E.T. My name is Edward Thomas, I'm a Professor of Physics at Georgia Tech.

Q: A lot of people think that nuclear capabilities remaining in the Soviet Union, and the great interest that's shown by very scary people—terrorists, countries [of concern], even the drug cartels of South America in purchasing those nuclear materials, that's the greatest danger facing world stability right now A lot of emphasis has been with Nunn-Lugar and continues to be trying to stabilize the Soviet Union Would you agree with that. Do you think that nuclear weapons are one of primary threat to world security , particularly U.S. security.

A: I certainly think nuclear weapons getting loose and into the wrong hands are a major threat to world security. And my big concern really would be that a complete weapon with the means to detonate it would get into the wrong hands, because these can be relatively small, very dangerous, and if they do come as a complete package, they will explode. I think the danger coming from getting the materials to make a nuclear weapon into the wrong hands is probably far less, but the impact on society by a blackmail threat from an organization which claims to have these materials could be considerable. I think when it comes to building a weapon, the threat is more blackmail than anything else , but if you've actually got one, you could let it off and the impact would be considerable. I think it's a major problem.

Q: How difficult is it to detonate a nuclear weapon long distance….Everybody knows the results of a nuclear weapon. Everybody has seen Hiroshima pictures, they've seen movies like the day after. you'd have to be pretty crazy to set one off. Do you think everyone would believe oh they wouldn't dare, it's really just a threat.

A: I think there are enough crazy people out there, they blow up buildings, they kill hundreds of people at a time, I think we believe that if crazy organization claim they're going to do this, then we believe it It's very easy to set one off. You basically initiate a nuclear explosion through a conventional explosion If you can detonate a stick of gelignite at a distance with a timer, radio control a fuse You have to have a weapon and you have to set it up with the right detonator and you, it's not a problem. You have to work that out. Once you have the weapon, you basically connect two wires together. It's fairly easy to organize that from a distance. It's not difficult.

Q: Russia recently acknowledged that their computer infrastructure is not ready for Y2K . And high ranking officials in the past have acknowledged that the infrastructure managing the safe storage of nuclear materials is antiquated and has been for 20 years and needs replacing. Do you think there is more danger from a nuclear accident in the from a storage poorly run plant than from an attack from anyone. How likely do you think an accident is?

A: We've already had nuclear power station accidents, I should imagine some day someone will have an accident with a nuclear weapon, but you have to recognize what the accident is likely to be. The accidents which happened at Chernobyl , three mile

island were relatively small events. Immediately At three mile Island, nobody was hurt. What happened at Chernobyl was thirty people were killed. It's not clear how many people were injured, there's a lot of misrepresentation of what happened beyond that, but you're looking at relatively small numbers of people. Now in Bhopal in India when Union Carbide's fertilizer plant blew up, it killed six thousand people. You have to put these things in perspective. What would happen if you had an accident in a nuclear weapons storage facility? I should imagine you would not get a situation where a bomb goes off. Many things have to be done to arm a bomb, they're not sitting there ready to go, so that up connect two wires They're sitting there with many pieces essentially removed from the system which have to be put back in, keyed back in, before it is ready to go. It takes a series of steps. I think any reasonable person manipulating these things has got these weapons in a completely safe situation. To let off an American nuclear tipped rocket from a submarine requires two people, each of whom have got a key. You've got things like that People have got to turn a key. It's not a question of a computer saying it's time to let it off. Some Joe Blow wearing a uniform has to use a key, and it's in his pocket or somewhere safe and he's got to go get it and find the other guy and that's for a weapon that is ready to go, a weapon that is stored is even further reduced from a dangerous situation. The real problem that I see is these things have radioactive materials in them They can potentially if mishandled give rise to a small scale explosions Just putting too much fissile material together will make a small explosion. It may devastate a few miles around but this is not the end of the world, it's a big hole in the ground, it's not an international disaster, but it a big mess. there is the possibility of something like that occurring but I rate it as rather small, and I don't think Y2K has anything to do with it.

