

Don Nielson
Oral History
Interviewer: Leonard Kleinrock
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LK: So Don I am very happy to have you here to talk about those very day of the ARPA funding, to begin with why don't you tell us a few words about yourself, who you are, where you are, where you've been. Just a short summary

DN: My name is Don Nielson I spent my entire life at Stanford Resource Centre, I was involved with ARPA probably for a period of 15years or so, not necessarily as a PI but having to deal with but having to deal with them, those years for me from the early 1970's to early 1980's a little beyond. Actually I became a manager at SRI I continue to (()) to almost important client in variety of area so it never left my intention probably when I retire in 1998 but if you can imagine what you are on the frontline so to speak you pay more attention than you do if it's a lab or 2labs or 3labs under you, so anyways that's the time frame I came to SRI in 1959 out of the Army and hoping to get some way to get to Stanford Graduate School and they kind enough to pay my way through a Masters and PHD program there, all I had to do is to work almost a full time and that turned out to be 10years of ((arduous)) labor. Anyway that was essentially why I went to SRI was to enable me get through Stanford and I want to go back and teach in the ((northern)) country ((northern)) state that didn't work out at that particular point so I stayed at SRI for my entire life and that should be what it is, no regret anyway that's kind of the contact stuff. I entered what was called the communication laboratory and actually worked on things as (()) I think maybe a short rave radio and things like that at some point we saw the convergence of computing and communications and we partition the SRI to a ((move our)) laboratory into the computer division in order to make that possible, pretty soon we were fairly involved in digital communications maybe then digitally oriented operating system for communication based devices so it was a good move we made and that was predictive I think of things so that's how I got into the whole question. Now, how did I first got involved with ARPA maybe that's a very useful thing we should cover....

04:07:3 – 04:32:5

LK: Surely I like the fact that you have been involved with all this since the early 70's (()) you have a very mature (()) to what the history is like because I will like to hear about your works at maybe the network information centre and the interaction (()) the network packet radio, focus on packet radio I think will be (())

04:33:3 – 07:34:9

DN: The 3areas I will like to cover some point; you can take it anywhere that you want. One is packet radio and the centuries of beginning of internetworking that's one, Artificial intelligence at ((DARPA)) am somehow familiar with that because it wind up been under me, I was at the division level and I was a laboratory under me, it had lots of identification with ARPA over the years and then there is the

interactive computing – I came to know about that fairly well because I wrote about Doug's in a book form but in a way which I think we will maybe for the first time and only time the atmosphere we had at SRI and how that matured and how he dealt with both his own staff and people who sponsored his work. There is one out there called the surgical tele-presence which is a miles full but it led to an important breakthrough in operative care and ARPA was involved in that at some point and that was important to me and ARPA had less impact on it. We can deal with those and for me probably I will start with packet radio because that was my initial exposure to ARPA. So the time frame was the early 1970's and the first thing I remembered was Larry Roberts came to SRI wanted SRI to help him develop a radio, and some sense compatible was the networking stuff he was building(ARPANET), there was a fellow by name (()) at ARPA who had worked closely with Larry for awhile and in fact wrote one of the earliest report I have seen to ARPA suddenly define what the ARPANET was going to be like because people don't know about it but in it you find hangers or things like visual socket and things like ((physics)) started to come into the language but it was early on he just had to not go on the that (()) he also helped I think Larry a specifications for the imp..

07:36:0 – 07:36:9

LK: You talking about (())

07:36:9 – 10:41:1

DN: Am talking about (()) and he was in fact when the network working group was first formed he was the first leader of the (()) at SRI and he quickly surrender that wisely I think to Steve Crocker but little things which Crocker actually admitted at one point and RFC1000 and it think it was Omar who gave him the idea for or the name RFCs' so there is a little kind of interesting beginnings there and Omar didn't want to be in this whole thing and he left and actually when Larry came to introduce the question of a radio or call it a packet radio as called at that time, he put it in the wrong place at SRI because Omar wasn't stick on radio unlike that particular group he was in wasn't easier so he eventually migrated to us and overtime in the lab called the "communication laboratory" and we knew a lot about radio, we don't very much about digital radio but we knew about radio so in the beginning – I can't remember when this happen but we were actually name by Bob Khan to be the assistant integrator and tactical director of packet radio and they were a number of other players involved one was UCLA, their role was in my recollection was essentially simulation, productivity of network behavior, one was (()) for good reasons, one was network analysis cooperation who lasted awhile but whose impact in retrospect I don't know about I could measure very well and then of course ((a big elephant room known as)) Collins radio who built the radios.SRI contribution in those early days was – some people who received communication theory and give some of the original design work on what the analog portion of the radio should be like, how it should detect signals in noisy and (()) environment, I was a little bit involved in that because I was interested in the impulsive noise and the traffic situation and all the stuff that comes out of cars and things that the import noise do to a small signal packet or so, so we measured noise and things like that, we measured multipath we did a lot of that stuffs that helped trying to the set parameters for adequate detection of the signal for the (()) digital world.

10:41:1 – 10:48:9

LK: (()) of dropping into (()) by you guys?

10:51:11 – 13:25:5

DN: It was partly I think Bob had a sympathy too and he asked one point to write a paper for ((eastcom)) about it, I think I went overboard a little bit and I think I didn't me want to go that far, the whole notion of (()) and the ability to come back with multipath and other signals was becoming in vogue at the time and was clearly the right way to go whether you want the co-divisional multiple access within the time divisional multiple access how to (()) discrimination against interference signals and whatever so we were involved in that and but it want hard to sell I think Bob wanted, I think Collins wanted it because they wanted to dance their own interest in this new world as well but whether will be post detection combining pre-detection combining all that phase stuffs we were involved in that and in retrospect I think we can be pretty proud of it I think it worked quite well, did it worked perfectly? NO, did it work as well as cell phones today? Absolutely NOT but it was a kind of a benchmark I think by the way I guess it should safe our record in terms of the first mobile digital communications system ever although there was at ((Lowa)) and Hawaii but that was fixed and they were transmitted back and forth we even took some terminals a ((Lowa)) terminals to Hawaii just to see how that works out maybe it was just a pull out of the way I don't remember I didn't go anyway so we aware of the ((Lowa)) net but this was a different animal and so we will made trips to San Francisco to get in a really stiff ((urban environment)) for the noise, reflection and multipath will this work and we had to make – I personally made a bunch of measure as about how the multipath patterns were, what was the worst you will see, what was the best you will see and that had a lot to do with zeroing on data rate to packet ((lengths)) and things like this and this was important foundation I guess before Collins got to be building the radar..

13:25:5 – 13:33:2

LK: Where you involved in the experiment allegedly non (()) interference in the air traffic control with the aircraft coming in

13:33:2 – 13:35:7

DN: Sure Bob Khan was a long time (()) in the snow.

