SKYLAB

William E. Thornton, M.D.

Some ten years ago, and probably even now, space flights were considered to be one of the more hazardous endeavors man could engage in. I guess this was brought home to me by an insurance representative. When I first applied for entry into the Air Force as a senior ROTC student, a very good insurance salesman of a reputable old line company came around and sold the entire class a rather nominal insurance policy that had a lot of extras in it, and one of the extras was an aviation rider. If we killed ourselves in an air crash, it didn't pay off. He convinced us that, in spite of going into the Air Force, this was quite reasonable. As I said, this was a good salesman. True to the military fashion, 15 days after getting in I found myself not only flying status but with a jumpchute on my back. I was expected to bail out if anything happened and do certain hazardous things on the ground. A few thoughts passed through my mind about insurance salesmen that sold policies with aviation riders, but I didn't have the opportunity to express them until I was out in medical school and the same salesman came around to sell more insurance. The first meeting wasn't very successful but he was persistent. At this time I was in medical school and married, apparently more sensible and settled, so he sold me a rather large amount of very cheap term insurance with a convertible clause. Not long after that I graduated from medical school and was accepted for the astronaut program. One of the funniest letters I have ever seen was from this man trying to think of some way to talk me out of this insurance program that he had sold me. Apparently his superiors had had him on the carpet and thought even less of insurance salesmen that sold policies to astronauts than I had thought of him as an individual that would sell to persons in the Air Force with an aviation rider. NASA takes a little different view in that they give all government employees the same policy. I think some place in between lies the truth. There is no question that space flight is hazardous. When it began about 10 years ago, the speeds we were talking about weren't heard of; 18,000 miles per hour for orbital insertion was almost an astronomical figure. Obviously, in order to get these speeds in a reasonable time, fairly large accelerations are required. In order to return to earth this energy dissipation, heating effect of deceleration, and the stresses on the space craft had to be considered. All of these obviously place unusual stress on the technology, particularly the technology 10 years ago. Look at the propulsion system; rockets for a very good reason were not noted for their reliability. There were structural vibration problems, and anyone who has ever designed an instrument, as I have spent a good deal of my life doing, will find incredible the accuracy that is required of the guide-ups in navigation. For example, if you listen to the transcription of Pete Conrad, he said on the lunar surface, most of his talking was "hey, there it is!", "look at that, right where they said it would be, there's the landing site!" I can understand how Pete feels because after traveling a quarter of a million miles, then to come up even within a few miles of a site on another body still leaves me a bit breathless. There is a complexity, we're all well aware of the long chain of events, any one of which can wreck the mission. Millions of parts are involved here and I could go on and on about the difficulties of even getting to complete such a mission. Add the human factor and you've added another order of magnitude. This is certainly one of the most hostile environments man has explored, the absolute vacuum. You can alternately freeze or fry, depending on the configuration you place the vehicle or suit in. There is a radiation problem, not only particle radiation but so-called solar storms, Van Allen belts, but also just the visible land, near visible radiation from the sun, ultraviolet, infrared. The problems of weightlessness with peculiar problems of meteorites which have been added. In addition, I saw a parallel in earlier efforts that man had made. For example in the 18th century some very learned men were writing about the dangers of riding in railroad trains and of how there was a danger of having your breath taken away at high speeds of 30 miles per hour. I was struck by the parallel of some of the other theoretical things that were put forth on space flights, and it is easy to be wise after an extent that some of these things that were considered were the difficulties that men would get into on EVA. I listened to one very erudite paper that showed how a person would wind himself around the umbilicus and end up in a hopeless disoriented mass. Others were concerned about eating problems, various problems of digestion under zero G, the under psychologists had a field day with such things as the break away phenomena, research time was spent placing people in conditions in which they were almost totally deprived of sensoring inputs. I never could quite understand how that parallels space flights, but a lot of these concerns were voiced as well.