Q: What about leakage or contamination. Is that more dangerous from poorly run facilities?

A: Yes, that's already happening. The material leaks into the ground, that is in the groundwater, where it may be ingested by humans and animals, and then you worry about what it's going to do there. There's a lot of concern about this. Maybe overrated concern, I don't know, but there is a lot of concern. The standard for nuclear radiation problems is that a human being should not be exposed to more than one percent of what they would get naturally, that is to say just one hundredth of what they should naturally get, and anything over one hundredth of what they would naturally get is considered to be bad, it should not happen We get radiation all time, from around us. It's not completely clear that a very small amount of radiation does you any harm at all. In fact, I think frankly there is some evidence that a small amount of radiation does you good. If you look at the reports of incidents of radiation induced problems in populations, that would particularly be cancer or childhood leukemia, you look at the incidence of those things in the population of Denver Colorado, which has one of the highest radiation levels in the country and compare it with a similar city which has a much lower radiation level, you find that in Denver they actually have smaller incidence of cancer and childhood as opposed to places with smaller radiation levels. There is a thought that a small amount of radiation, a very small amount of radiation, conditions the body so that this kind of problem is actually killed by a small amount of radiation. If you want to be treated for

cancer you often receive radiation treatments. If you want to cause cancer, you give radiation treatments. It depends on how much, where you put it and what you're trying to do with it. It is not clear what the danger level to people really is. Even from the Hiroshima and Nagasaki explosions, the number. if you exclude the people who were killed immediately or within a very short space of time from the immediate blast and the immediate radiation exposure, the long term mortality statistics show that people who survived the first year or so have no more incidence of cancer and leukemia than people who were not exposed to these things in the first place. That's a bit of concern, a bit of a problem particularly for people who really worry about these things. But that's the case. Those are the statistics.

Q: What is nuclear fallout?

A: Nuclear fallout is the waste product that comes out of a nuclear explosion. These are generally radioactive products, that's what people are concerned about. These things may get ingested into the body , they may congregate in certain places, this gives rise to high levels of radiation in the body, which gives rise to mutations, leukemias, cancers, and so on. So fallout is the rubbish that is left behind after the explosion takes place. It may be almost any material in radioactive form.

Q: A lot of it's invisible, right

A: It's a bit like pollution. If there's a only a little of it, it's invisible. When you get a lot of it, like on a day like this, you can see it. The immediate effect of a nuclear explosion is a large fireball, dust clouds, these undoubtedly have high levels of radiation in them, and you can see them. the individual atoms , the radioactive atoms, which are dispersed long distances by the explosion, you will not actually see them. The way you pick them up is by the various nuclear radioactivity detectors.

Q: There are countries like India and Pakistan that are adding nuclear weapons. Basically the world is disapproving…tries to pretend two new members have joined the nuclear club. A lot of emphasis has not been placed on acknowledging that there is a nuclear club whether we like it or not and that people do need to follow standards and practices for maintaining nuclear weapons…Do you think it is important that we acknowledge that there are nuclear countries and encourage those countries to adopt standards for maintenance and care of their facilities or should we just be disapproving?

A: The countries that are doing this will not pay any attention to requests for standards and for taking care of these things. They are not interested. They are building them because they feel they should have them. They are already building them in defiance of international treaties In the case of North Korea, I believe North Korea has actually signed the nonproliferation treaty, saying it won't do it, but they are manifestly doing it. India and Pakistan I believe have actually refused to sign the treaties and said flatly that they refuse to be bound by international treaties. This is not very helpful. There is no point in having countries that don't intend to build them to sign up saying that if they have one, they'd look after it properly. It's a difficult thing. I would much prefer that

there shouldn't be any. I think one should be very disapproving of countries and persuade them not to build them. There's always two components to this. There is the building of the weapon and setting it off. Secondly, there's the delivery of it, where somebody is going to suffer for it. Just because you have built a nuclear weapon in your backyard, it doesn't mean you can deliver it to New York or to Moscow or Kurachi. Delivery is a different matter. Even placing the bomb in a form where it can be delivered, like putting it on the tip of a rocket is a difficult technological problem. It's not completely clear to me what is the status of the bombs such as the Indian bomb or the Pakistani bomb. Whether these are bombs that can be put on a missile or put them on an airplane to deliver them or whether these are test assemblies that you can build up a lab, drop down a hole and let off but that would be quite unfeasible to put in a plane and deliver them. I don't know.