13:36:5 – 13:40:1

LK: It got to be an amazing experiment

13:40:1 – 14:34:1

DN: The frequency we got allocated was close enough to the air traffic control, it was then we had – by somebody I don't know it's somebody we needed to run a test so we had to put people at various radar installations around the bay, they weren't very many and then to run a series of experiment to transmitting again first with the Collins radio to see if radar could see them, those frequency I think they

were spread spectrum, both of those I think are good pretty well to say there was many but there was something we did the whole thing I remembered was when Bob got caught in the snow.

14:36:4 – 14:48:3

LK: And you mention Bob Khan acting as the ARPA representative, how much did he influenced the direction putting constraints and guide?

14:51:1 – 16:22:7

DN: I think this is one of the first things I will like to relate about the atmosphere at ARPA at the time and this is my personal view I could be right or wrong you know as well or better than I, I find a mixture of competence, vision and I will come back to that in a couple of ways or maybe I will mention that who know I forget, I think is more than anyone else I was dealing with at the time, what the digital communication world could produce that thing that pops me to (()) is digital libraries and things like that and that was the first time I heard about digital libraries is from Bob he also had a notion about packet radio that I can't forget what he said and this was not before we began was as if we were going. Supposing you have a bunch of radios well he didn't say radios supposing you have some communication chips and you throw them in a bucket could they form a functional working network to produce something you want it to have done, that was a visionary statement I think we eventually made packet radio do that effectively bucket of course but the bay area

16:24:5 – 16:29:4

LK: Then you know it didn't work in case it didn't form a network shake the bucket and then they will reconfigure

16:30:8 – 21:56:4

DN: That too have forgotten that part a little bit but had to be self forming, self healing and that was part of the design goal we had not formal in any sense but we knew the digital world was capable of doing that (()) I mean we had intelligence in this nodes which could do it and so almost from the beginning we had the protocols were design called CAP protocols were design so we can set the radios unto (()) or (()) peak or south bay hills and they will find each other and form a network in two ways one either completely distributed or crossly had the presence of a station ,we felt the station was necessary came to be necessary when gateways came about so it could use the centralized or decentralized, it worked better centralized at that particular point because I don't know the radios were intelligent enough to face all the things you get throw at them but nevertheless that was part of the design (centralized/decentralized) self forming, workable networks capable of transporting information throughout ((the six steps)). I thought back to back for a second I found it open and he was certainly clever enough to know what was lying in the wings of communication even though he wasn't a communicator ((like spec-spectrum for example)) he was aware enough and that gave us some not only direction but flexibility and I thought that was very important, we were accountable to him in ways but the other thing he had at that time which I don't think existed until today if am not mistaking is

patience. He wasn't in for the patient we actually had it demonstrating itself but I talked to a number of people on (()) well it still happen today and that doesn't appear to be quite so available today, you are given evaluative measure maybe quantity measure, you are given quarterly goals you may compete with other seniors in your same field to make things work but it is a different ball game than I saw at that time. Personal reasons I will like to come back to that at some point for that but anyways that was the early days of ARPA maybe it was openness, flexibility, advanced technology as we were building this new kind of network I heard from the start how this new (()) will be built if it hadn't been built in that way and I actually don't know I will tell you regard to packet switching I will say this is what am thinking, I think one of the great enablement of internetworking was the failure of AT&T to appreciate its value, nothing better could have happened in those early days and the fact that they couldn't come in that's huge to me and I actually consulted back to ((Del labs)) at one particular point and I found very interesting packet switching at the time and even after the ARPANET was working by the way well that was visible but I think the fact that they didn't come all those stories about the network working group was sitting and waiting for them for the big guys to come and I think the fact that they never did was an absolute blessing in the evolution of the technology, they were sitting there with (()) and sockets and things I didn't quite know how to get rid of probably there mind was in a different place and nothing against them I think they were constrained but am glad they didn't come in and try to force a thing at their direction or compatible standard of the day or whatever, but to me it was part of the openness the fact that you can take graduate students(few guys) had them start from scratch with impunity and Bob was there to fund them.

21:58:4 – 22:23:9

LK: So am especially interested in the role that Bob and ARPA in particular played in providing the goal and vision. How deeply did they get involved with guiding, directing, watching the work you were doing and how much flexibility (()) a fair amount of flexibility

22:24:8 – 24:17:4

DN: I felt there was a weekly report when we had to gather the contributions of all those other five players or so and we had meetings, Bob will call meetings and (()) and the other people who succeeded Bob, I think he was more interested in whether or not the radio was divided into analog and digital part and he was interested in things like ((bitrate)) of course, reliability those things-- those kind of high level measures and he was the students and our focus to no one we were chatting straight with him or not I mean with all the terrible and open honest world I don't remember anybody trying to fool anybody sometimes (()) which means we had how to try to carry when they are not producing or whenever BBN or (()) at the time because they need (()) software and everybody has their own schedules that they are working with but I remember that there was somehow tasty mostly collaborative world but Bob had his hands on that and he want to see how it went but I think he was quite right to take up recommendations for how this things could be built and their time frame over and over (()) he gave which was a few years, i didn't see him like a manager at all

24:20:0 – 24:26:6

LK: where you aware of or made aware of any military driver for this work?

24:27:4 – 24:28:7

DN: Oh well they deeply involved in that

24:30:0 – 24:37:6

LK: So was there a product, a final item you had to produce?

24:39:6 – 30:15:8

DN: Not in that sense but it was military relevance, I don't think after this time in the 80's and 90's I think military relevance got to be capital and huge influence but at this particular point I think there was always in Bob's mind and Vint later the notion that we are a department of the defense organization and we need to have some relevance or output to them and so we very much involved in giving the army – later on in the 80's we were extremely involved with the army, but in those early days we had the virtue I think that the technology was further long than the army I will say the frontline of people in the army couldn't quite absorb – they never couldn't quite bring themselves to say yes there is a military requirement for this ; they were interested, they tried to long for years so that was a salute to whoever it will be handed off to but there is always this issue of the army's own providers and they will not in this line and one of ARPA's great challenges was to make sure that the technology flows into the server long going extremely expensive powerful developmental chain you know they provided all the radios for the field and everything, pushing into that was difficult even when I never think that was the radio of the day how you will bring that to the digitally world was always a bang-bang thing you couldn't bring it to cross and as a matter of fact when we actually took packet radio to the field they weren't participating they been the developers (the military data developers) so we went to the field naked with this dome radios and did things that some part of the army were importantly clever and visionary because they coming to rely on computing like everybody else, the computer was quite expensive that they had to (()) you couldn't put it in the back of a jeep and move around I think this is for me important tread to internetworking, it was pretty hard – they had the ARPANET but it there was some interest in that but the fact that computers were coming into their various life and they were expensive in the need to share that in some ways but long came the packet radio and I said Larry Roberts was the first guy that brought the opportunity there but we soon switched that into the communication lab and Bob became interested and eventually took off with those contractors that I mentioned but these mobility was in direct response to the fact that the military was mobile (()) wasn't (()) my opinion and I anticipate server or digital server or anything that was a military need plus the fact the mother ships and big computers were back in the space they wouldn't be out in the field whatever the field may be so then they needed the satellite connections so here we think about some mobile world where we had what we called terminals not even very intelligent terminals but packet radios which had (()) a network and a terminal interface you know that's what you think going back into some satellite input point back to some computing resource or database whatever and the motherland that to me was the beginning of internetworking no more complicated in that, no more motivation I can think of other than that to begin the TCP world I think what they did with TCP was in part visionary because they had such a channel of

solution but it turned out to scale wonderfully well they could have done a lot more constrain way but I think universal gateways and all that kind of thing I think had some visions in it , it certainly didn't put the (()) as tight as needed to for that particular problem and I think that had to do with the contribution of later on when other people started to accept those concepts and the technology, anyway I think to me and that went through the 70's into the early 80's I can't say the military ever accepted the packet radio.

