Computer History Museum

Xbox Oral History Panel:
Nicholas Baker, Todd Holmdahl,
and Albert J. Penello Jr.

Moderated by:
Dag Spicer

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Dag Spicer: Well, sorry, we're so far apart. But hopefully, it'll be OK. Thank you all for coming today, Albert Penello, Todd Holmdahl, and Nick Baker for Microsoft Xbox. And we're delighted to have you here to talk about the history of the original Xbox and Xbox 360. If we have any time left over, we might touch on Xbox One. But the chances are that we won't have time for that. We'll have to do that in another 10 years or so.

So thank you again for coming today. I wanted to start out by asking, why did Microsoft do a game console? It's a software company. And what opportunities did it see in doing a game console?

Todd Holmdahl: Yeah. I think all of us were around back then. I started in 1999 when they first came up with the console idea. We felt that the living room was a threat. That we thought we saw what Sony was doing with the PlayStation. And they were gaining a lot of traction there. They were talking about being productive in the living room. And we wanted to make sure that we played in that space.

And the reason primarily, in addition to the Sony threat, [was that] we wanted to make sure that we were controlling the end-to-end experience in a meaningful way. And if you look at some of the great products out there, the person who controls the hardware, the software, and any services, the experiences, they can make sure that all the details are taken care of.

They can make sure that everywhere from unwrapping the game package to unwrapping the box to inserting that first game into the hardware to playing that first game is controlled the way that they want it controlled. I think that, in addition to the threat that we saw from Sony, were big reasons why we went into this space.

Spicer: Can you tell us a bit more about what Sony was thinking?

Albert Penello: Well, it's hard to know what they were thinking. But what they were saying, to Todd's point, was that gaming was their business. But they demonstrated a lot of intent. They talked about computing in the living room. They talked about productivity under the television. So they used those words. And I think that was a lot of the things that the early Xbox founders saw us potentially moving people away from PCs and into the living room to do the productivity-type work. That was probably the initial genesis of having the conversation.

Nick Baker: Yeah. There wasn't any real good, at the time, platform in the living room. You did have a few game consoles. But in terms [of] having a piece of consumer electronics that you could put in the living room that was, say, Microsoft-branded, [it] didn't really exist. Media center PC was still a few years

after that. And just as a Trojan horse in terms of getting something in there. A lot of the early thinking on why Microsoft should do a console was specifically for that.

The discussions had been going on for a little while already. But the-- I remember going to some of the ISSCC [International Solid State Circuits Conference] presentations in '99 when Sony first started talking about the PlayStation 2 silicon. And that's when it really started to gel that they could be doing something seriously there pretty soon.

Spicer: What was the role of the original Xbox for Microsoft? There were some strategic goals as well as the marketing goals. Can you talk about those?

Holmdahl: The original role? Just to be sure.

Spicer: For example, in-- I believe, and if this is incorrect let me know. But it was basically to establish a presence and get Microsoft's foot in the door in the gaming space.

Holmdahl: Yeah. As we discussed earlier, we saw what was happening in the living room. People spend a lot of time in the living room. I think the average American watches five hours of TV [per day]. A lot of that's in the living room. But the role for us was to have an opportunity to get in front of consumers, create a great product, create a great consumer product. And we felt like we had the talent, and we had the team of people to be able to do that.

Penello: Well, I was going to say, I think by the time that the product was shipping in coming to market the team had pretty squarely focused on establishing themselves as a game console. So I think there's a lot of strategic reasons why the early conversation happened, but by the time we launched I think everybody understood that we needed to be credible and believable as an entertainment brand because that wasn't something that Microsoft was known for. So, [for] the very first console, the team was like extremely laser-focused on video games and establishing themselves and winning in the video game market.

Spicer: As opposed to 360, which went beyond that?

Penello: Well, I think 360 was more about starting to bring in some of the other things that Microsoft, some of the other assets Microsoft had in the living room. It was still, 360 was still about gaming, but we had credibility by the time we launched 360. The original Xbox was about establishing that credibility.

Baker: The goal was clear early on that the 360 was really to be number one in gaming. That was the goal.

Spicer: Yeah, I think I read at some point [that] $15 to $17 billion was allocated, in one of the marketing plans over the life of Xbox for the next 10 years or so. Tremendous investment by Microsoft. And I want to ask how the original Xbox was received in the US, in Europe, and Japan. Can you talk to that at all?

Holmdahl: In the US I think, it was received well. We had generated a lot of good information about the product and the capabilities of the product, and just the abilities for us to deliver the most powerful gaming experience possible. We really focused on power and building off of the work that we had done with DirectX, hence the Xbox name. And taking some of that work in the PC gaming space, which was arguably some of the best-looking work and bringing that to the living room. There's always, for every Xbox launch we've done that I can remember, and I've been involved in all three, there's been just an incredible, intense fan base, particularly in the US. Japan was more muted. I wasn't there personally, but I believe on the first one it was much more muted than the original, than the original Xbox was in the US. And in Europe, I do believe, you'd probably find it someplace in between how we did in Japan and how we did in the US. We've always done well in countries like the UK, and some of the more Scandinavian countries. The southern part of Europe has been harder for us--France, Italy, and Spain. And we continue to message those places appropriately.

Spicer: What lessons did you learn from the original Xbox? It could be technical, it could be marketing, cultural, social, that you applied to 360?

Penello: From the original?

[INTERPOSING VOICES]

Spicer: I'm sorry. That's not what I meant. Yeah, from the original Xbox.