Now, after all this and with the benefit of ten years of hindsight, I would like to look at what has actually happened. First of all, let's start with the population. The astronaut population that has been in space so far has largely been composed of military test pilots. As you people are well aware these people bring their own viewpoint. They have to have their own viewpoint when they fly such vehicles, even test aircrafts. It's a little different from the individual that has a 9 to 5 job, his off-duty activities and his general approach to life is probably a little different even from people that fly airliners. Most of the astronauts have ground vehicles in which they are capable of demolishing themselves, either overblown motorcycles, muscle cars, sports cars, this sort of thing. Their viewpoint is unusual shall we say; however, ~~they bring with it~~, I can say here with no fear of contradiction, these are the most skilled pilots of the group that you will ever find. Let's just stick to the people that have flown. There have been a number of us that have come into the program and had to learn to fly after coming in. Let's not touch these. The average age of the population is about 39 years with a range from 32 to 48 years. You can generally say that they are in above average physical condition. Most of the population pays a good deal of attention to this. Now what are their duties? The first duty is flying because the T-38 is still used for rapid transportation as well as maintaining pilots' proficiency. The average is around 20 to 40 hours per month in this aircraft. You're probably familiar with the characteristics of it. It's an unusually good plane, although a bit short-legged, and you have to watch fuel. You can get yourself into problems that way. It's not the best weatherbird. We have modified ours with heavier windscreens in them. We've added some navigational gear and some backup communications equipment as well as attempted to get a bit better performance at high speed.

The second responsibility of the astronaut is to prepare himself for the mission. This begins some eighteen months to two years before the mission. A great deal of sitting, listening at conferences, he takes an active part in the design and preparation of the aircraft. One of the major stresses is simply going from one part of the country to another, one side of the country one morning and the other side the next morning, getting there in between and the psychological stresses are fairly large. The training, needless to say, is rigorous as can be and made as realistic. The trainers are probably the most realistic if any of you have ever seen them, for example on the lunar landing. We have a sort of earth bound rocket vehicle that allows a pretty exact simulation of the descent and then the other trainers themselves, the abort modes, virtually every aspect of it. Tremendous amounts of time are spent on the emergency situations and these contingent situations are planned in so far as possible to the nth degree. Probably far more time is spent planning contingents than in actual flight.

Let's come to the side of the picture that many of you have to view. That is, the failure side of what has happened, and there have been failures. The losses include one from a bird-aircraft collision in the airfield traffic pattern where two crewmen were lost, and another T-38 in a weather landing accident. One pilot was lost with a control problem in the T-38. He got out late and was subsequently involved in an automobile accident. You all are aware of the three that were lost on the pad of the Apollo 4 fire and the problem with pressurized oxygen. There was one reason to bail out. These were some of the fatalities. Now the potentially fatal accidents included one recent bailout; again, material failure was involved in weather. There was also a bailout at the lunar landing simulator, and there have been two spacecraft problems. You probably remember Armstrong with the reaction control system that went out and was spinning the vehicle up, and then there was the thermostat that failed and caused the explosion in Apollo 13. These two were both material failures. Now what's the nature of these failures? To me it's very significant that they weren't caused by meteorite damage, they weren't suit failures, they were structural failures. They have all been earth failures. The sort of things you people deal with every day. Automobile accidents, weather problems, instrument problems and of course the largest, the material failure. This says several things to me. It says that an extraordinary job was done in terms of knowledge that has been generated in the past that would allow such a mission to proceed without running into unusual failures. The fact that these are the same old things says a great deal about the state of knowledge, the ground work that people such as yourselves have done, that allowed the planning and execution of these missions. Let's say a bit more about the failures. As you know, NASA has the most elaborate quality assurance program, the most safety oriented program that the world has ever seen. In spite of this, material failures have still slipped through. Where have these come from? They haven't been at the upper levels, they've been down at what I call the work level. For this reason I still consider the individual that may be wiping the windscreen on my aircraft, the one servicing it, the individual that's putting rivets in the spacecraft, that's inspecting the thermostat, making electrical connection, I still consider his role in safety as equal in importance to the managers. This may come as a shock to some of the managers. True, the ultimate responsibility is on their shoulders but the same varied accidents that would most likely kill an individual is the result of some physical act done by some supposedly low-level individual. Safety has to cut across the whole program itself to literally the last man in the link. I've mentioned again that I'm struck by the same old problems that keep coming up again. So much for the failures. Now let's look at the successes.

I mentioned the fact that knowledge from people such as yourselves made it possible to carry on a successful program. These failures all occurred. The last one was over a year ago. Since that time there have been tens of thousands of aircraft hours flown. There have been a total of about 8500 spacecraft hours flown without fatalities, men have walked on another object other than the earth for the first time as a result of an incredible complex program.