Q: People like to use the example, you can learn how to build a bomb on the Internet. How easily could the average person build a bomb if they had fissile material. Can you get everything you need from Home Depot and Radio Shack?

A: In principle, yes. You can read up how to make a jet engine on the web, I'm sure, and you can in principle buy all the metal for a jet engine from Home Depot and all the other supplies in town. Just cause you have read about it on a web site, and you can buy the aluminum, the titanium and the steel, it doesn't mean you can build one, and even if you can build one is it going to perform like a jet engine, and have the lifetime and the characteristics of a jet engine that you put in a plane? So the answer is, yes, it's feasible. Getting the fissile material is a good question because you can't buy that at Radio Shack, you can't buy that at Home Depot. There may be rogue suppliers around the world who will supply it to you, but just cause you've got it, it doesn't mean that you can build a bomb assembly to let it off in a controlled fashion and deliver it One of the greatest dangers is you will bring them close together and it will go off prematurely, in which case you've killed yourself. It's like making your own fireworks. It kills a lot of people who do that. It's a dangerous thing to assemble these weapons.

Q: Nuclear materials can fit in a suitcase, but what about a bomb. Have there ever been nuclear bombs that actually fit in a suitcase?

A: Yes, and you can go see one at the Sandia Air Force Base in Albuquerque, New Mexico where they have an exhibit of all the bombs that the United States has ever put together. They've got no uranium or plutonium inside them, they're just the shell, completely safe. The smallest one sits about a foot high and six inches in diameter, designed to be fired out of a bazooka. It will fit in a suitcase.

Q: Americans in the cold war were conditioned to feel that much more danger from conventional bombs built from easily obtained materials What did the bomb in Oklahoma City consist of, besides fertilizer?

A: It was fertilizer and I think either diesel fuel or fuel… and the detonator to get it started, which was probably the same kind of detonator used in commercial explosives.

Q: What makes fertilizer so explosive?

A: What you're doing is oxidizing the material very rapidly, causing a very rapid chemical reaction in a large quantity of material which just spreads through that material. It's a burning, in the presence of a large quantity of oxygen

Q: Why fertilizer and not hay, or something else? What's special about fertilizer?

A: I'm not quite sure. I haven't learned about these bombs. I think actually it's probably the oxygen which bound up in fertilizer that does it. And it just happens to be a good chemical reaction, it burns and it's cheap to buy. It's available in large quantities from your average seed and feed supply house and you can get diesel fuel from your gas station. This is why it has been used in the states and it's used fairly frequently in Ireland, too.

Q: In the 50s and 60s, a lot of work went into bomb shelters…In high school civics, I had to learn the location of every bomb shelter in my city and the quickest route to get there. I remember the auditorium was a bomb shelter and so was the basement of hospital. And everybody who grew up in that time remembers the little triangle sign that indicated a bomb shelter. You don't hear much about bomb shelters any longer I'm not sure those places are even designated any longer as bomb shelters. Is the bomb shelter program still in existence? Was it ever really a deterrent, would it ever really have protected a lot of people or was it just a placebo to make us all feel better?