Penello: I would say the entire program was lessons applied to, lessons applied to 360. It was a learning experience, I think, for the company from everything from how you build the hardware, how you engage with customers, how you build relationships with partners, when you're a platform holder versus building tools. Or the difference between running Windows partnerships and running Xbox partnerships is much different. Your engagement is much closer. So I think that, I mean almost across every dimension, you had a lot of Microsoft people. You had a lot of industry people that were sort of just learning how to talk to this customer and how to be present in the industry. And all those lessons applied to 360.

Holmdahl: Just from a product development standpoint, we did the original Xbox with a handful of people from Microsoft, and worked a lot with Intel and Flextronics to do the design and the motherboard. And when you do something like that, you have less control over the design itself. And you have less control over the cost structure. And so on the 360, you saw, and Nick was a big part of this, that we were involved in almost every aspect of the hardware design. We were doing, controlling the silicon, we did the motherboard. We had relationships with IBM and ATI on the CPU and the GPU. We were doing everything that we possibly could to create, not only this great experience, and once we launched the product, if you look at the financials, you have to drive cost out of it really aggressively because that's a huge part of the overall profitability. So we wanted to make sure that we had the opportunity to do that and that we controlled the design in that aspect. We did that, and I think that allowed us to have a much better experience, as well as a more profitable business.

Baker: And just on the point on designing the silicon for a console, you have the concept that when you come out with a new generation you know is going to be out there for a long period of time, so five, six, seven, eight years. And you want to push the boundary as much as possible at the beginning so it all stays relevant several years into the generation. And if you're doing that with off-the-shelf merchant silicon, you buy your CPU from vendor A, and the GP from vendor B, it's hard to get the right feature set, hard to get the right cost structure upfront, hard to get the control over the course as you go through the lifetime. Whereas a 360 from the outset was designed to be cost-reduced, cost-reducible over a long period of time. And if you look at our launch configuration we had four individual die in the core silicon when it first came out in 2005. And if you open up the 360 now, you'll find a single… basically most of that reduced into a single, to a single package That's really only possible if you get control over the silicon upfront and can design to be able to reduce the cost of the box over time.

Spicer: I think related to that, was you had a sort of shoot out at the OK Corral between ATI and Nvidia, I believe, as a vendor for 360.

Baker: I wouldn't call it a, I mean, so we go through and try to get the right technology at the right price at the right time. I wouldn't really call it a shoot out, but there is a big investigation that goes into trying to understand what it is that game developers want to do. What does our software as a platform want to provide to the customer. And really who is capable of meeting that at the, at that time. And as always, you catch people in different cycles on their development, and just what they are willing to do in terms of customization for you as well. And you have all of that. It's a very, it's actually a complex decisions in terms of picking somebody. It's not literally put everybody in a room and say, OK you run this demo, you run this demo, and picking the best one. It's a lot more thoughtful process than that.

Spicer: Now to Todd's point, was ATI willing to release the, [to] give you better IP terms than Nvidia was, in terms of controlling your own IP, which Todd was…

Baker: For the lifetime, we want to be able to control our destiny. And so, working the structure of the deal was an important part of the overall decision.

Spicer: Why is it called 360? This should be an easy question. Maybe the marketing guy knows?

Penello: Well the name was a fun discussion at the time. And my favorite thing about naming is how much everyone sort of dislikes every naming option until you decide on one, and then the product determines the name and vice versa. So, the idea behind 360 was [that] the original Xbox was a dedicated gaming console, and 360, we had these ideas that Media Center [PC] would plug in that you would have Xbox Live and your friends. These notions of marketplaces and really early notions of things like video, well before Netflix or any of these other types of things existed. And the idea was that 360, the Xbox 360, would sort of always be around you. It would always be part of your life. And whether it was gaming or friends or communication, or other types of entertainment, the Xbox was always around. And so you saw the circular elements in the design on the circular elements of the console. And then the name itself was sort of designed to invoke this idea that it encompasses more than just a video game console.

Spicer: That's fascinating. I don't know if you know about the IBM System/360. In the 1960s… it's the most successful mainframe of all time. And it was marketed and called the 360 for almost exactly that same reason, that is, at the time, computers were divided into business or scientific computers, and the 360 merged them together, covering the whole spectrum of customers. That was the idea of the 360 degrees.

Holmdahl: I think it's appropriate that we're at a history museum, and things get recycled.

Spicer: Yeah, there's only so many, throughout history, I guess. In fact, IBM has reused its model numbers on several occasions, for calling laptops the same model numbers as they used on mainframes from the '50s, for example. OK, this is an interesting one: How important is photorealism as a driving factor in performance? And are there any other factors that you need to take into account when designing or architecting the console?

Baker: Well I think the ultimate, when you can say you're done with game consoles and graphics is when you can render maybe even say, Lord of the Rings, which now if you really look at it, you could probably start telling the flaws as compared to what's coming out in innovation today. But in terms of graphics, the end result clearly is, can you render in real-time what a render farm can do over several hours and several days? And that is still-- I can't remember the exact numbers anymore, but I think you would have needed something like 25 teraflops or something like that, or more, to be able to do Lord of the Rings. Gollum real-time, for example.

And so in terms of game consoles getting there, we're still not there. Is that important? How important is that to the overall game play? It has to be fun. The AI has to not suck. The physics has to not suck. And you can't really extract one piece out and say, that's what defines a game. But for, in terms of the visuals, what the GPU delivers as its core part, I think there is a long way to go before you get to that end game, where you can really look at something and get over the "uncanny valley," and really believe that you're seeing something you'd take a picture of.