30:17:7 – 30:52:5

LK: As I recall one of the issues was that this things were I hope my numbers are correct 25 long, 25 pounds each, cubit flip not quite mobile enough for ((astrologist)) to run around the field with even that someone had to agree this work that was been done was gonna be a multi decade effort until the technology could reduce such parameters to what we have today and where was the visionary to say yea this is a long term goal?

30:52:4 – 34:03:4

DN: Clearly we run around with those cubic sort of radios for a long term part of that was money, part of it I don't think the technology was quite nailed down enough the army hasn't really put (()) very much but there came a time under ((Beryline)) and others were is whole time was asked to build a lot of real cost radios Collins never – he was the one who integrated from two separate unit into one and there was classified – an encrypted version which didn't seem as one but ((his whole team)) won the contract but this were now still not (()) but they were a little lot of those and what happen in those later days strangely was that ((those things)) goes to the filed so much even though they were cocky and they have military nomenclature I think what we did was take all those and work networking problems while we have a lot of nodes available, I remember their were racks in the laboratory of this whole packet radio maybe 30 of them so we had a network in the lab with 30radios so you can play all this different kinds (()) algorithm and things like that , I wish I was more aware of how the military absorbs this kind of technology if it ever did I have the (()) inclination that it almost went commercial it went commercial first and then came into the military that were irrelevant coming also the military developed small hand hold radios digital based and then add them into the commercial world I think it really went the other way(my opinion), but anyway that whole question of relevance for ARPA is always been ((bugaboo)) it's hard for them and maybe that one reason when Tony (()) and others came into the directorship of ARPA and maybe the constrains of congress in terms of funding brought those arises in or whether it was the (()) of this packet radio but others things brought the men's' they looked better before congress, they were more attractive to the military that ARPA was feeling heat maybe in ((transit)) role of technology development for military purposes I guess on my part, anyways that's not the packet radio.

34:05:5 – 34:08:8

LK: I think we should address – what about that mobile van experiment

34:13:4 – 38:22:3

DN: That's kind of funny thing, we were starting to do some of the experiment this is the earliest days of packet radio and possible like 1973 or 1974. we knew we needed something mobile because obviously we facing a mobile digital communication system, I was tired of riding around in this little panel trucks you know we had to sit down we couldn't stand up at all. I wanted something we can stand up and I didn't know the implications of something like that I thought about it and Bob Kahn who is masterful in things like that build us first van which was from an engineering point of view was excellent it had internal generator one phase will go to the equipment the other phase will go to the air conditioner so they wouldn't interface each other we had racks which were mounted on cushions and so we could drive around with 3-4 racks in that thing, we could load it everything and I load it when I was doing noise measurement and other part measurement, tape recorders and stuffs and then come to packet radio world of course had two packet radios probably most of the time they had a channel interface which contain TCP and maybe a channel which was the source plus some other sources eventually had packet speech I mean it was the very useful thing we didn't put in signs or any address thing because we didn't want anybody to mess around because it look like a big goal (()) bed truck, what happened of course was when Bob wanted to bring the army on board that was part of the ((send off)) again so it wasn't too long for the first time Russell came and he was head of IPTO and he came and rode along on the ((bay, he love to do that)), and then Bob did, Vint did and before long we were seeing 3 or 4 stars generals I can't imagine them sitting at the back of a ((panel)) truck you know you have to sit down in fact that you can stand up and walk around and watch this things also ((())) around the bay area was very helpful I think to ARPA and again am not going back to what I said whether the army accepted this or not but at least there was a blessing I think the army in particular gave to the work at ARPA and SRI so anyway that advanced (()) and I got a call at one point from computer convention valentine's day saying where is that thing we like to put it on the floor there was flat tires lying on the back (()) I personally wrote another (()) a mechanic trying to make it run took the car wash it , scrap it all up and took it down without a license to the convention center and then we try to have the computers to museum wanted it so they got it, so that's the internet van I somehow apologize id didn't name it says the internet on it but I funded the thing but kind of lose control of it, I will call it – it wasn't internetworking van am not sure it was the internet van but things have a way of getting out.

38:23:3 – 38:27:8

LK: Experiment going through the tunnel especially (())

38:27:9 – 42:11:0

DN: This is one of the great design virtues of packet radio am proud to say built into packet radio of course is the packet is acknowledgement into the whole protocols system and there was this thinking phase of how to get synchronized but the protocol required retransmission so if you lost the packet I will retransmit. So the virtues of that was and obviously is a necessity (())tunnel the signal will stop and what we used to have or (()) to (()) you will see a series of numbers that was the way we demonstrate it just 1234567 and it just the pattern on the screen you run to the tunnel blinks it stops, you come out of the tunnel it continues right where you started with no errors it was simply put under the checks at the end so you could kind of determine went a packet wasn't good I never remember saying it here, the

only thing you could do is to go into the (()) and then the radio could pull out radio will stop push it back in the data string will continue that was the virtue of the protocols and the ability to do aerial checking and that sort of thing but it was astonishing necessary absolutely necessary we had to have that otherwise computer communications doesn't mean anything but the fact that it was there and works was kind of nice,(anything else about packet radio?) some people like to say that packet radio anticipated (()) digital (()) world am not so sure so (()) was I think came along with (()) as you were aware but I think the fact that – what's the company that provides all the hardware of (())? COLCOM they went to CDMA I mean in this packet radio design there were the CDMA world there was multiple access all that kind of stuffs so all this things about ((voting)) receiving everything where anticipated there not knowing what will come but you know but technology was anticipatory I think not that there will be this bulging world of cellular eventually digital cellular but it was of course internet and internetworking and digital technology that force that all over into the digital world as we see it today absolutely if I look at all that I can't help saying it's one of the great revolution of software technology and used in the world its huge I will never expected it just it very hard to see (()) anything else about packet radio?