A: Bomb shelters would have been useful if you were some distance away from the epicenter of the blast. If you are right close to the blast where the big bang occurs, this is going to excavate holes in the ground and destroy bomb shelters, and a bomb shelter won't be any use to you. but people die in these explosions from blasts, if you are protected from the blast you're going to survive. People also die from radiation If you are in a self contained environment with a clean air system where you can stay for a while until the radiation levels die down, even go away, maybe you will survive it. If you are some distance away from a bomb and you are properly sheltered, you are likely to survive it, with proper precautions. I would think in the case of a massive attack on the United States of at least some tens of weapons, some hundreds of weapons, an array of bomb shelters, available to the population as a whole, might have been a valuable thing to have. If you're being blasted by thousands or tens of thousands, I think the Soviet Union has about seven to ten thousand weapons, the damage across the country may be so severe that nobody really is going to escape these things. I don't know how valuable they would be against an all out nuclear attack by somebody like the Soviet Union, nor how or for that matter how good the Soviet Union bomb shelters would be if we were to attack them. There is a huge amount of damage in an all-out nuclear war. The original bomb shelter program was begun when the number of weapons on either side was relatively small so you were not looking at huge fields of destruction across the country.

Q: Is there any point to the program any longer or is it just an anachronism from the fifties and the sixties?

A: I suspect there is no point to the program. I think the government may do it for its senior executives, so the president has a bomb shelter even if you haven't. In terms of the whole population, I don't think they bother about it, and that's probably the right thing to do. The chances of a significant attack in terms of a large number of weapons is exceedingly small. It's very dangerous the possibility of an individual weapon somewhere or even fallout from an individual weapon…

Q: Do you think there would be any utility to a bomb shelter for…airborne anthrax and things like that?

A: Some of the bomb shelters were made airtight. If you tried to protect yourself against radiation, radioactivity fallout, you would have to have a proper air supply, an air filtering supply, so that everything was filtered out. You preferably want an enclosed air supply. If you had that, you could protect yourself from anthrax spores and anything else. If you had your own water supply, bottled water, you could protect yourself from water contamination. A really good bomb shelter, an enclosed environment separating you from the outside world will protect you from those things I suspect most bomb shelters, like the ones you were talking about in the basement of buildings, were not sealed. The main thing was to protect people against the initial blast and provide a certain amount of protection against the initial radiation exposure and maybe some of the fallout. There's no controlled air supplies, no protection like that. That kind of shelter is not going to do any good in protection against chemical warfare or a biological warfare situation. we had an example of that in the release of the sarin gas in Tokyo. People actually dropped it in the subway system which is probably one of your best nuclear fallout shelters. They put it in the air system at the station in the subway system and it spread around and killed people. Once it gets in there, it's terrible, it's more of a death trap than being outside.

Q: A lot of the effort of the Nunn-Lugar program, Nunn-Lugar one, focused on the disposal Nuclear material in those weapons has a lengthy half life. Please explain the concept of half life

A: Materials which are radioactive decay in their radioactivity as a function of time. The half life is the time it will take for the radiation level to drop to one half of what it was when you started measuring. Tritium, which is used in fusion weapons, has a half-life of about thirteen years, the radioactivity drops off. In the case of tritium, it's converted to something else, so then after thirteen years, half the radioactivity is gone and the radioactivity is just a signature that it's tritium so half the tritium is gone, Converted to something else, helium and nonacting hydrogen So after a period of time, these radioactive materials do decay They become radioactive materials, which may be less dangerous, or they become nonradioactive materials. So in terms of getting rid of the materials, if you wait long enough, it will all be gone. But the amount of materials in weapons is relatively small. If you take the seven to ten thousand weapons the United States has got with the few pounds even tens of pounds in each. You put all this together,

you've got a fair sized lump of materials, a couple of times the size of this room. You wouldn't put it together in a room, it would blow up but it's not a huge amount of material. So in terms of putting it somewhere and letting it decay off, this is not a big problem. The big worry is that the half lives of these materials runs to hundreds of thousands of years. People worry about the long-term custodial situation Whose going to guarantee that someone is looking at it in a thousand years time and making sure that people are not messing with it, dispersing it, getting mixed up in it.

Q: So…The real issue is will there be continuity of management.

A: Correct.