Holmdahl: Photorealism is important, but things like the story are always important. The game play, the ability to play with your friends is important. And I think that we not only unlocked some of the graphical world with what we did in the gaming console space, but we were able to create this great live experience where you can play with your friends. We had arguably the best storytellers through the developer story that we were able to create. All these things, there's never a single variable. They're always multi-variable. And you always have to try to piece it together in the most efficient and optimal way.

Spicer: And then, although when you go to conferences and they're showing off a new console--whether it's Microsoft or Sony or anyone -- the graphics, the realism is always what is shown. I guess it's too difficult.

Baker: It's not just what they do, they do physics demos as well. That is an important part of a game. And increasingly the demos are getting more into AI as well. So if you look at some of the papers, a lot of the papers, if you get to SIGGRAPH, is about… it's a path finding, if you have a crowd of monsters, how can you make them look like each one is an individual entity and not just multiple stamps of the same few objects following a set pattern? But how do they interact with each other? How do they interact with the world? How do they avoid bumping into each other? How can you set them in the task to go and fetch something from the other end of the room, and not have to have a program layout absolutely every single step of that? How much is it going to take?

Holmdahl: I think it is super important to watch out for other things happening. If you remember back when we launched Xbox 360, we thought it was going to be a graphics war between us and the PlayStation. And we did all of our analysis, our war gaming on what is Sony going to do. And then Nintendo came out with this motion controller device, really just took the whole industry by storm. So where you see where all the graphical stuff that you're talking about is super important, but again they're just other variables that can be equally, if not more important. And you have to make sure that you factor all those things into the overall equation.

Spicer: What was the most successful game for Xbox and 360? Were there launch titles that were particularly important to early sales?

Holmdahl: Halo with Xbox for sure. Both Xbox and Xbox 360. Yeah.

Spicer: Is that Halo 2?

Penello: Yeah, Halo 1 and Halo 2 on the original Xbox. And then Halo 3 on Xbox 360.

Spicer: Just as an aside, by the way, on the Kinect, is the vision for the Kinect [that]a lot of people resist gaming because of the controller and the learning curve that it takes to become good at it? Is the Kinect's purpose to do away with the controller and open up a whole new group of users that can use games?

Holmdahl: Yeah we looked at our Kinect about as an opportunity for us to make gaming more approachable, not just gaming [but] to any computing device that you have. And when we were developing it, we talked about a couple things. The only experience you need is life experience in order to be able to get into these things. Because it was tracking your body and what you've learned in the real world could be applicable to what was happening in the gaming space. And the other thing that we said was, you are the controller. You didn't have to jump in and learn all these different button combinations. And I do think that has helped with computing devices and game consoles. It has made it more approachable. That said, there is a huge business and a lot of interest in gaming around game controllers. And there are a lot of people that love the ability to be able to control those buttons and hold that in their hand, and be able to have people do magical things.

Baker: I think it's worth having the right controller for each experience, so I'll even resort to having a universal remote control infrared sending commands to the Xbox 360, when I'm just watching some of the media applications. So it really, really depends.

Penello: You could do a whole other thread on Kinect. That, in and of itself, that whole project was sort of lightning in a bottle. I think Todd's absolutely right. There were a lot of things happening both in the industry and with the thought process behind Kinect that really made it sort of a fascinating program. And it wasn't any one thing. It was the combination of, yes we, absolutely saw that there was a class of gamers, who either through dexterity, just getting not as good at manipulating the controller, or just general approachability. We saw an interest in getting kids more physical. That was also part of it. There was also just a sense of you have a fixed number of buttons on a controller. And believe me, as a hardcore gamer there's nothing greater than learning the skill and mastering that.

But after a while, you want to pick up a light saber and you want to swing it around and pretend you're a Jedi and use The Force. And so there was like these three, I think, major things happening creatively inside that made Kinect so interesting. The super approachable, it got people up off of the couch and got them active, and then it allowed for these new game types. Just things you can do with your body that are really interesting. And we use the term 'magical,' but trust me, the first time we saw some of those demos where you're waving your hand or you go like this, and a light saber lights up, you're like, this is amazing.

And when I think back about Kinect in the future -- I don't know if I'm just looking at it from our point of view -- but when I think about all the innovations in vision, in voice, in natural user interface that are happening right now, Kinect, the success of Kinect, was, I believe, the genesis of all the work that's going on in that space right now. Because it was the first time you saw a massively successful consumer product that was all natural interaction, voice, identity, using your body, knowing your skeleton. And that has just spiraled into all the other types of new activities you see today. So I think Kinect had… it was a great story. It was a really interesting time. But I think people will look back on it and realize it was the first real successful product that spawned a lot of thinking in computing. It's happening right now.

Baker: I think just, not just even going and picking up a light saber, but even when you do have a primarily controller-based title, you are being able to use visual cues from the body. So you want to duck underneath something or behind. Or, I even remember watching a lot of my members of my family first time they tried playing a 3D game, the tendency was to start moving around the television. Right? And so if you, before Kinect you couldn't change the visual cues or the fact that you're moving around the television, try to get a different angle, it doesn't do anything. But, so those are all like just enhancements that you couldn't do when you have another input that is based on more physical characteristics.

Spicer: Do you have any… I'm sure you've noticed that Kinects are extremely popular in the research community… in computer science research.

Baker: Robotics.

Spicer: And robotics and prosthetics and just all sorts of... Do you have any favorite non-gaming applications you can think of or interesting experiments that people have done?

Baker: I've seen the Kinect mounted on a quadcopter.

Penello: Yeah, there is a huge community. It's funny. I was paying a lot closer attention to it probably in the early days. That was probably an interesting, unintended consequence. And we had to catch up with the ability to be a commercial product and allow people to program for it. And we started the Kinect for Windows program probably a year or so after we launched. In retrospect, it would've been nice to foster that a little earlier.

