds per suitcase and inspection is now down to an "optimistic" six seconds. SAIC hopes to get the time down to X-ray equivalent levels of four seconds per bag, according to Hadi Bozorgmanesh, vice president of SAIC.

TNA machines are ideally sited at a chick-in counter for accessibility to the departing passenger and the requirement for numbers of machines could thus be huge when one adds up all counters in all terminal buildings at all airports. SAIC says it can build 100 machines each year, while critics say the company has privately estimated closer to 50 per year.

TWA security sources (who asked not to be named) put the airline problem this way: For New York's JFK International Airport, which is getting the first TNA machine, assume the 20 daily widebody international departures during "rush hour" are lightly loaded with only 200 passengers each. Further assume that each passenger has the established average of two bags each. (The number compiled by the Air Transport Association is actually 1.8 bags per passenger.) Given the six-seconds-per-bag speed of the SAIC machine, that means it will take three hours at one airport for one airline. This, said the TWA security source, ignores any mechanical downtime, hand inspection of false alarms (which itself requires a nine-step reconciliation process) or oversize bags which also require hand inspection. The airline, therefore, figures it could potentially need as many as 35 TNA machines at JFK alone.

The FAA has been exploring the TNA concept since the mid to late 1970s and some patents are held by Westinghouse, which won FAA-development contracts along with SAIC. In terms of bulk detection of explosives, therefore, TNA is what might be termed a mature technology.

A complicating factor with TNA worries many airport officials; it requires licensing by the nuclear Regulatory Commission because it has a radioactive neutron source — californium 252. FAA wanted contractors to develop a non-radioactive neutron source, such as an electron tube. That proved so expensive, said Billie Vincent, that the firm didn't see much of a market even if it succeeded. SAIC is now switching from californium 252 to another neutron source, deuteron-deuteron (DD), but that is also a radioactive element.

There is a question of the neutron sources as a potential security problem in itself. One SAIC competitor wondered if the radioactive source might become a target for nuclear terrorism. The amount of material in the machine, however, is on the order of a few milligrams and would hardly be worth the effort, said SAIC vice president Hadi Bozorgmanesh. SAIC buys its neutron sources from the U.S. government but says anyone can buy DD. The reason for the changeover is that DD has higher reliability and a longer duty cycle.

SAIC believes the market for TNA machines is not nearly as large as the X-ray machine market, and the firm expects to build about 100 machines in 1990. At $1 million per unit, prospective buyers will be deterred from extravagance, but Bozorgmanesh said SAIC hopes the cost can eventually be halved. The total market is unclear, he said. Besides the current model, a smaller machine is under development for use in terminal areas dealing with carry-on bags, and efforts are being made to develop a non-nuclear neutron source.

Employment of TNA machines must be carefully planned by airport security officials. The machine must be close to the check-in counter so bags can be matched with their owners. It would be pointless for the machine to be in the baggage room, where a suspect bag could set off and alarm and the alleged passenger be miles away. Security staff want the passenger at hand if a machine triggers an alarm. There is, however, the question of an interline bag from a small rural airport where there is no TNA inspection. It is yet to be determined what one does with such bags.

Compounding the industry resistance to TNA is the size and weight of the machine. Each unit weighs ten tons and the first one being installed at JFK airport in New York requires a separate building measuring 19 by 40 feet. The airport pays for construction, as well as for modifying terminal buildings to withstand such heavy floor loads when several machines must be put near each other in high-traffic areas.

SAIC's John Battema responds that the placement of a plate beneath each machine would help spread this load by making a larger "footprint," but AOCI's Art Kosatka says this does not alter the basic weight load being added to the building's structure.

## FAA Fines Airlines for Airport Security Lapses

The U.S. Federal Aviation Administration recently announced more than $1.2 million in civil penalties against 27 airlines for alleged security lapses at airport screening points.