Q: I know that lead is considered impermeable to radiation. Are most nuclear materials stored in lead containers? What is it that makes lead impermeable?

A: The elements of the periodic table, which start at the bottom with hydrogen, where the nucleus is relatively small then it goes up eventually to uranium, and lead is very close to uranium and the nucleus gets bigger and bigger. In a sense, the nucleus is so big that radiation doesn't pass by. When you put the atoms together, The radiation effectively gets absorbed in those large atoms, so lead is a good absorber so any material at the high end of the periodic table, tungsten is an example, tend to be good absorbers of radiation, which means if you want to absorb radiation, you can do it with a relatively thin piece of material. All materials absorb radiation, attenuate radiation the wood of this table will attenuate radiation, it just doesn't do it very well. To get the same effectiveness as centimeter of lead out of concrete, you may have to go to many feet of concrete but it will work just as well as lead, it's a question of quantity Lead is considered one way to do these things, in terms of protection, but you can protect with concrete.

Q: When I was growing up in Louisiana, there was talk of using the old Morton salt domes for storing radioactive waste. What is it about salt domes that make them suitable for nuclear storage?

A: Salt domes have been there a long time and they are presumably not penetrated by ground water because if they were, the salt would leach out and it wouldn't be a salt dome any more…These are very stable geological structures. There's no water moving through them…no air moving through them. They're a great distance from the earth's surface. People are not moving close to them. If you put something in them, it's not going any where. And even if you put it in a container which eventually deteriorates. Lead eventually deteriorates, concrete certainly deteriorates. Even if it deteriorates and spills out on the floor, it's not going anywhere, it's just sitting there as an ugly mess of stuff on the floor An isolated area with very little activity. These places have no seismic activity. It's quite unlikely to be an earthquake or anything like that. You've got a very stable structure

Q: I've also heard there's concern that these storage facilities will deteriorate. Do you think there's much danger of groundwater contamination. Is this already happening?

A: We do have it. It's already happening at the University of Georgia where they used to bury stuff in the ground I think Emory had a problem a few years ago. It used to be when you had radioactive materials of very low usage, to get rid of it you threw is in the ground, dumped the earth back on top and hope that nothing could go wrong. We do not do that any more. There is a danger of groundwater contamination, but not coming from radioactive materials. There's a huge amount of radioactive material used elsewhere, it's used in hospitals its used for cancer treatments, its used for tracer analysis, diagnostic techniques, dental procedures for x-raying, rotor blades for jet engines, industrial techniques, for x-raying and that material is not as well looked after as it should be. There tends to be a much larger volume once you get away from nuclear weapons. Think about all the wipes and clothing used by diagnostic technicians in hospitals. Once they get small amounts of radioactivity on them, somebody has to do something with them and what they do is pack it in these containers and hope somebody's going to dispose of it in a thoughtful fashion. That doesn't always happen. There is a considerable amount of nuclear waste that comes from activities that we as civilians would generally approve of. And somebody has to get rid of that, too. That, in terms of the volume, is a problem. And that in terms of previous mistakes in storage is where a lot of our leaks occur. Now the government does have some problems in nuclear weapons sites. These sites tend to be very in very, very large areas and the problem is right in the middle of it and it's going to be a long, long time before the problem ever gets from the middle of the area to the outside of the area where the rest of the world lives. There's some problem with the ground water at the Hampton plant in Washington state but its entirely confined and they know where it is. In principle if they put it into concrete tanks and dig the dirt up and bury it somewhere, maybe in Louisiana, the problem would go away.

Q: The consequences of Chernobyl were devastating to the Ukraine. What about the rest of the world? Did anybody else feel the consequences of that accident.