Holmdahl: I think some of my favorite, there are a certain category of people that don't have fine motor skills. For whatever reason, they can't really use the controller and Kinect would allow them to be able to play these games like the Kinect sports adventures and things like that, or the Dance Central where large motor skills were great. And the whole gaming experience is a fun, immersive experience, and to see people who previously weren't able to be part of that was, yeah, one of the reasons why you get into this space.

Baker: Being able to map your world, as well, so not just as a motion controller for a console or for Windows but to be able to walk around your room potentially and build up a 3D image of that. I thought that was one of the more interesting uses that I saw.

Spicer: We spoke about this, Nick, you and I, a bit offline, but can you tell us just for the record what the architectural difference between a PC and a console is? And their lifetimes and how that affects your design choices?

Baker: If you look underneath the hood of a 360 you can find very similar components to what you can on a PC. Sometimes we actually use the same terminology, technology as well, so in essence we are taking the best from what we can find on the, from the PC technology and applying it to a console. The real difference is in terms of where do you want to spend your effort?

On say, the power / performance trade-off, cost, and particularly designing it for a console lifetime. Also some of the partitioning and some of the custom technologies we use. The big bet on the 360, for example, was going with multi-core, probably one of the first consumer electronics with high end multi-core CPU. Multi-core PCs weren't common then either. Then unify that with a powerful graphics subsystem.

So that was the big choice, as whether to go, really keep pushing that single-thread performance on a single CPU versus taking the bet that developers would spend the time to program multiple CPU cores and multiple hardware threads. We actually present six logical CPUs to the programmer on the Xbox 360. And going from a model where most likely they are developing on a single CPU core, and writing everything serialized, saying you now have to do it parallelized was a big, it was probably one of the biggest bets we took on the 360.

Spicer: How did you move people into paralleling, you know, writing more parallel programs? And did you provide specific development tools?

Baker: A lot of it up front was just talking about what can you keep doing at the same time. And talking about what can you do on the multiple threads. Giving specific examples to developers, say like I'm going to run my AI on one thread. I'm going to run my physics on another thread. I'm going to run my rendering submissions on another thread. And so we do have a group of programmers in Microsoft Advanced Technologies Group, as being part of Xbox from the outset. And they were really the front line in terms of how to develop as educated on the new system. Would you add anything else?

Holmdahl: No, I think it was slow. It took a while. A lot of the first games were single-threaded games or just a couple threads. And it wasn't until the developer team got out to the community more and more, and people also wanted to start making their games look more advanced, did we start to see adoption in

these additional threads. It's, I think anytime you make a change from one paradigm to another, it takes time. But when people see the power of it, and they realize, I have all these additional transistors that I can use to do cool things, they want to jump in.

Spicer: Because this problem of multi-cores and multi-processor systems says -- Dave Patterson called it the single biggest problem in computer science today -- how do you program for these things? And I guess if you have five or six threads it's one thing. So you get into the dozens or 20, 30, 50 threads, it's like in a supercomputer perhaps, so more difficult. But I'm interested in how you brought these game developers along. Did they have to basically acquire the skills on their own or did you provide some guidance?

Holmdahl: I think it was a combination of things. Some of them are super smart and they figure it out on their own. You tend to see that there is a, like in any field, there are certain people who are more advanced than the others. And the more advanced game developers, they would latch onto it with little help from us. It took us awhile, too, to also get our tools up to speed to be able to take advantage of all of these different cores and threads.

So we were working just a few steps ahead of all the game developers. And so there are, you can look, the first games use a smaller number of threads, maybe one or two of launch games have multiple threads. And by the time you hit six or seven years in a life cycle, it was commonplace to be able to use all the threads, and get as much processing power as possible out of the design. But, yeah, to your question, it started slowly. Some people just took off right away, and then others, once the tools evolved, they were more easily able to take advantage of it.

Baker: There's a middleware component as well. So certain developers and companies will do, say a piece of the equation, so pick physics, for example. And so they may come up with an optimized physics library that can run on, run parallelized. And also you get the game engine, like a real engine which is licensed to multiple games, and so once you have one certain set of people figuring something out, then that can enable a whole bunch of other companies and developers to leverage off of that, as well.

Spicer: Now this was quite a bold decision in the year that you made it, to go to a multi-core architecture, was it not?

Baker: Yeah, like I said, it was. If you looked at what was happening with the PC at the time, Prescott was probably the big thing that was shipping. If you look, at and I remember seeing projections as to where CPUs would be in 2006, 2007. They were pushing six, seven gigahertz. And we all know that that didn't happen. And so everybody took a step backwards. AMD, Intel, major step back. Produced clock frequency significantly went to a different design point, and it all became about multi-cores.

Spicer: Right, which are now used everywhere.

Baker: Yeah, yeah.

Spicer: Can you tell us a bit about the underlying control program behind Xbox? It's a version of NT, I think. Or, is that right?

Baker: Derived off of . . . Xbox 360, I know for sure was derived off of earlier versions. It was power PCs. We had to reach back into NT to get the early kernel from that, but it's a . . . We try to keep where possible, the API layers, but after that, it's there's only one GPU, so you don't need a driver model. So everything gets combined essentially into the graphics library, talks directly to the hardware. But you keep the familiar programming, API calls where possible, but rewrite everything else, just to take advantage of the system.

Spicer: Great. I didn't know that Xbox came from DirectX.

Holmdahl: That is my, my belief, my understanding. There were actually four gentlemen -- and I think this is all well documented -- that started the program before I started in the summer of '99. Seamus [Blackley] and Kevin [Bachus] and Ted [Hasse] and Otto [Berkes]. I think the code name was Xbox, right?