42:12:3 – 42:21:7

LK: No, we want to be clear as I mention AI and (())

42:21:7 – 48:07:6

DN: When Vint came on I didn't see much change in that regard I think that was more hand on the board but I still felt somewhat the same about how we were treated and what led us to (())I said that was a time we had to show some military relevance so SRI was asked and went to the field with it (()) and other places we went to (()) we did all this kind of things that Vint wanted to make sure that if we had to go before congress we can defend its existence so we had sack experiment we had (()) going through (()) and (()) things like this we try to prove its utility but (()) it was military (()) I think successful down there in the sense that the particular part of the army saw the benefits of digital systems in the field and the linkage they could provide back to resources which they could not carry around and this is in the 80's (late 80's) so it was a powerful exposé that doesn't mean they took the packet radio around with it but the influence clearly (()) no question, I was trying to see if there is anything in packet radio that I have missed out on whatever, for me it was beneficent, wonderful experience and for very fortunate I don't know how much it contributed I will say when we first got the TCP one thing that people don't recognize that I will like to say (()) and some others who are Vints students came to SRI and really I think helped put TCP in working order and particularly the (()) into an MSI 11which is enormously small, a very small memory in capacity that took some talent and we were the first to shift all that into small machine and I think we ran some of the very first internet experiment using that whatever the weekly report ones in august of 1976 first time I know that we have been done using TCP but our pictures we took out of the TI satellite writer or whatever it was clear down under the ground and it went to the various other members whoever had TCP at that time which was not many was probably may have been solely BBN and am not even sure probably UCLA we had higher sizes we have TCP and we have (()) as well anyways through (()) we can send it to packet radio community and

so that was early we maybe mistakenly I don't know we want to celebrate that because we knew that we had at least inside of our little world we had accomplished something so we went out to a remote thing and make sure it's going through a packet radio network to do that and had a little celebration I took some pictures when we finally included the satellite network a year later nobody remember anything about that I drew the picture of that routing and everything so the one that's public today but nobody took any pictures nobody did anything It was by that time more of the same and demonstration by the way demonstration were a big part of our role (()) we started drawing RMD we said we were doing (D and R) which is demonstration and recovery and every time somebody wanted to come and see this work we were obliged to do it, so towards the end it was a little hard sometimes get the progress you needed and the stuff you wanted to work on but absolutely necessary (()) we had this nice van you could ride around and we sort of partitioned some of that stuff also we could go do that anyway they all saw something's later on (()) came to SRI there was some gateway stuffs and also Ruben who went to Microsoft eventually did some great works in the stuffs but most of them ended—packet radio ended in the field and I think ended SRI role in networking and internetworking.

48:08:4 – 48:25:4

LK: Where there any long range goals or experiment that you wanted to pursue that you inhibited during the course of finding constrains of any sort

48:25:4 – 49:52:7

DN: Good question. I found constrains but I don't know that I will blame ARPA for them, I think we saw ARPA's role winding down by the way (()) ARPA takes projects for 4 or 5 years packet radio went on for almost two decades which was powerful and important but I remember going to the field to (()) saying we had this technology that you will like to sponsor always rebuffed they did not see – maybe we didn't present it (()) and of course there was nothing they could go by on off the shelf anyways so that was also an encumbrance I think I sort of felt that ARPA had maybe more than it was ever expected to sponsor in that way so I don't remember pushing a bit constrain I just may have been -- lack of my own imagination I don't know.

49:56:3 – 50:03:3

LK: Don maybe now we can move on and talk a bit about the (()) that he and you were working on at SRI

50:06:4 – 1:00:11:8

DN: Let me start by saying I knew Doug pretty well towards the end I never did actually work with him or for him, particularly the division which he was part of about the time SRI had decide that they needed to move his organization out because they couldn't get funding anymore it come to a point where SRI couldn't afford to subsidize it anymore, so I didn't ever supervise him specifically anyway I came to him and (()) met each other so started seeing socially I think, I know him somewhat towards the end of his days as CEO he started with memory and capacity and some severe dimension, so when he start was I think the beginning of the story for him and he is been told in books I will tread lightly here but (()) was

a very important person and Doug and so is (()) and Doug Bob Taylor, and Doug's early funding how did they come together in my opinion first I have read enough about (()) that I know that he had come to a point in his career where I think he was at Lincoln lab at the time and he will come to (()) information and what he do with all this information since he was more of a psychologist than an engineer he was curious of how to manage this in a way how will the operators be able to use this information intelligently and perform a function they need to so it came somewhere to a point that they knew interactive computing as he called them was important . over here and the other part of the country was (()) and he had first had his awareness when he was still under the Navy and I think (()) whatever (()) and others that were influential and looking forward but anyway he came to Brooklyn want to get a degree, want to know the things outside of human computer and work on devices he was a great guy but he eventually get to this place in life where he saw computers as a very personal (()) to human behavior or performance and that seems I think am quite positive was part of the virtues formulation was not (()) they came together at some point but I think Doug idea from what have read about (()) I think Doug was a more generalized version of this whole issue roles that computers have it ain't mean to do complex problems as opposed to (()) I think he came in from more utility from a point of view and eventually came to the notion of this was a powerful thing because he was an acute station and went to BBN he saw a lot of interface issues that I think brought him into this room so Doug eventually went out SRI given Doug some money by the way you will find some of his oral histories and some statement while Doug was antagonistic I guess towards and the people there didn't understand him were Bob Taylor leaves to begin (()) SRI believed in what Doug was doing I think was totally false because I have looked in detail all of his personal records I looked at the funding he got at SRI he got in the order about sixty thousand dollars SRI gave him in other to lunch this world he had a hard time expressing himself and in some cases that didn't harm both inside of SRI and eventually at ARPA he had a vision and I will call him a true visionary of any person I know of I will call him a visionary without a provocation because he had this glimmer of something that should be done and deliver more but I think ultimately he was able to surround himself with some talented young people who are able to deliver that and put it into practice I think he would have struggled for a long time but he was a leader and they build him as a visionary and a leader so they were devoted time for a long time helping him to bring this thing into realization but in a nutshell he believed that computers were there to enable individuals more importantly groups to tackle the most complex problems of the day whatever that might be, maybe sociological, maybe the environment whatever or there are some tough problems the computers can help us do that so this whole notion of argumentation came to end and that was to me unique at the time there was projects not going on there was time shift things been developed things which where gravitating individuals towards responses use of computers and computers will react to them in real time the whole batch mode and everything but that was early in that and I think more than anybody else he had that vision tough time expressing it he didn't quite know how to bring it about but he saw the potentials in the most generalized way, so SRI gave him some money, wrote a proposal I think air force for scientific researches was the first one to fund him that could have been I know there was (()) I don't know whether he was there the first time or not but Doug had made some friends at the air force (()) for scientific research to try to realize this (()) under existence SRI bought him CDC160A equipment he didn't have total use of it at the beginning but that's where they first started exploring that machine interface and they test it in lots of different ways I have pictures which I should tell you that the first

computer mouse Doug died just last year that first mouse is going to (()) and so I found pictures to tender (()) I only have one picture to show and use the original one as long as (()) refer to that it's a big radio screen with circular --- this was a computer monitor and over here in the size of 160A that's a great picture so here is the mouse a little command button (()) with short cut command that you might use (()) and the original wooden mouse but mouse came into play after a lot of things have been looked at like pens and we even had a ribbon wriggling thing (()) to try to move the cursor on the screen but the mouse went out that's history of course but anyway I think Bob Taylor was at NASA he knew Doug, captained Doug and believe in Doug and gave him some money at NASA that was in the early days of this device discovery and I think he went to ARPA of course continued the funding there Doug eventually got his own machine but it was a long struggle (()) want him to do a remote connection to the SDC computer (()) and he didn't like that at all.