This marks the fifth time civil penalty actions were announced against a group of airlines for failing to detect test objects during security checks by FAA inspectors since October 1987 when the agency began imposing heavier penalties for those violations. The agency said that the 27 airlines receiving the notices of proposed civil penalty failed in 178 cases to detect simulated weapons and explosives that were taken through airport screening systems by FAA inspectors.

The latest fines brought the total amount of civil penalties proposed against U.S. airlines for weapons screening failure to $6,455,500. The airlines involved have been cited for a total of 935 alleged violations.

The FAA said, however, that increased emphasis on enforcement has resulted in a significant improvement in airline detection rates, which have increased from the 1987 level of 78.9 percent to 87.9 percent in 1988 and 91.9 percent in the first six months of 1989.

The FAA noted that on July 26, U.S. airlines announced the adoption of the first industry standards for the hiring and training of the security personnel who check passengers and carry-on items.

Under FAA rules, the airlines are responsible for screening all passengers and their carry-on items prior to flight. At some airports, contract personnel perform the screening function for all carriers. At other locations, a single airline may provide this service for itself and other carriers using a common facility. In either case, each individual airline is held responsible for failures of the screening system even though the functions actually are performed by others.

Agency inspectors regularly check airline screening systems to measure the effectiveness of airline security personnel in detecting test objects hidden on their persons or in carry-on baggage. The agency ran more than 6,800 such checks in 1988. The FAA program of testing the effectiveness of security systems is performed only at airports in the United States. In foreign countries, security measures are regulated by the host governments, which frequently participate directly in passenger screening functions.♦

## Does It Work?

Thermal neutron analysis fundamentally detects nitrogen, not explosives. This means it can be triggered by anything containing large percentages of nitrogen, such as leather, wool and similar common materials. Critics of the FAA proposal say the number of false alarms will be so great from this source alone that it will bog down the system. Not so, says SAIC, which contends that the machine is able to distinguish these cases.

Dr. Charles Eisenhauer, a physicist at the U.S. National Institute of Standards and Technology (formerly National Bureau of Standards), said a machine such as the TNA device may be defeated by packing a bomb in boron, depending on several factors. “It doesn’t make much difference what form you buy it in, it’s going to have natural boron in it and be a fairly heavy absorber of neutrons. Certainly it would still overwhelm the nitrogen. Boraxo cleaning powder from a supermarket would work.”

Dr. Eisenhauer, author of a number of scientific papers and books on radiation shielding, said this is because boron and its variants are neutron absorbers, even in highly diluted form. However, it’s not that simple, he added. “Essentially, you get a gamma ray out for every neutron that goes in, but it’s a different energy level for boron than for nitrogen. So, if the TNA device measures and displays all gamma rays, the bomb could get through; but if the TNA device also measures their energy spectrum, you wouldn’t only see gamma rays at the nitrogen capture lines, you would see a different line corresponding to the boron gamma ray, and that would tip off the operator.”

SAIC marketing director John Battema said this is precisely what the machine does: detects and analyzes all gamma rays, feeds them into a computer and decides whether an alarm is to be sounded. Further, he said, the machine detects mostly but not exclusively nitrogen. It also detects other elements common to explosives and computes their presence using an algorithm.

It is theoretically possible that a bomb could be made of boron-based explosives and serve not only as the bomb itself, but also as its own neutron absorber. Boron is the basis for very powerful rocket propellants. If such a bomb were made to resemble a common item, such as a pair of shoes or a bottle of liquor, it could get through both TNA and X-ray examination. But theory and practice are different things.

## Cost

“As far as the airline market is concerned,” said John Battema, “the government has already told them they can make a charge per bag or per passenger to pay for it. After the initial airline screaming and roaring about this, I think they'll discover that the TNA units can be amortized very nicely, including operating costs, with the money they can charge the traveling public. The bottom line, just like the X-ray systems, is that the traveling public will pay for it. There's no free lunch. It's got to be paid for. I've seen polls where passengers say they would be very willing — 90 percent of them — to pay a surcharge."

"Needless to say," replies AOCI's Kosatka, "we are not thrilled with this proposal. We are accepting it only if the federal government pays for it. Even so, you cannot put all the eggs in this one basket. It's the sledgehammer-on-a-mosquito approach.