Penello: Yeah. DirectX box.

Holmdahl: DirectX box and it was like, take the power of DirectX and put it into a console.

Spicer: Amazing. So this one is, I guess, more towards Todd and Nick, but tell us about managing or planning for the supply chain. Or Albert, whatever you think.

Penello: Definitely these guys. I plan for the demand chain.

Spicer: I'm imagining the supply chain for the global release of a multi-unit consumer electronics product...

Holmdahl: It's hard. And when you start to look at, hey you have, you guys have two years or three years or whatever the time frame is to build this thing. And it seems like a long time, when, in fact, the time to actually build and test and design is a lot smaller. The lead times on a lot of these components are four months, if not longer in some cases.

And when you're doing what we did in the 360 and Xbox original when you're doing pieces of silicon that you're customizing for the design, those have several, two months in every spin, or at least, in order to get the chips back. So you have to, this is what's interesting, working in a software world, we have to lock things down two, two and a half years, three years ahead of time, in order to get the design that you want at launch.

So we would, it's not necessarily the way the software world works, but we would lock our designs down early on. We'd have to work with our partners, like either Nvidia or ATI, and IBM and get them to lock their CPU and GPUs down. And the best thing that we could do, in order to make sure that we hit Christmas or a holiday season, and we always launch on holiday, and it never changes, as you know.

And Nick does a really good job of this. It's just test and verify and simulate these designs so that you can reduce the number of spins that you have on silicon. So we would do that. I think we did a pretty good job of that. And then you have the 999 other components to deal with in a design. And you have to have a big team of people. We have developed a pretty good supply chain over the years that watches the handful of custom components that we do, as well as all the commodity components to make sure that they come together. And sometimes you just run out of time. The 360, I think, was more the US launch, wasn't it?

Penello: We were trying to do global, but we ended up, yeah.

Holmdahl: The US launch, and we just ran out of time. And we could only deliver a certain number of units at that time. But you got to think early and often about what you want to do. Make sure you limit the number of mistakes as you go through that iteration process. Then, have a team of people that's just tracking everything as you go towards the launch window and the launch cycle.

Baker: I mean, it's not for . . . by the side of the design. It's not so much the supply chain. It's the amount of time it actually takes to get from architecture drawings to getting silicon in the lab. And then, getting that to having it be stable and characterized and validated. And then, actually start mass-producing that so that you can get to a launch. Any-- I'm sure any silicon company has to deal with the same timeline. And I've heard before and can easily see how that's true, that from a CPU design you're talking potentially like seven years from initial investigation to actually getting that out into the market. So it's a very long, very long timeline and three years of that I probably spend on actually silicon designs, pre-silicon verification bring-up in lab, going through characterizing the silicon. You just say, we're going to ship in 2005. Work backwards from that and you're pretty much starting January, 2002, which is when we did.

Penello: The other thing, I think, was interesting that I recall is that the original Xbox was the first game console that really looked like a PC. And it was really using PC components and the PC market is used to having the ability to sort of manage supply chain through flexibility. If I run out of this memory, if I run out of this hard drive size, if I'm running out of this processor, I just sell a slightly different configuration with

the components that are available. For us, we're going to need that same exact memory or pretty close variance of it for the next 10 years. I'm going to need this exact hard drive specification for millions of units for this time frame. I'm going to need this exact same component over and over again, which became an interesting supply chain challenge as you move to more PC components. How do I ensure regular delivery of these components consistently that probably are going to outlast their PC counterparts?

Baker: Another point that I try to make that differentiates us from a traditional PC component is that, whereas most of the industry applies Moore's Law into performance and features, we're really taking Moore's Law and on the console generation applying that into cost. So we fix the feature set and the performance and we launch. And after that, we're trying to ride down Moore's Law and make it as cheap as possible.

Spicer: And to Albert's point, was it difficult convincing vendors to produce the same part for seven years, for example, which is probably much longer than their, those things are maybe not at the leading edge anymore, and by the time seven years have gone by, they might want to produce something else? Or were you such a good customer that they kept their lines open?

Holmdahl: On some of the components it was harder. For example, the memory gets outdated pretty quickly, but on other components, the silicon work that we were doing around the CPU, and the GPU or the optical disk drive, it was easier. We were good customers, we were going to be partners with them in the future. And they wanted to maintain that partnership. But the only place I saw us having problems was with things like the memory because we would just outstrip it after three or four years.

Penello: On hard drives we just changed direction. That was the other thing is that hard drive capacities would increase. And on the original Xbox, we tried to keep the same size hard drive through the end of the life cycle, and realized that was a real challenge. On 360, you saw us catch the cost and the size wave. Because it would just be easier for the customer and easier for the supply chain to move to the next, most common hard drive size. And we would leverage those throughout the years to add more value with the box for customers.

Spicer: So the more recently made an Xbox 360, the larger hard drive it would have to have. Tell us about the decision to put in half a gigabyte of RAM, which I've heard was the most fateful decision of the entire program. That's one person's opinion… versus 256 [gigabytes of RAM].

Holmdahl: You know, we are measured often on the cost, obviously. At the time, an additional 256 megabytes of memory would have been a lot of memory. We did some war gaming. I remember this was at a hotel in Bellevue. We were looking at the images with 256 and versus, and with 512. And you could see enough of a difference that people felt it was warranted to spend the additional money. I can't even

remember what the additional money was. But looking back it was the right decision because memory later in life is super cheap. It may be $10 when you launch, but by the time you get down six or seven years, that cost delta gets a lot smaller. And you look at what game developers could do and did do with that additional memory. I think it was well worth it.