1:00:11:8 – 1:00:18:4

LK: Did Doug approach Taylor at ARPA or vice president to get the funding, do you know?

1:00:18:4 – 1:02:32:8

DN: Taylor met Doug at NASA, Taylor funded Doug from NASA so he knew Doug before he went to ARPA ((Willy Crowther)) had funded Doug too ((Willy Crowther)) had two 10 years at ARPA but Doug at one point was getting both money out of ((Willy Crowther)) and Bob Taylor, I don't know anything about rolling the (()) I will have imagine he eagerly want NASA money after Taylor came to ARPA he continued to get money from ARPA sometimes in the air force but this went on for awhile as he developed this NLS and this sunlight system that was the operating system to support what he thought he needed to do so a lot of things came out of that and we think of dark ranges (()) that they both know he was the inventor of the mouse and he got (()) for that and anything else but it was such a paltry part of what he was trying to convince people to do, as we mentioned earlier it was the PI at ARPA that he was willing and anxious to take the network information centre because he saw that as a reservoir of information and stuffs that they could be managed for whatever I will say for two decades if he wants to get on the ARPANET or the internet you came through the network information centre until he went out for bid got transferred to DCA went out for bid and some people inside of DCA I think mistakenly won and he left DCA and formed a company that was a disappointment to us and so network information centre evaporated at SRI anyway and the people made a lot of money in the process.

1:02:32:8 – 1:02:36:3

LK: Was that the same time the Arpanet was transferred to DCA in 1975

1:02:42:7 – 1:13:48:6

DN: But the other thing Doug did were like journals and everything he call them book scraping and I felt well that's okay but was true in fact, everything they did they did online I don't care what it was they will do it online and so things like general keeping and stuffs all the records of that are until this day available on tape I think the museum is dealing with them but anyway all that stuffs that went on was

logged expect from the first transmission into the SRI I didn't remember to include notebook about that you cannot find it anywhere either it just (()) of the people of the memory and I remember looking at the SRI project report at that time in 1969 and it does as a matter of fact to go on to say yes we have a connections it doesn't give any details at all even (()) was kind of influential in that link up but the other thing he started to do of course was have more than one individual collaborating via computers there was an (()) machine at the beginning I believe what they say was a PDP (()) whatever and so all this people thought different terminals on same computers people worked in the (()) back and forth and then I can't begin without talking about what has become a mother of them and by the way somebody has written a play which will be premiered at Stanford next spring call the demo about that it's a play its gonna be a theatrical production, part of what happen that day is still somewhat astonishing to people I will show it a thousand time to people and what happened on that day in san Francisco 1968 the first time they see the mouse, the first time a big audience who is never seen ((ARPATEXT)) ideas about (()) I don't mean to diminish that but you wonders here in front of 2000 people with a demonstration of ((ARPATEXT)) blinking the computer was in (()) a micro wave relay was established on skynet (()) to go to the civic centre in San Francisco especially for this demonstration so he was sitting at the tunnel at San Francisco computing power was back there, so he is (()) he shows we are processing and this was at least 8yerars before EMAS the first probably used (()) but he was doing entertaining (()) and air division and all those stuffs (()) which was a command or actually (()) so he went to(()) and he went to ARPATEXT so on the way home I may have to stop at the library what do I need do in the library and then click on that it will show you all the things you need do with the library so that was the demonstration of ARPATEXT from the beginning but then sort of a (()) there to me was that he opened up another connection with the fellow and every terminal and then (()) and together with both video and audio connections on the screen people entered into the same document the same time I mean that's not easily done today nothing is impossible and it was (()) in a way that it wasn't you know the video signal was analog but it was also composed on the same screen at the same time the audio was of course analog but he showed what he was – that was his basis I guess for collaboration I guess this was his technical realization of what was needed, I think that was the crown of his achievement that particular demonstration I don't think after that he was ever quite for a lot of reasons he was able to make a better more convincing demonstration of what he had in mind which was a side tale as he pointed aspect of the – partly because I think his vision about such generality but at some point you start wanting the people to change not just the two of what they have, well there was no psychologist we had this notion that people will change their behavior because of the tools you offer them. I had discussions with him and I said look Doug this things are happening which you mentioned and I will mention the second he also cut short NO!!! you don't understand its more than this and he almost went to his grave thinking that we have not got to where he believed the world should go and that's not about technology as I said that's human behavior but I will give an example like rapid prototyping and I care much about rapid prototyping. Rapid prototyping meant that I could take in the internet world input from all over the world I could do a problem design from beginning to end involving all those people and cut my orders of magnitude the time required to do it all because of this computer supplementation and network supplementation and unlike the (()) was a big thing with him I tried to convince him that Google, Wikipedia for nothing more than realizations of what he saw as accessible knowledge basis, I don't need to be complete about this there are certain things that I have written

about him but this were couple examples of things he didn't say oh yea that's where I was going well his humble, quite way and not quite satisfied with what the (()) had produced I think in fact I get another access look do you think the human gene whatever have been decode without computing power or without collaboration(microsecond) then no one single person understand the microsecond those are ultimate examples of things he was hoping for and saying if people work together and collaborate you can do complex things maybe his problem was more elevated than, that I don't know that's a bit about Doug I think I have read correspondence were((Willy Crowther)) got a little frustrated with him because he wasn't demonstrating what he was trying to advocate and I don't know – I think that was((prior)) to the mother of all demos but there was some unhappiness there I barely remember ((Willy Crowther)) so I can't recall his correspondence to get a little of the when you talk about Taylor and will like to reflect on this story I mentioned earlier and that nobody understood Doug at SRI and he did (()) but pretty soon he was so far ahead of his time that he was (())he tried to get money by selling NLS circuit on the SRI computer which means some people in the government otherwise tried to buy into that go cross trying to do NLS (()) but it was this people (()) for them and it was outside of the normal development circle of operating system and the decrease in computing – by the way I need to mention that Doug wrote the paper once he knew device technology he said he wrote some patterns on something at but Brooklyn he wrote a paper which he called (()) when (()) told me he was (()) in his thinking Doug knew how to project where technology might go in terms of size and cost, Doug had this notion that things will scale down but in his life, people weren't catching up fast enough and he was running out of money ARPA could did continue the funding and he tried to sell NLS circuit and that's a very difficult financial arrangement at SRI to pay his staff whatever because that was so (())

1:13:48:6 – 1:14:27:3

LK: This is an interesting issue you raise because the tolerance for ARPA for long time funding on one hand even change or failed expectation on the other along the way is an important element, maybe you cannot take it all, was ARPA supportive of his long term vision but not realizing it rapidly was that an acceptable, continue funding or are you (()) path of frustration?