Battema said the operating cost of the TNA machine will be "on a par" with X-ray machines over a ten-year period. In other words, where X-ray machines need three operators due to frequent changes to maintain alertness, the highly automated TNA system will require one operator, or two at most. Labor costs will thus drop. Maintenance will be minimal, said Battema, because the radioactive source must be changed at a cost of $15,000 only after two and a-half or three years. SAIC promises 24-hour response time for breakdowns and can monitor machines via a modem installed on each, which will allow early diagnosis of impending problems.

## Other Aspects of the Problem

The FAA and industry are also examining the possibility of reinforcing cargo containers and aircraft themselves to reduce damage from explosions. If bombs become small enough in terms of their power, perhaps it would be possible for a cargo/baggage container to limit the bomb's damage to the container itself. But what if a bomb goes off in or near an airport while baggage is being inspected?

"Many airport terminal buildings — because of large windows and glass walls separating interior areas — are a disaster waiting to happen, with either a small inside bomb or a large outside bomb," says Thomas P. Carroll, Director of The Center For Blast Resistant Design in Silver Spring, Maryland. He points out that flying glass splinters can be as deadly as any other kind of shrapnel.

Bombs are the weapon of choice at the moment because defenses against them have been vulnerable, said one expert, and it will not take long for terrorists to switch to missiles, chemical agents or merely incendiaries in cargo or baggage.

"I don't understand why it is that everybody doesn't understand that if somebody wants to get something aboard an airplane that will blow the thing up, they can do it," said Al Teller, president of Explosives Services Co., former president of the Wasters Society, and former special operations expert in the U.S. Marine Corps. "You don't even need an explosive. As a case in point, if you take permanganate and glycerin and devise something that will break a seal between these two substances during a flight, you'll have a tremendous fire aboard that airplane."

It was "a tremendous fire" rather than an explosion aboard a South African Airways Boeing 747 which recently caused the aircraft to crash into the Indian Ocean near Mauritious, killing all aboard. As if an encore, another South African aircraft, a Fokker F-27, suffered a spill of only 200 ml of sulfuric acid being illegally transported by a passenger. Fortunately, the acid spilled while the aircraft was on the ground and evacuation of 43 passengers was possible. It took the fire department three hours of spraying with bicarbonate of soda to neutralize the small amount of acid, which nonetheless destroyed the baggage of nine other passengers.

There are terrorism specialists who say terrorists don't like high technology because they want to be sure the weapon will work. That is why, say these specialists, terrorists use grenades and AK-47 assault rifles. But that statement is true only within certain parameters. Terrorists planning to raid a bank, kill worshippers in a church or synagogue, kill passengers in an airport terminal, or assassinate an individual person will use quite conventional weapons such as guns and grenades. This is not true when the target is a multi-million dollar jet carrying hundreds of passengers and surrounded by a security net. To defeat the security net, terrorists need high technology and they use it.

The choice of technology has changed, especially in cases involving state sponsors of terrorism because those sponsors have the technology and the technicians to make it work. Air India, TWA, Korean Airlines and Pan Am bombs were all very sophisticated devices using powerful explosives and high-technology barometric or time delay circuits. There is no reason to believe terrorists have stopped being creative.♦

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*McGuire's first published article on industrial security was in "Law and Order" magazine. A past president of the Aviation/Space Writers Association (AWA), he has been an accredited correspondent to the U.S. Congress for more than a dozen years.*

*In 1985, he won a national award from the Newsletter Association for investigative reporting after a series on aircraft safety.*

*The new edition of his standard reference work* Who's Who in Terrorism: A Security Intelligence Sourcebook *is expected in late 1989 and will include profiles of terrorist groups and leaders, areas of operation, tactics, links with other groups, statistics on terrorism and other data.*

*His 100-page report* Aviation Security — Strategies for the 1990s *has just been released by McGraw-Hill Information Systems Division.*



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