Baker: I think memory is probably the easiest thing to provide to a game developer to have them a, speed up that development, or just have richer and richer worlds, richer textures. It's a very easy ROI [Return On Investment], from that perspective.

Spicer: This source I have claimed it was a $900 million dollar decision over the life of the program, that it added to the costs. I don't know if…

Baker: There are a lot of $900 million decisions.

Holmdahl: Yes. Whenever you have, we sold 100 million, close to 100 million. Any $10 decision is up there.

Spicer: Wow. OK, this one I don't know if you can answer, but I'm going to put it out there. Is it true that console makers lose money in the first few years and then recover that as the cost curve, as they go down the cost curve?

Holmdahl: It depends on how you design your console, obviously. I know that there are some console makers that are out there that never lose money. I would argue that Nintendo likely, I don't know this for sure, but I would argue that they likely never lose money at the start. And there are others of us who look at it and sometimes you can't control all the costs, but you know that the customer is only going to pay a certain price.

And you're kind of fixed at what the customer's going to pay and what the competition is going to do, and so you have to put the product out there at that price in order to compete and to compete well. And then the engineering team has to work really hard along with the marketing team to drive costs out, as quickly as you can. And in addition, to make your marketing materials and your packaging materials as least costly as possible.

And you get the products so that you're profitable. You should also know, too, that the business is… it's a multi-faceted profitability business. Most people don't make a ton of money on the hardware. They look to make the money on the razor blade, so to speak. And that's in the games. And we made it, we did make money in hardware at times but we made a lot of money on our games, both first and third party. And we also made money off of our live subscription service.

Baker: You know, the hardware is the enabler, like Todd says, for getting scale on the software, on the software side. That said, you don't want to intentionally build yourself too much of a hole on the hardware, because then it actually becomes hard to sell additional units. Because on a per-unit basis, you're losing money. So you try to stay away from that as much as possible. Certainly in the early years or so, the new generation, when the volumes are still relatively few, you can maybe take a bet, but you want to get out of that space as quickly as possible. So when you're hitting the peak years, you are really trying to sell the hardware at a neutral or even a profit at that point.

Spicer: How about the industrial design of the 360, anything you learned from the original Xbox that you applied to 360?

Holmdahl: Yeah, I mean, the 360 was [where] we learned a bunch from the original. On the original one, we were coming at it from a standpoint of powerful. We talked about this in the past, that we wanted a super powerful box, that we were taking the power of your PC and putting it in your living room. And you would have all of that in a console. We were big and bold and the black coloring on it. And I think it did what we intended it to do. And people, gamers, responded to it. The 360 ID [Industrial Design] was more of an "inhale," like get in the position to show all the power that we could unleash.

Not only was it a really powerful gaming console. You look at that particular box compared to what was happening in the PC space, we were much more powerful. We had all of that, but that was just kind of [the] tip of the iceberg. We were unleashing this, built from the ground up, live service, and arguably that's the best online service that's out there. We were unleashing the -- Albert talked about this ability to get your media to be able to do more interesting things than just play games -- and I think, I actually think we did a really good job of that. It was planful and we learned from the Xbox original. And then we were able to apply some augmented thinking on top of the foundation that we had already built.

Spicer: Were you getting any feedback from the initial Xbox experience in Japan that the Xbox was very large for the average Japanese home?

Holmdahl: Albert travels all the time.

Spicer: Or the controllers were too large?

Penello: Look at Todd's hands.

Holmdahl: They would say the controller was designed for somebody with my hand size. We learned quickly. We came up with a, by the time we launched in February, we launched a smaller design and that continued to be the main controller throughout the life of that product.

Spicer: And then how about the Japanese games available on Xbox? Were they, I know this is a very competitive area. How did Microsoft do?

Penello: I think that was one of the longer plays. And we have a third party group whose job it is to go out and build relationships, both business relationships and technical relationships with our third parties. I think there's a cultural difference. There is a sales phenomenon difference. So obviously even though the games business is global, just human nature is to make business decisions based on what you see locally. So for North America, for Europe where we were, [we] had modest and increasing success getting those developers online. Because they could see that you could walk into a retail shop, you'd see TV advertisements. You'd see success. Your kids or your friends' kids would be playing it, and so you felt there was a movement towards Xbox. And in Japan, we've struggled there, both from the standpoint of getting the original content, and then getting the third party publishers. And so it just took more time to establish those relationships, that trust. The Japanese games industry, a lot of the people that run those companies have been in the games business together since Nintendo in the early '80s. And so you have to establish trust and a business relationship over time. You have to demonstrate success. And I think that team did a fantastic job of building those relationships and educating the Japanese publishers about the global business of games. And then our investment in first-party studios doing local content shows a commitment, as well. So it was probably one of the longer and more thoughtful types of business relationships we had to build. A lot of great content has come from those partnerships. And today we have fantastic relationships with the Japanese developers.

Spicer: OK, can you tell us a bit more about that, but with respect to EA, and how important it was to get… I think at E3 in 2004, they announced they would do 15 new titles for Xbox, and that was a huge success for Microsoft undoubtedly, to have that. They were going to put 1,000 programmers on [Xbox titles] for the next 10 years or something.

Penello: So I actually came to Microsoft from Electronic Arts. So I was working at EA prior. And I wasn't central to that deal at all. It was more just a circumstance of it [being] a small group. And I'd had a working relationship with a lot of people there and still do. They're very similar companies. They're very similar types of people. I mean, I think they're good competitive people who want to do good content and be successful.