1:14:28:2 –

DN: Well am not really qualified about giving opinion, I don't know but I think Doug had hidden kind of a threshold in what he could demonstrate. I think there was some difficulty in trying to say what's the next logical step and the fact that computing had not come to an affordable extended that particular point where a lot of pretty differnt people can have them it wasn't implemented but if he had another metal level to go to it was hard to realize because all he had the ARPANET and the (()) I will say and there weren't many of those around so where are the collaborators and what can I demonstrate whatever, I think that plus the fact that he had maybe his champions had left him at ARPA((Willy Crowther)) was no longer there..

1:15:30:1 – 1:15:31:9

LK: What year are we talking about now?

1:15:31:9 – 1:18:23:5

BN: Well, it would have been(()) I will think, he left SRI in 1977. Doug left with a portion of his staff to (()) corporation in 1977 and there have been struggles for years before that so that was when the funding was winding down and he couldn't sell enough circuit to bring enough profit in to support his staff, and I think that was one of the (()) of what -- I don't know enough about who took Bob Taylors place at what particular point I don't know that chronology well enough maybe he lost his champion there and by the way I just wanna interject this because I think is crucial to the ARPA world there is hardly anything more important at ARPA than a program manager who will stick in the field and will stay working that has an ability and the patience to work through a developmental time in whatever field that he's sponsoring I think Doug had that full time we certainly had that in networking no question about it but if you take somebody who doesn't have that commitment, vision to go on with you it is a pretty tough road at ARPA and so I think that having the right program manager at the right time was really (()). One other thing that entered my mind -- there are three things I think that generate innovation brought to-- one is pressing needs, the second is (()) in the development of a technology -- the technology became pregnant with potentials and the third one is vision and when I thought back to this time I tried to see what was operative ,which of those things were operative in networking and stuff to see if I could pin point the reasons why things work well I think in Doug's case am not sure that somebody came along at the right time in other to continue this for him if you don't have the right program manager it's a tough sell at ARPA.

1:18:24:6 – 1:18:34:5

LK: Do you think that if there is a change in the nature of the PM

1:18:34:5 – 1:19:45:6

DN: What have been told by some that this whole notion of military relevance has brought horizon in someone, the whole notion that we will have (()) and some of the autonomous vehicles that they did you know we have some competition between the two same of the good some of them I will come back (()) but I think when you are required to get quarterly evaluations and measurement of things quantitative you tends put a little on the bid on the high risk, high value discoveries I don't know if that's completely true but I think present day ARPA is a different -- but am told because am not there that sometimes you don't even have the program manager to change and you get somebody who don't even know what you were doing am sure that's weird

1:19:52:9 – 1:19:54:0

LK: So let's return to some of the other project as well that ...

1:19:54:0 – 1:25:58:6

DN: There is two of them that I will to attend to briefly one is artificial intelligence again I didn't not work in that but I have laboratories under me and I had some awareness of that and another one is something called surgical tele-presence which will be very brief lets go to AI for awhile there was a time

way back in the early 60's mid 60's when that was an attractive topic in the evolution of computing power some people purchase for different reasons I will go back to portion because he wanted the argumentation of it because he wanted to replace people with computers of course there were this different avenues but AI was kind of blasted to it one of the first thing that came along was robotics SRI was involved with ARPA early on with robotics perhaps the first intelligent mobile robot called ((shaky)) to a very large computer either with wire or with radio he did his best to find his way among obstacles and learn scientific process I might say that some people lay claims that there is a threat that goes all the way from A-star that was a program unit used for ((shaky)) to find his way around to the GPS and the (()) in the computers today a lot of generations but that was a very general solution and it had some impact on the computer and then of course robotics had and then evolution it first took on board computers which could do more that was another SRI generation called FLAKKY and eventually it got to more autonomous collaborative robots which will work together (()) which 50 (()) running around them building, mapping things and whatever and then the last one SRI worked was a train robots that worked off the digital models and stuffs like that so it was an evolution of robotics with DARPA that went on for years and years and years but it had his beginning in the 60's so robotics have a kind of a tread you can draw maybe not continuous to ARPA for a long time that had an urgencies about the same time SRI was involved in it somewhat in the early part but not always with ARPA they build a network system called pro-spectrum that had to geologic mapping and when we way find you know that sort of thing I think that eventually got (()) to US he has geological survey or something like that but expert system kind of die out (()) it came to a time and that was almost (()) and so it changed the machine intelligence of course it didn't miss his potential and of course the potential was enormous, his aspirations were enormous particularly the whole (()) thing where he wanted essentially to duplicate it and capability so it went out of favor for a while and I think ARPA lost in wind it's a good way to think about it the way it went to ARPA the waves were robotics here was a peak*3 and so technology enable more complete different functionality I think there is wave also that went through to some other things like natural language for example and it went from recognizing task eventually recognizing speech emerging of the two it went through waves by the way there was general by the name of (()) who was a pop PM at ARPA and this was part of the (()) whether or not is good to have competition or measurement versus an open field, natural language understanding which is essentially text was moving on this part and speech recognition was moving on this part Alan merged the two wonderful, wonderful thing and he also gave metrics to know how well we are doing and that was a good thing it really focus things and brought things to reality more quickly and I think an open ended thing will have done so that's good sometimes openness is good sometimes it is not you go back to those three things and a technology that is evolving rapidly on to the right place in his vision and we don't have will those (()) combination of things (()) expert systems didn't go I can't say intelligent (()) to things we see today, one thing I could say maybe but expert systems as define doesn't exist today

1:29:59:5 – 1:26:06:6

LK: Was the collaboration of (())

1:26:06:6 – 1:29:38:5

DN: They knew each other there was discussion that was a different animal that was health (()) expert systems and he was the (()) player (()) and geology interaction but no (()) no duplication of effort but strangely later on ARPA came back to this whole thing there were times when they were trying to do and again there were times (()) how would you do planning how does a group of people bring together a plan for a military operation expeditiously so there were a number of this probably the crowning one that am aware of this goes into the 2000(()) called (()) is a military based a very bright fellow by the name of (()) eventually came to lead that and it was a collaborative issue what happened at that particular point is that ARPA I don't know who the PM was brought together almost every AI centre in the united states and some overseas to work on this problem how we could bring this into existence and that went on for a high funding level very recently 2008 or 2009 whatever one thing that came out of that thou (()) which plays different role and different audience I think ARPA people played with some pride what was an outcome which goes into absolutely broad use and some people love it certain people can't make it work whatever but it was an outcome of that and so there was another way that went through because this was kind of an AI issue how do I bring together different aspect of the plan and make it work, there was the same (()) this family of agents suddenly have this software (()) are called the ((agents)) and they could execute task collaboratively or independently all the demonstration he made which were outstanding to me he could have a connection via text or speech and whatever one will fail and another will pick it up the agents were about generality so a lot of good insight came out of that I can't map all the derivatives where they went and let me mention very briefly (()) tele-presence.

