Interview with Doug Garland at his residence in northwest Toronto, suburb of Toronto. Generally talking about the days that Doug spent at AV RO Canada in relation to the Flying Saucer program involving the AVRO car. So, Doug, over to you.

Thanks, thanks, Les. Well, I came out to Canada when I was 26 yrs old in 1955 from Bristol England. I joined up with AVRO in England the November before to come out as an aerodynamicyst working on the Arrow. I arrived in May, no april '55. Then I worked on the stability and control group on the Arrow and got involved with the wind tunnel testing of the Arrow and at Cornell and at Langly I had a small involvement with the models of the Arrow that were fired out over Lake Ontario and the analysis of the data. So, I gradually streamed into the experimental side of aerodynamics testing, test work and so on rather than the theoretical side, or the aerodynamic load side and all that kind of stuff. Then AVRO had an aerodynamics course which they had arranged with the Institute of Aero Physics, as it was then called. Now, in the Institute of Aero Space Studies part of the University of Toronto. About 13 guys went and studied for the Advanced Applied Aerodynamics course and it was said that the guy who came out best in that would have a 3/4 salary scholarship for a year to study full time at UOT at the Institute. It just so happened that I got hepatitis a month before the exam and I was laid up for a month and I studied my books for a month. Then I came out top in the exam as a result. And, so I left AVRO then on a temporary basis for about a year and that was in October of '58. Whilst I was away in '59 at the University, course we had the black Friday on the Arrow. I was laid off with everybody else on the Friday afternoon but I was rehired the next week on a special basis and

told to carry on with my studies at the university getting a Masters degree in Applied Sciences, it was called, which I did. I came back to what was left of AVRO in August of '59. The stuff I'd been working on related to ground effect machines. And Professor Corbacher was my professor at UOT and one of his interests at that time was in ground effect machines. Now, I didn't know at the time, at least I don't think I knew very much about the AVRO car, practically nothing. Cause of the secrecy surrounding it but I had talked with Don Whitely before I went to UOT and there were, I had two choices of theses to work on. I think one was to do with helicopters and the other was this ground effect machine. And Don Whitely suggested that the ground effect machine would be more appropriate to AVRO's future so that's what I did. In fact, I eventually had a UTIA technical note #37 published when I finished my Master's and it was called Studies of Ground Effect On An Inwardly Inclined Annular ___ Jet. UTIA Technical Note #37, August, 1960 - Part 1, actually. But, you can see if you look at these diagrams here that this shows kind of flow patterns that, in fact, were the aerodynamic basis of the AVRO car. In ground effect the annular jet, which is inwardly inclined on the AVRO car, is turned around, if you like, by a positive pressure underneath the AVRO car when it's in proximity to the ground. It generates a positive base pressure and that's your ground _____. (Doug is looking at Figure 23 in his booklet here). And in free air there are various flow patterns which are, which in fact are generated depending on the details of the geometry and pressure _____. But, what was called the focused jet from an inwardly inclined annular nozzle became the basis or was the

basis of the AVRO car, although I don't suppose I knew it at the time. And when I got back to the remains of AVRO, of course the Arrow was gone and I joined the special projects group. John Frost was the head of that, Chief Factotum in all departments, had been the leading light in it for many years, I suppose. Des Earl was the Chief Aerodynamicist and Don Whitley was the assistant Chief Aerodynamicist, I think he was called at that time. That was August 1960, August 1959. So, I joined the group and got involved in the small scale model testing of the AVRO car. We had an 18 inch square wind tunnel, ejector driven, which wind tunnel was known at DeHaviland's at Downsview.(?) Same wind tunnel, no longer ejector driver is now drivin by a commercial fan. The wind tunnel basically is still there and we still use it. In that little tunnel we tested a small scale model of the AVRO car, in particular we did slow visualization tests using a mixture of air and steam so we could see where the jet was going when it came out underneath the AVRO car. And we did it when testing ground effect and in simulated free air. We looked at this focusing of the jet and we had what we called the tree trunk jet. The jet came from the annular nozzle, it coelesced to the center, the underside center of the AVRO car and then turned and went downwards and so it made a circular jet of diameter of about a half or less than that of the AVRO car itself. This was called the Tree Trunk Jet. I mention this because the basis of control of the AVRO car, both at zero forward speed in free air and forward speed, the basis of control was to move this tree trunk jet. Move it around so that it's focus point moved around underneath the model and later under, hopefully underneath the real machine. Also, the angle of the