I always used to say that when you have two people that are similar, you're either going to get along famously, or you're going to argue. And I think in the beginning, this is my opinion of observing the people I'd work with was, a lot of similarities led to some early maybe discussions that were harder. And then over time, you start to realize that you're actually out for the same thing. And I think we built a great relationship with them over time.

But just like everybody else, there's trust and… is Microsoft in this business long term? EA's got one business. It's video games. It's all they've done. It's what they're-- they were founded on. And so they

wanted to make sure before they go take the opportunity cost of developing on any platform that they believe that we're going to be in it. I would say that's true of everybody, by the way, in the games industry not just EA.

Baker: I've got to say, though, the number of times I get asked when I meet some developer is, is Microsoft in it? How are we still investing? And how do we see-- how do we see gaming. It's fascinating that always, always comes up. The answer's always, yes. Absolutely. Number one.

Spicer: And is their enthusiasm tied-- or their desire more tied more to software titles than games, your support on the games or on the hardware platform side? Do your-- do they question the commitment on which side?

Baker: On, I think, on the product platform.

Spicer: OK.

Baker: Yeah.

Spicer: I think we're getting there. Just-- do you know what time it is? See how we're doing here.

Penello: It is--

Holmdahl: 11:15.

Penello: 11:15.

Spicer: OK. Great. OK. There are two different SKUs for the 360, right? One with the hard drive and one without. Can you tell us a bit about the decision? I think it's maybe a marketing decision more but whatever. Whoever would like to address that. Why did you go ahead and do that?

Holmdahl: The-- it was a good discussion. The situation, the hard drive is one of the most expensive parts of the design. And you look at the price of consoles and. You look at the ability to sell lots of consoles. You want to get below $200. And we wanted to be able to get below that magical price at the right point in time. It's a big decision, though, because it basically says, your games are going to be developed for the lowest common denominator.

And so then, you have to figure out, OK, what does this mean to the game development. And we felt, at the time with the tools that we had, that we could still develop great games without having to have the hard drive there. And I think we showed that. You look at what people can do with having the optical disk drive and be able to stream games off it. You just get wonderful experiences.

And going back, it had never been done before to have this multiple SKU strategy going back. I think that was one of the success stories of the 360 to be able to do that and separate that. And it's turned out to be a way for us to increase the market size and get to scale quickly.

Baker: I think something that helped along the line as well was when we actually started building flash into the consoles. So before you always had to have your MU. If you didn't have a hard drive, you wanted to save anything or have your profile, it'd have to be on the MU. And I think for me, at home anyway, the big difference was when we started building the flash into the console. So just to those little things, you didn't have to reach out for an MU.

Spicer: Now, Nick, you're not only the architect, but you had to bring up 360 on the production...

Baker: Long time in the lab and in production.

Spicer: And on the shop floor?

Baker: Yep.

Spicer: Manufacturing floor?

Baker: Yep.

Spicer: Can you us a bit about how long it took and what kind of problems you came up with and what it was like to work probably very long days?

Baker: Yeah. Well, so when we first-- so silicon comes in, staggered. So when you're looking at trying to orchestrate four pieces coming together, the schedules don't line up perfectly. But you try to ensure that the moment you do have one piece that you're able to use that as much as possible. And so… you some of the length that we went through, for example, is that the CPU which was being developed by IBM wasn't going to be available for two or three months until after we had the GPU come in.

So there was a lot of discussion as to, how can we start bringing up the GPU without having our eventual CPU there. And IBM came up with a strategy of actually developing a dummy CPU. So we took the bus interface that the real three-headed monster [i.e. the real CPU] was going to have and take an essentially off-the-shelf PowerPC part from IBM and bolt on a bus interface adapter. So we… it talked to the GPU. And so for first few months, we were actually able to start bringing up the kernel and writing code.

So it's-- when you're trying to meet that-- the ship date of the console, it never moves. You have such a large industry lining up behind that date. Everybody's making bets on beginning to develop titles for that. And you-- just postponing just isn't an option. So you're really trying to, as Todd said earlier, upfront verification. So both on the Xbox 360 and Xbox One, Microsoft invested in hardware emulation technology.

So you can go downstairs in our labs here at Mountain View. And you have these large boxes that are running the almost the full system -- you can't get the whole system in emulation at any one time. There's too many transistors. But you could say, you have all three of the CPU cores and part of the GPU or the whole GPU and one of CPU cores. And you're really trying to run as many cycles before you tape out. I think on the 360, we were trying to get to somewhere in the order of six to eight billion cycles emulated.

And you really can't do that when you're talking about simulation. So you really have to invest in those tools to get that extra confidence. And the goal was to ensure that when silicon comes back, you have a functioning computer. So at least know that you can talk to memory. You can boot the operating system. If there's an occasional graphics bug somewhere, well maybe we can figure out how to handle that down the road.

But [there is] a lot of upfront investment in terms of ensuring silicon is correct. And then, you go into the lab. And you're trying to get it up and running as quickly as possible. And then, if you look at the scale of the-- I think Todd actually probably spent more time on the factory floor than I did. But just the-- there was my first time seeing a production line come up. And I never really understood that before you can start manufacturing a product, you actually have to start manufacturing the test equipment. So I walked into this floor where there was just a sea of test equipment. And I was like, wow, this is a different scale.

Holmdahl: Yeah. The-- Nick and team did a really good job on the silicon work. And Xbox original, the hard part was the DVD drive. On Xbox 360, the hard part was the test equipment, the manufacturing test equipment, specifically. We had 900 pieces of the test equipment that had to get put together, starting in August and had to get done in the end of September.

So at that time, everybody became a test engineer. And probably had Albert going over there, too, in China on the test floor, putting it all together and getting it up and running. And ultimately, we were able to

get it up and running. But it was 24/7 work to make that happen. And the team really came together to pull that off.