1:29:38:5 – 1:29:59:7

LK: AI had some as u mentioned peaks environment in terms of the funding, was that due to ARPA influence and direction or was it the technological breakthroughs or failure that caused the ups and downs?

1:29:59:7 – 1:35:23:3

DN: I think a lot of the failure people perceived to be the potential (()) I mean what can machines do and we are struggling here to bring language understanding into existence you are trying to figure out what an autonomous piece of software (()) that was hard I don't know how would natural language interfaces the databases it was a big deal where you will you know what do the ships see at what particular point what two ships are crossing with an 100mile things like this and we go to this databases and we will churn in whatever and provide an answer but I think it was a lot of disappointment I don't know how much was with ARPA and how much was in the other user community people you would hand this off to whether this is a utility or not it was hard it was really a generally hard problem I think for that reason it went through winds at both ARPA and like I said there was point where in the popular (()) AI had a bad name I think it was hard for ARPA to maintain enthusiasm in that light as u know it was (()) about how was it maturing as hoped I think when it rose again it was again coming back to one of the 3things I need a demonstrated need a military planning tough and really having dynamic role now where things come and go instantaneously how does military plan on the short run how do you do tactics I think that as the big issue that bubbled up at ARPA and therefore it resurfaced back then I don't

know that anybody will ever call that Artificial intelligence again it has some of the name even though it is roots were(()). He is a fellow at SRI that invented this and the notion was that can you make a device that will operate inside tools (()) and operate inside without doing massive surgery and he invented this and he got some money out of NSF and build it and it embodied into a company called the (()) and its revolutionary they were trying to (()) all over but as gone through all the (()) approval and stuffs but it's a very growing company what happened after we have build some models of it a colonel (()) come he is a colonel surgeon in the army he was fascinated he come and said how do I get to ARPA and I said well as far I know you do this, this are all the detail I will give you names of people to call so he went up at ARPA and he brought the continue development to a point where it was really persuasive demonstrations to the head of DoD and what he brought was the battle field imperative and I had imagine (()) so it was this device that essentially separated the surgeon from the patient he could be anywhere but we did cross based experiment and other things they have to do but the operating tools and the patient are over here the surgeon is over here serious (()) view, tactic feedback , sound anything you want that's inside and the sensors can go inside to solve and so you are in there powerful so he saw this and he said here is a battle field model for that we can't afford to send surgeons out to (()) magic if you can get treatment in the surgical part to the battle field that's a boom anyway he promoted out of ARPA, gave the seven years of funding associated with some hospital in the DC area so anyway a few more of this were made to the point where it became commercially attractive

1:35:24:7 – 1:35:25:6

LK: Which year are we talking about here?

1:35:29:8 – 1:36:55:1

DN: Good question I think its genesis was in the mid 80's and early 90's sp this is after the 60's and 70's that we were talking about but there was another model of somebody important to the PM going into ARPA with right vision and the latitude to make something happen that's the only reason I raised because it is not in the late 60's and 70's the program managers were so (()) at ARPA and no one can understand how one can explain anything there without looking at their competence and their vision and whatever and the fact that ARPA has been eager to bring them on in area of their own specialty as opposed to career employees as different in with world and this was one specific case and went on anyway (()) surgical was a very, very successful company in the world today and this things cost about a million dollars per piece and widely spread across the country and across Europe, they were in Europe before they were here and to create advantage and so (()) basis surgery

1:36:59:6 – 1:37:52:1

LK: Let's give descriptions of the projects that you have worked upon in your career at SRI, in terms of style we recognize that one of the characteristics of ARPA/DARPA was to give some flexibility and some delegated authority to the people that they were funding , as a PI as a researcher you had people working under you with this ARPA funding projects did you promote that same philosophy of delegating, responsibility and project implementation to the people under you or was it tightly controlled, loosely controlled from your level down?

1:32:52:9 – 1:43:06:8

DN: My philosophy was to try to hire good people and give them latitude that has been my whole philosophy in my whole life we were fortunate I think we need to have people join us at that particular point who could grasp what needed to be done I don't know that we could have written a prescription for what where they went our priority this was all new ground they design receivers before only as well but this particular environment was (()) and this has to be perfect you know (()) and they could take that and walk forward , in software it was a similar thing I mention a (()) by name (()) who came from Vint's group from Stanford and essentially wrote the first TCP we had anyway , implementation that was the spec he had to try to match so pretty soon you had to start converging because have made demonstration and that was over your head all the time (()) I got involved in the commercial project once developed it waiting for some commercial company who had a (()) and the time scale was enormously short and we will funded ARPA so I thought that will come to the distinction and notion that at least there wasn't a trade show and there was demonstration of relevance and things that had to be put on but they were (()) I think Bob and vint were happy to find where those were I remember the Arpanet demonstration that Bob collected that was sort of (()) we got to do it and that was a big deal and I thought probably had some sweating nice involved in that and some have a feel of this but we had a luxury of years not months , enormously helpful to us yea I like that and we have to give way to a progress report and (()) meet that very specific milestone or not ((that was a boom for us)) I think one of the characteristics of program manger if they have the latitude am not so sure they have that much latitude today I don't remember Bob ever saying the latitude didn't bring his money problems to us and I don't know how much he had obviously he had ((()) I don't remember what led us down because we have 100k we don't have 300k and that was a great enablement for us today I think there is a lot more attention to the funding much more limited I think for people who watch for progress a lot closer today than they used to be I don't even remember the director of ARPA the saying that was going up their was Bob that was IPTO (()) there wasn't any kind of accusation of progress for that sort of thing I don't think (()) but certainly (()) did and there was another fellow whose name I can't remember but that time I was involve in several things.

1:43:07:9 – 1:43:28:6

LK: So on another (()) did you collaborate much with other PI other than SRI, the PI meetings or other gatherings where you are involved if so was there any impact on the joint, collaborative work or each of this independent work?

1:43:29:4 – 1:47:14:3

DN: Well giving mind to packet radio was a collaborative project we had for 5 of our participant there were regular meetings for those and so a lot of that was trying to figure out where we were going in the early days and those helped define what it was we were going to do BBN was going to the station for example ok that had some implications Collins was gonna do this (()) and we would kind of drive that truck a little bit so those meetings were really crucial at the beginning and a whole lot of them I don't remember that Bob was there and all of them but they had to take place after things got defined better

then I don't think we met enough what happened was you were so engrossed in what you had to make to make happen so u start emails to go back and forth and that's weird what they called those first emails flaming emails those kind of took the place of design (()) the design was already kind of done now make it work ,you don't have a gateway yet let's get it whatever so that was the implementation nature when all came to the final I think there was a lot of mutual pride between all of us who had to do something that as very quite successful and valuable we met our goals when I tried to think outside packet radio was my most familiar PI meetings before the competition and the contracting now came in 1988 I think PI meetings were a time were ARPA did some really human things there were identified things that needed to be done and they will speak the PI's to do it I think in the PI meetings (()) getting the network information centre was an assignment at that particular point that was a Larry Roberts thing as the network measurement centre and I think those were (()) moments she didn't want to miss those because (()) capacity at work, competition contracts as I think changed that a bit going to ARPA anybody else in the government now had the strings on it and those were constraints that ARPA I think there is a work around just call it DDA and that was helpful I think ARPA used that as the best they could to try to avoid the question of do I have to give it to you because you are the (()) I think that went totally against ARPA's (()) and so they went to people that believed in it and trust in it.