There have been 137 hours of EVA activity and no suit failures. None of the other things we worried so much about. I think people such as yourselves can take a great deal of consolation from this. To me it seems like an arousing success story because all of you are familiar with the failure rate that is likely to be incurred in the testing of a new aircraft type, but here we have not one, but three entirely different and new spacecraft series and not one lost during the actual flying itself. What about the future? You've all heard about the Skylab. This is to be our first temporary space laboratory. Medicine is going to play a large role in this one. A lot of the medical experiments will also be astronautical experiments, a whole series of others will be working with new technology, working with high temperatures, and with new techniques inside the craft. The craft itself is a modified Saturn 4B fuel tank, 68 feet long, 28 feet in diameter, and it's had solar panels added to it. It has had telescope structures added and an adapter section so that the standard command service module can dock with it and undock. The first of three missions is to begin approximately six months from today; the first mission will be a three man mission position, two pilots, 28 days, primarily medically oriented. This will be followed by two 56-day missions; again one scientist, two pilots in each of these. It's a light limited vehicle, and at that time it will in essence go out into space until the shuttle comes along.

Just running briefly through the medical experiments, there are some fairly elaborate vestibular sense of orientation experiments, and a very elaborate metabolic calcium balance study. This would be elaborate even by ground base standards. Every gram of food is to be accounted for, all of the waste materials, samples are to be brought back. I might add that some of the major difficulties are encountered in the waste collection system. Some of the astronauts consider this waste collection system one of the more hazardous aspects of space flights after living with it for 56 days. In looking at some of the other experiments, we have a bicycle engometer on board to allow exercises and maintenance of condition, we have low body negative pressure apparatus to put on known stresses and follow the man's deconditioning such as occurs. As for the safety aspects of it, the atmosphere itself is 5 PSI, 70 % oxygen, 30 % nitrogen with little higher than average CO_2 content of probably 5 mm of mercury. Again we've checked the atmosphere and it presented no problems. We had a mock up of the craft itself, in matter of fact it was smaller, and that presented no problem. The weightless aspects is one the major things to be tested. You will then get into such items as water. The water will all be carried up. There is a minimal microbiological control, one part per million iodide. This will be measured and checked before usage. The food has had a very rigorous program. Assuming they'll get a couple of dietary questions worked out, provide enough food.

There'll be no problems there. Major medical experiments all have elaborate safety measures including shock protection. For example, there is extensive monitoring of subjects that are grounded, so a good deal of design effort has gone into this aspect of it. We come into the more hard line of the safety aspects. There is a micrometeorite scatter s~~c~~hield since this presents a rather large target from meteorites. There is part of the caution and warning system. There is a pressure late censor. The plan mode here is that if some opening should occur individuals will have time to go to the command service module, use this as a light boat to get back. The large volume of this should ~~con~~preclude any castrophic decompression. Radiation is not anticipated to be much of a problem. We're deep enough into the magnetic field so that we don't worry about solar flares, and we are below the Van Allen belts. We do have some rather nominal radiation monitor equipment on board, badges, and we have some ionization warning devices, survey meters. The big hazard, I guess, the one that most people are concerned with is fire, which was unfortunately demonstrated in a chamber shortly after the Apollo fire. This is still a hazardous atmosphere. I am afraid some people are lulled by the idea that there is nitrogen present, but things burn very briskly with 70% oxygen. There is both a water hose system aboard which the individual has envisioned if necessary to fight his way through a fire with; there are foam bottles on board; there are U.V. censors in all the critical areas as well as overall surveillance with censors. Very elaborate precautions have been taken on this aspect of things. I don't know how many of you are familiar with the precautions that are taken but every bit of flammable material is either covered or protected in the spacecraft. Fundamentals of the program is the quality assurance that I mentioned earlier and NASA has the most elaborate and also one of the most expensive programs that the world has ever seen. Any item that goes aboard of any size, for example, an experiment, an experiment package as such,has a documentation for this. The testing and all is going to come to this. We use the rule of thumb, of about one hundred thousand dollars to make sure that this thing is primarily safe and will also perform its job. We do have one advantage that we haven't previously had and that is it will be possible to effect rescue. It will be a bird on the pad should anything happen, there will be the possibility of going up, docking with the two-man crew and bringing the three-man crew home after a reasonable opportunity to turn around. So these are the major safety aspects of the SKYLAB program.