tree trunk relative to the AVRO car was supposed to change. Now to move that focused jet, originally there was a control system that I wasn't too familiar with, and when I came on the scene John Frost had just decided that the original method of control wasn't satisfactory, wasn't powerful enough or something and he went to what was called the focusing ring, I think he called it. It was a complete ring suspended underneath the tip region, the perimeter of the AVRO car and the jet impinged on this ring and the ring caused the jet to focus toward the center of the underside. This ring was suspended on rods and as this ring was moved fore and aft, or laterally, it caused the focused tree trunk jet to move a little bit. As it turned out it didn't move enough and we never really had sufficient control power from this focusing ring control. I'll get into that a bit later on. Anyway, my first job was to do the model tests on that ring and some of the flow visualization pictures were later published and some of the force data we measured was published in the article in the CASI Journal _____ the story of the AVRO car. That was a nice little model, nice _____ pictures and a lot of the, I think, control power data was published in the CASI Journal. So I did that for a few months with a couple of other people, Pete McGee was one of them. A couple of people were leaving at that time, what's his name, Brians? Do you know Brians, a guy called Brians? He was around there and was a leading light but he left about the time I joined. Pete McGee was on the experimental side too. A lots of other people I can think of in the, doing other aspects. Ron McKee was involved in the design and theoretical aspects of stability and

control and I suppose he had been able to demonstrate they had given a sufficient control power and response rate that the AVRO car had sufficient to give it stability and control. Anyway, I went on to Des Earl asked me one day if I wanted to be the aerodynamicist in charge of the test of the AVRO car in the 40 x 80 wind tunnel at Ames. People like Al Wheelband, then Peter Martin were involved with that test. Lots of other people too. George Jackomen was Chief Programmer. I was supposed to be the aerodynamicist in charge. The date , no, let's see. We went down to Ames with the AVRO car the following March '59, '60, March 1960. So we did the first wind tunnel test in a 40 x 80 wind tunnel, the free world's largest wind tunnel in March 1960. I drove down with my family, no I didn't, I went down by train I think. I think we went by train the first year, yeah we did. AVRO gave us a week to get down there and a first class air fare so we could take our families. And my wife and I and our youngest boy and Betty was pregnant with Peter at the time, our second laddie. We went down on the train. It takes days, as you know, to get to California. Anyway, we did this test brought back the data. There were certain deficiencies in the control power. I've forgotten all the details of it all now. The airplane, of course is basically unstable. The airplane itself is statically unstable longitudinally as any circular device is with the center of gravity at the center of the circle. To cut a long story short on that we went back again for a second test in the tunnel the following March 1961 now wouldn't it be? March '61 we went down again and now that time we added a tail plane to it amongst other things.

We had a modified control system and propulsion vanes, one thing and another. We, for example, I think we blanked off the whole of the forward nozzles, I think and ended up with like a jet flap at the rear. But, the most obvious external change was that we tried putting a tail fin and tail plane on it to get some stability into the thing. Some body was telling me lately, recently, I think it might have been Don Whitely, that, or Peter Martin, that John Frost was absolutely horrified at the tail plane, although I think he must have been involved with it. But anyway, we put the tail plane on and suddenly it was no longer a nice simple circle anymore. And as it turned out it didn't do too much for us because the fin wasn't big enough. The tail plane was so close to the upper surface that it didn't have much, didn't have anything like the effect it would have had if the tail plane had been on a taller fin. Or much further aft. Anyway, we, that was March '61, in the summer of '61 or somewhere around June or July or something like that there was a review of the whole AVRO car program which up to that time had cost about 10 million dollars I understand. It had, we had essentially built three AVRO cars. Although the third one I think hadn't been completely assembled at that time. Anyway, John Frost and Des Earl were shown the door in a very unceremonious manner by all accounts. They were quite upset. The AVRO car as a project, I think ceased. The United States Air Force, The United States Army which had been jointly backing it, one of the few jointly backed programs ever, I understand, U.S. Air Force and Army. That was stopped and Des Earl left. _____ went down to Bell. John Frost went off to do all his various things. Don Whitely became Chief Aerodynamicist and a lot