A: think the consequences of the accident are somewhat debatable. First of all you did have the initial impact, and there were thirty people were killed mostly from burns, the burning, you had a fire Some people died of radiation sickness because they got very close to very high level radiation. They tried to follow the consequences of the accident, in Ukraine and elsewhere, and some people feel the consequences are not very great. most of the things that are going to happen happen in the population anyway . the real question is whether the incidences of the problem have increased or not. I think there are some things, childhood leukemia, where the incidence rate has gone up in parts of Ukraine. In terms of people dropping dead in the street, that doesn't happen Whether they could actually say that the number of people who died is more than the thirty who died on the site, I don't think anyone can put additional numbers to that. I think it likely the number is zero, or close to zero. Incidentally, the childhood leukemia problem which arose can be treated. The issue is can you find them, and you do. Did blow over Europe and countries took precautions. The precautions continue today. There are some livestock in Scandinavia which cannot be sold because the government considers they ingested too much radiation, so farmers are actually paid to slaughter these things and the

carcasses are buried . I believe something like that is also going on in certain parts of England, and the radiation, the dust cloud has traveled as far as Scotland and Wales. The government takes precautions. They use the standard that you should not be exposed to more than one percent, and preferably much less than one percent of what you normally find, and on that basis they feel these things need to be taken care of, so they do.

The dust cloud has dispersed but the material that that was in the dust cloud is still there and the dust has settled down onto the ground and the problem with animals ingesting it, it is spread around, it gets into water, it begins to congregate in certain places. It's got nothing to do with the radioactive nature of materials, but you have something like radioactive calcium it will eventually end up in bones because that's where calcium in the food supply does. So you get some concentrations of these radioactive elements just because of the natural concentration in the human animal and biological systems. Fish, for example, take up a lot of this radioactive material. They're exposed to it in the water, they ingest it, it goes into the body, builds their body structure and sits there as radioactive material. The question is whether this is really a concern.

Q: You used to hear back when there was concern, during the cold war when we were concerned about a major nuclear attack, about the concept of nuclear winter and the fact that it would last a long time and be very devastating to the planet. Was that ever a real threat. What exactly was nuclear winter?

A: If you had a huge exchange of nuclear weapons between the great powers, which was something we thought might happen you would create huge fires around the world. These fires give rise to a huge amount of soot, which will blow about the atmosphere. There will also be dust raised up by the explosions into the atmosphere. the dust will prevent the sun from shining on the earth' surface, and when that happens everything on the earth's surface is going to die, it will be like a winter, it will be dark Now this is just due to the dust and the dust clouds. As a result death of living things, the food we eat will not be there, and we will die, and animals will die, and there will be a considerable reduction in the life on the surface of the planet. There is a thought that this has happened already as a result of meteorites before man was on the planet. They created huge amounts of dust as a result and they created victims. There were changes in the animal population may be the reason why the dinosaurs died out, because of a meteor induced winter which was created due to the effect of a meteor on the earth's surface. very difficult to predict with such a huge amount of energy being generated, with the amount of rubbish thrown up, the air circulation in the world will change. can't just look at current air patterns and say there will be some dust flowing around up there. It will completely change the weather patterns of the earth. I think it will be completely impossible to predict. I do not want to have anything to do with a nuclear winter. I think it will be catastrophic, it will last through lifetimes of human beings.
It's not something that will go away after twelve months. It will destroy life as we know it.

Q: What would it take to cause nuclear winter, a lot of nuclear bombs falling at once in a concentrated location or scattered throughout.

A: Scattered would do it. In fact, concentrated probably would not do it. You're looking to set the world on fire, literally, blow bits out of it, so you'd probably want to have them scattered fairly broadly as you can across the surface of the earth if you wish to do that. I think one has to recognize that the consequences for everybody involved in such an exchange is catastrophic. This is a nuclear winter for the world, and that involves both sides of the conflict. It does involve large numbers of weapons, the setting off of one weapon is not going to cause a nuclear winter. We've already set off weapons in fairly large numbers one at a time and it didn't create much of anything. We have a dust cloud that may spread over a large part of the earth's surface, it disappears in a matter of days it creates disruption of radio communications, a number of things you would prefer to do without It creates no really long-lasting effect. A nuclear winter is going o be a whole different matter.