Then we come to the future. The thing that NASA has its hopes riding on is a combined aeroplane spacecraft if you will, the shuttle. This is going in some ways to move ~~more~~, back toward more conventional techniques over part of the mission in that probably a high degree of piloting skill will be required. There isn't going to be much go around capacity in this vehicle for coming back. The speeds singrates this sort of thing is going to be considerable on it. Now this is still in the design definition phase and so I can't say a great deal about safety but I will say one thing and that is, we're going to have to use the lessons learned on the previous programs and make the safety program more efficient. I mention this figure of one hundred thousand dollars. This vehicle ~~with~~, the shuttle vehicle ~~will~~ with all the payloads, -- you're not going to be able to spend that kind of money, so you've got to become more efficient in the safety aspects -- you've got to do it more efficiently. Hopefully the day will come when individuals such as yourselves, individual researchers in colleges and such will be able to put together a reasonable package, one that does not require a documentation that high, that you can go along with the package, spend days, weeks with it in space, perform the investigation, then be brought back home. We have simply got to cut things a bit more closely without sacrificing any aspect of the safety.

Finally, if you will bear with me for just the code of the amateur's plea to the experts, -- this is sort of a sum total of a few pet observations I have had from having been around the Air Force, airplanes and having been an interested observer in the space program. When you design safety programs, make allowance for the human being. As a human being, as all of you know, you have good days and you have bad days. Now I am not going to apologize for the human being because on the lunar landing for example, it was the computer that became confused ~~with~~ when the beam overloaded and quit. The human being pressed on and landed, but again, I would urge you to make allowance for the human factors. Make allowance for errors. They're going to occur. The important thing is to keep the bigger or the fatal errors out and if some errors occur, leave enough room, leave enough leeway. These errors may not be very great, particularly with the increased and positive control by controllers for people that fly little airplanes -- this can bring on a whole host of problems if one doesn't normally associate say with airlines, an airliner crew. Then, let's get to safety itself. As I have indicated, I have used this word a whole lot, it means a great deal to me. As a matter of fact, let's face it, safety is an emotional problem. It's not the frosting on a cake, I think this is lost ~~is lost~~ sight of too frequently. It's one of the most fundamental human emotions, and that is simple self preservation. Not too infrequently I think it gets confused, and again I am speaking personally now. People approach a safety program as something that is routine, something that can be accomplished by slogan, by elaborate charts, by generation of high level programs. It takes more than that to make it work. You've got to get all the way down to the individual crimping a connector on a wire. It takes a few extra minutes to look up a hydraulic leak to see where it's coming from. We can be wise in hindsight and say that on Apollo 5 for example, similar fires have always occurred when there has been high pressure used if you look back at the Navy, -- the Navy is very familiar with this thing. As long as people have gone into high atmospheric pressures, there have been catastrophic fires. It would be easy to look back on that, but remember, it took an ignition source. Some place along the way there was a wire too small, a breaker that didn't function, or a connector that wasn't properly put on. So remember the little man and the last detail. I can remember being a little discouraged about a safety program once. The Air Force was making a big drive. This was when I was in. They had gone to a great deal of trouble. This was in the McNamara days when everything was going to be reduced to cost accounting and they had a famous test pilot who was a general. They sent him around and he was making a canned pitch. His pitch was that being unsafe was not cost effective. Well I thought it took a good deal of courage to read this to a bunch of people. I tell you, as brave as this man was, he would not have had courage enough to have approached anyone on one of those days that a group of people go quietly into a chapel, smell the stink of funeral flowers, watch some poor kid, some poor wife, the chaplain trying to say some words that mean something to her, to quiet a lot of people that have to go out to see the hole in the formation that goes over -- you're not talking about cost effectiveness, -- you're talking about a very emotional situation -- something very close to home. You're not talking about the spilling of red ink. You're talking about the spilling of blood. When you think about the safety program -- like it or not -- no matter how detached a scientist you are, I think when you try to put it on other basis than this, you are making a mistake. Thank goodness, it usually is on a mistake, and you people with the dedication and on just such a basis as I mentioned not on just another program basis.

Finally, I'd like to say thank you. Thank you very much. You, -- the people like you in the past, people that have made it possible for an old man like me that would have been thrown out as an active pilot allowed me to realize a lifelong ambition. I didn't begin to fly jets, I didn't even begin to fly anything until the point a few years ago when I would have been thrown out of the program. It allowed me a great deal of pleasure since then. Every time I strap on a pair of shoes and sit down in an ejection seat and look at the instruments in a particularly bad weather situation, I say thank you very much for that.

Finally, for the future, I have some kids that I hope will be able to enjoy the same sorts of things. I hope they will be able to go a lot further than I will, -- beyond the moon. How well, how faithfully they do this lies in your people's hands, people like yourselves. And so my last admonition then would simply be -- to keep up the good work. Thank you very much.