of the direction of that special projects group then, I think, fell under the hands of Tom Higgins. And I think from what I knew of the heirarchy situation in those days which wasn't very much, I think Tom Higgins spearheaded the various activities of the group at that time. Tom Higgins is now with DeHavilland and was something like program manager on the -7. While a number of things were done in those days - one thing/on which we don't seem to have any literature and just before the AVRO car was cancelled we had the flying ball. This was a spherical, not another flat disc but a spherical airplane if you want to call it such. It had or was envisaged to have a power plant somewhere inside the ball. There was a fan, an external fan, blades blowing and skimming around at the maximum diameter. And the jet went down, coalesced underneath this spherical underbody and formed this conventional tree trunk jet. (Who's idea would that be, Doug?) I think it must have come from John Frost. (Never heard of that one.) Yeah, the ball. It was, it became a brochure and a project and so on. We did some design work on it. I don't know whether we did any experimental testing on it, but it was an unusual looking thing and I sure remember it. (What _____ would that be?) Well, that would have been before the summer of '61. I would think it would have been early '61, the ball. (I never heard mention of that one.) It didn't get very far. I don't think, I'm not even sure it got to the stage of being a model. But anyway, it was a development of the AVRO car family of weird airplanes. Now, the, when Tom Higgins came in with Don Whitely Chief Aerodynamicist, right after the AVRO car we got into a lot of

GET_____ Ground effect take off and landing. There were a number of projects being kicked around, merely paper drawings of things, like Hercules with a rectangular ground cushion. I would imagine Des Earl would have been talking about this kind of thing for many years because he went off to Bell, you remember, and built the Bell Bottom Buffalo, the air cushioned landing, ACLS Buffalo some years later. Well, there were a number of schemes along that line that were being kicked around. That was one aspect were the ground cushion was being used. Ground cushion, of course, is most efficient with a circular plan form. But it doesn't make much of an airplane to fly at forward speed. And I think I was telling you the other day, the basic problem with a circle if you wanted to take off vertically, you pretty well need the center of gravity near the center of the circle, otherwise it will take off all lopsided and you'll have a job to control it. So, once you get up in the air and you start going forward, forward speed, the center of gravity at the center and what aerodynamicists call the aerodynamic center, that's the point where the pressures on the vehicle can be ashumed to act just like all the weight is ashumed to act as the center of gravity. You have bits and pieces of weight all over. But, the net effect of all the bits of weight is a center of gravity, that's the point where the thing balances. The aerodynamic center is a little bit like that. It's the sort of a point where all the pressure forces act. And with a circle, a circular air foil these aerodynamic forces act at a point about 18% of the diameter from the front end of that diameter. In other words a long way from the center of gravity which is

50% of course from the center. It means for example that if the nose of the airplane starts to pitch up due to a gust or turbulence, then the, then the aerodynamic force gets larger as you pitch up, lift due to angle of attack and the more the nose tips up the greater the forces and the greater the pitching movement that tends to lift the nose even further. And in fact what happens with an uncontrolled circular air foil is the nose pitches right up and the airplane starts to spin. It will continue to spin given enough weight and if fact that principle is now being used, I was telling you the other day, by Lee Instruments of Ottawa to make a crash detector device with an emergency locater transmitter built into it. And they built a little thing that looks very much like an AVRO car model. It's a little circular airfoil and it sits somewhere on the outer surface of an airplane and it's held in place by catches and wires and things and the airplane is supposed to be able to, for example, fly into the side of a cliff and the intitial deformation of the airframe releases this little circular airfoil containing its transmitter;it flies off the airplane and immediately starts to spin in this unstable fashion and it performs a circular trajectory and comes to rest beside the crushed remains of the airplane having touched down at only a few miles an hour and the transmitter starts to transmit where your wreckage is to be found. (This is a crash locater?) It's a crash locater, yeah for airplanes. It's an ELT, emergency locater transmitter and it's a crash locater device. In fact, I think I've seen them on some of the DeHavilland Buffalos. It doesn't seem to have been widely adopted