1:47:15:7 – 1:47:25:9

LK: So the next statement appear in the second era, if the life's changed

1:47:25:9 – 1:47:49:2

DN: Am not there anymore, I shouldn't answer that because am not qualify to say how it changed I do have some feel about – it became more difficult for ARPA at that time to have the (()) that they exercise before let's just leave it at that

1:47:51:3 – 1:48:21:7

LK: The PI meetings early on were the kind u describe where we have McCarty (()), we have the networking guy the device guy and so on all together and at some point it point into most specialty groups a new (()) that changed the era you clear to comment on the effectiveness of the difference in those kind of meetings?

1:48:24:4 – 1:50:51:1

DN: Am not your best witness on that I have a feeling that they worked best when the person at ARPA either saw the potential of a technology coming, an impending need or some vision when he needed to collect the set of people he thought might help him solve that and then ((tussle)) out the roles , I don't know that those aggregate PI meetings were they really cover the broad (()) they could have been useful but am trying to remember whether they were AI meetings they didn't go to them am trying whether they really existed there were certain networking meetings that went on but again once you started the demonstration path it was in the implementation path and whether or not somebody in II could help work in very problematical and am not sure in that case maybe it has to do with scale of

people you invite to the PI meetings and within packet radio there were personal investigators and we should come together and (()) in order to create some implementation I think that could be the beginning of computing personalized computing I think at that particular point computers were coming into probably useful thing that made sense for AI got to be there so it made sense to have that (()) of people I have trouble thinking about any of the separate ways that computers get (()) then AI and they were (()) awkward answer I don't know am sure.

1:50:55:9 – 1:51:12:2

LK: At a very high level how would you describe the ARPA funding culture in that early year the culture that produce remarkable achievements can u characterizes the funding culture at ARPA

1:51:16:1 – 1:53:31:9

DN: I try to do that and I will try to repeat myself I don't remember us once we had the (()) packet radio implementation of having worried too much about money I think bob was able to budget an allocation for us knowing how many people we had knowing – he will maintain that I didn't (()) for the money I think we were quite aware of that what I tot I saw was the sufficiency of funding to do what we had to do how hard we had to walk in the background to make that available I have no idea he didn't ((burden)) with that for which we could be most grateful there were obvious time maybe we want to do something else or there was no money for that we had a relationship we can (()) to that and so we went forward the whole competition thing in competing for role that ARPA will have been level to me is (()) to ARPA (()) bidding to a dollar we could (()) could go on but it sorting out contractors on the basis of financial bid that's seems (()) am sure it's there today but I don't feel it in my time there

1:53:34:5 – 1:53:58:8

LK: You said quite a few things about program managers and the impact they had can u summaries whether they good program manager and any advise you will give to the PM today the ideal PM which is the person you interacted with as well as the IPTO director

1:54:04:7 – 1:57:19:7

DN: The best arrangement we had at ARPA was when the program manager is a collaborator in the good sense of the world he is not a boss he's not a funder he's a collaborator you will like to have that program manager and people doing the work to feel like their solving the same problem at the same time not an opposition the best program managers are those who have a joint vision it's not good when you have to educate the program manger to (()) its better if they come equipped with bright people we have placed PM SRI has at ARPA over the years that's somehow exclusive particular thing but putting the right people at the right time the whole autonomous vehicle thing whether they were racing across the desert and all that was started by a guy that left the (()) to go (()) so the quality in the (()) of technical understanding or collaborative or visions is only I think very important I have (()) today sometimes program managers have views that are interchangeable at ARPA I can't give you (()) one particular person who as to do with computer security I won't mention his name but he spotted some

really good stuff on computer security and one of the great pains of my existence is when people say why is internet secure and that's a long story itself anyway there were some funding (()) the person left went back to his school /college came back again good things happen you know the right person at the right time there is now a project to project at ARPA one is called crash and the other is called burn one is to build a (()) secured computer and the other one is called to build a (()) secured network (()) that will only happen because that program manager is there that's clearly a need there is no box to box about that's a need driven thing if the technology were able to do it I don't know but the vision is there so that's a good case of program manager doing what I believe was in the best interest of ARPA and the use their money.

1:57:26:9 – 1:57:38:9

LK: So is there way u can summarize what makes ARPA successful in the early period we talking about you basically talked about maybe (())

1:57:38:9 – 1:59:46:6

DN: I will pause this a bit I don't know if I can put it back together or not I think computer interaction, computer networking was all kind of (()) considering this computers and they are expensive anyway that's kind of (()) but they were budgeting with potentials the technology was absolutely pregnant because it was new and it was invasive wonderfully applicable to all over the place so there was a point in time when they wanna come to (()) like machine before and that was in the 60's I think network became part of it but it was soon clear that there was an emerging of computing and communications and that was another big (()) in technology those were all present at that point I think that was terrible important in the success of the 60's and 70's you could say AI and whatever (()) but this things are clearly (()) put good people at that time who had vision to able to make the most of that (()) technology I think that would happen I think it was for 2 (()) people like yourself and Bob and other came together at the time when the technology was ripe.

1:59:55:3 – 2:00:12:0

LK: Where there other aspect of the ARPA approach that u can articulate what ARPA plan to do at that time

2:00:16:7 – 2:02:09:9

DN: I don't know what you are fishing for I felt again (()) funding for that. I don't think that congress was hanging so much on them in those days there was an ally and (()) but there was a gentlemen who was willing to go to back for the concert you don't need much more than that one champion in congress and one sympathetic director I think that was the time when the microscope was not quite (()) in the whole while things were run have been told that (()) again (()) this is (()) the military here is where you are (()) for congress I can't imagine that happening in our day u know we had to go (()) and explain (()) this is where we are and this is why you need us on this particular demonstrable outcome I don't know what

else to think about at ARPA other than people there the validity of funds and the freedom they must have felt (()) to this world whether is ARPA (()) am not sure I answered that

2:02:09:9 – 2:02:18:9

LK: That's very helpful, so is there anything that you care to elaborate on, anything we have missed you will like to talk about

2:02:32:9 – 2:03:12:0

DN: Here is what I wrote (()) as an extra "filing maybe the capstone of what I saw at ARPA was there relatively open and (()) atmosphere, attitude that the exceptional PM's had in retrospect an usual degree of freedom and sufficient resources to make what they saw a reality sometimes I didn't change the world that requires consistence and sometimes it did like the convergence computing and communications whether of which were necessarily predicted" that's kind of it in a nutshell ; thanks for the opportunity.

2:03:12:9 – 2:03:20:5

LK: Don thanks very much it's been a pleasure we appreciate