but what it does do is it uses this unstable aerodynamic principle which all circular aircraft are faced with. If the center of gravity is at the center of the circle the aerodynamic center is so far forward that the thing is basically unstable. Now, a bird without a tail is also basically unstable too. But a bird has such powerful control capability in its flexible deformable variable geometry wings and such fast response from all its feathers that an unstable bird can still manage to fly almost as well as a bird with a long tail. I've noticed this with a cuckoo for example, Canadian cuckoo. When I had personal experience of the cuckoo's flight both before and after losing its tail. Todays aircraft are just reaching the point where a margin of instability can be contemplated about 5% negative static margin today is contemplated which means the airplane is unstable and couldn't be flown or only just be flown by a pilot but with automatic stabilization systems fly by wire controls and powerful control capability you can actually fly an unstable airplane. No pilot would want to do it for very long. It's, (course, we're talking now about 22 - 24 years downstream from the demise of the AVRO car, which is state of the art development.) That's right and state of the art now is 5% negative static margin. Most airplanes course have a few percent positive static margin, makes them stable. That's what the tail does at the back of the airplane, that's why tails are at the back, it makes them stable. Conventional airplanes. Now the AVRO car had a negative static margin of 50-18 32%. The 32% negative static margin and the idea was that that could be controlled given a sufficiently powerful control with a sufficiently

fast response. So that if it, if the nose for example tended to flip up this control would move the focus jet underneath the model, underneath the airplane, move the jet aft and that would give you a nose down pitching movement to counteract the aerodynamic nose up pitching movement. And then of course the model would start, the aircraft would start to pitch down and then you'd have to bring the jet back the other way to stop it going too far. And in practice, of course, what happens is the automatic stabilization system is designed to be continuously responsive to any slight out of balance. This is how automatic stabilization systems work anyway. Sass systems. They're used on many aircraft today, as yaw dampers. The Arrow had yaw dampers on it. And I think lots of commercial aircraft today have yaw dampers. It makes the aircraft more steady, stable and easiest pilot workload. On short takeoff and landing aircraft such as the augmenter wing buffalo, a number of automatic stabilization systems are used. Anyway, this is state of the art today. In those days 32% negative static margin was enough to make anybody gasp. Not John Frost, though. And he was quite happy to try it. The system he had wasn't a fly by wire complicated electronic box of tricks. It was a mechanical system and the, what he used was a gyroscopic inertia forces of the rotor, the fan rotor body, rotating like a gyroscope and that had a limited degree of freedom. It wasn't rigidly attached to the structure. It had a certain amount of motion capability and because of its inertia it would tend to act like a gyroscope and so if the nose of the aircraft pitched up for example, the fan would try

to stay where it was and it would therefore move slightly relative to the AVRO car and that motion was mechanically amplified. And I'm not sure what else was in the system whether there was any hydraulic power boost with it or not, but anyway, it was a basic mechanical amplification, which was applied to the control system and provided the controls were aerodynamically powerful enough and provided the mechanical response and aerodynamic response was powerful enough it was theoretically possible to control this enormous negative static margin. I think what happened eventually was that the controls were not pow.. were not found to be powerful enough. I don't think they ever would have been controllable at forward speed in free air. In fact, that report you showed me recently of the flight trials told me more than I knew at the time, I think, that the thing was rather unstable at 30 miles an hour even in ground effect. It was hard to control. I've often said that it was probably a good thing that the performance of the fan and duct and nozzle system on the AVRO car never did live up to its design point thrust otherwise the AVRO car would have got into free air and we may very well have got there too soon before the controls had been thoroughly developed and found ourselves in the air with an uncontrollable airplane which could have been quite disastrous, Fortunately, as I understand it, the fan never did reach its design performance. It had been developed over at Orinda and it worked, nothing wrong with the fan at all. Tip driven fan, it was, as it turned out is was a very cheap development of the tip turbine driven fan. General Electric, I think, about the same time had done

the same thing on a quite independent program for fan and wing research. The cost of their program was many, many times the cost of John Frost's fan program. There was always a source of some considerable satisfaction on the AVRO car program folk that he'd used to develop that. Anyway as I understand it the hot exhause from the J69 engines, the 3 J69's which drove the fan, _____ fan in the AVRO car, that hot exhaust was let out, emitted into the same structure downstream of the fan inside the AVRO car as the fan efflux, the fan flow. And it didn't behave itself in that ducting. I think it separated from one of those surfaces and contributed to very high pressure losses in the ducting system within the AVRO car. Most of the structures in the AVRO car were a monstrous duct leading from the fan radially outward to the nozzle at the tip around the periphery. Anyway, as a result the pressure losses were very high, the effective nozzle area was never as great as the geometric number and the fan was never able to get to it's designed operating conditions as designed for a certain nozzle area downstream. And that nozzle area was never really there because of the high pressure losses. As a result the AVRO car never did develop the thrust and life therefore that it should have, was designed to develop. So it never got more than about 3 feet off the ground. Well, maybe we should stop there for a minute ....