Spicer: What kind of these 900 pieces of test equipment-- what was that? A special tester for the--

Holmdahl: Yeah. That's the way they do-- you have to-- it's an assembly line. And you look at the-- when everything is soldered on the circuit board, you look at everything that's soldered on the circuit board. And you have your "bed of nails" that comes down and tests it. And you put everything together. And then you have another thing that clamps around and plugs in to all of the different input and outputs. And takes a look and make sure that you assembled it right.

Then, you do some additional more fine-tuning on the product. And you just have these racks and racks of boxes, what we call Xstress. And you just stick an Ethernet cable in there. And you… [it] runs through the code in order to make sure that you're exercising the whole box. And that can take hours in order to do all that work. And then, you have a final test. You just want one last look at it.

You have a bunch of auditing test equipment that you run for auditing. You have test equipment that is special for either functional type chambers where you're putting it at extreme heat or cold or humidity. And you want to make sure you have that up close to the assembly lines. So there's a number of different pieces. And then, you just have to multiply it by the number of lines that you have.

Spicer: Are these one-time tests that you're doing just as you bring the factory up?

Holmdahl: No.

Spicer: Or is it on every unit?

Holmdahl: No. Every unit built gets tested.

Spicer: Wow. So every unit. It might take five minutes to assemble by robot but hours to test on the computer.

Holmdahl: I don't think it's five minutes. But it's definitely hours to test.

Spicer: Yeah. Interesting. And you are working with Flextronics, I think?

Holmdahl: We were working with Flex[tronics] and Wistron, I think, at that time.

Baker: Yeah. Wistron.

Holmdahl: We had two different factories that we were bringing up. And so in addition to the number of pieces of test equipment, you have to manage that across two suppliers. Each supplier had a different infrastructure. So you had to ensure that you're able to accommodate both infrastructures.

Spicer: Tell us about the launch, Albert. And-- the 360 launch. And I understand that you, Microsoft rented 90 jumbo jets to airfreight… get them in stores.

Penello: The launch of 360 was a multi-headed sort of operation. And it's almost like any campaign. Where was I? What beach was I taking in when the launch of that campaign [happened]? You had-- just to correct what we had said before. The original Xbox was [a] US-only launch and launched in Europe after the first, in March. And for Xbox 360, we were trying to launch globally. We had just less units. So we had launched in, I think, I want to say eight or 10 territories on 360.

So not only did you have a global launch, which we hadn't done before, you had fans. So the original Xbox was about a lot more on the ground trial. We did the midnight thing on the original Xbox in New York and LA. We were trying to get people to come experience the product. 360… the anticipation was so high. We had-- we were air freighting in units around the world, the units that we had. We were out in the desert with 1,500 fans doing an all night marathon gaming session.

It was-- we had the rolling trucks that we're going out and touring prior to launch. It was a rock star experience, I think, for a lot of us on the team. Very exhausting but super rewarding because we had built such great credibility with the original Xbox. And 360 was like if the original Xbox was Star Wars, this was The Empire Strikes Back. Right now, everybody's in line, waiting. We got the word of mouth on the first one. This one, there was a lot of anticipation. So there was a lot of things going on in that launch period.

Spicer: Tell us about the little Burning Man Festival-- well, not little but, your Microsoft's own version of Burning Man in the desert with your 50--

[INTERPOSING VOICES].

Penello: Yeah. I think it was Ground Zero was what we--

Holmdahl: Were you there?

Penello: Yeah. I was there.

Holmdahl: I wasn't there.

Penello: Yeah. I mean, I think the idea was you just had all of these fans and obviously getting that ex-- getting all of the content and the state that it was in. All the consoles around to everybody was complex. And then, you can't really have a curated experience. You can't get-- at that time J Allard and Peter Moore we're very front and center. So it was just not only logistically easier to get everybody in one place, but it became kind of a-- yeah, like a Woodstock or a Burning Man for gaming.

And people were there. They were safe. They could stay up. And we played. People played games for 24 hours straight. And it was like a carnival or festival. It was a great-- I know a few of us actually got in an RV, had some early 360s with wireless networking LAN set up in an RV playing games on the drive down, ourselves. We know lots of people that did that. So it was a really amazing experience.

Spicer: That's great. And how we're the sales of 360? How did that roll out the first couple years?

Penello: I wish we had had more. That was probably-- we were definitely supply-constrained for the first year, easily. And we were selling them as fast as we could make them. Air freighting for quite awhile if I recall.

Holmdahl: Yeah. We-- Yeah. We sold everything that we could make for almost a year.

Spicer: Did that have implications for you in the market with your competitors?

Penello: Well, we were ahead of the PlayStation at launch. So it wasn't quite a concern because we were sort of first to market. But being first market has its pros and its cons. But no, I wouldn't have really consider it to be implications in the market. I think you wish you could have sold more. But scarcity also increases the energy around the launch.

Holmdahl: Desirability.

Penello: The desirability as well. I wouldn't have wanted to manufacture-- you don't want to manufacture scarcity. You don't want to hold things back because then customers lose trust. But when it happens organically, it's great. When we're producing it as fast as we can make them and they're selling out, that's not a bad position to be in either.

Spicer: Right. Can any of you discuss the 3-30-300 plan? Or do you even know what that is?

Holmdahl: I know what it is. The—J [Allard] and-- I think J and Robbie [Bach] were the creators of this or proponents, if not creators. But it was a simple way to really get the team rallied. That… Robbie Bach, being the leader, was in charge of the three-pager describing the vision, what we wanted to do in the marketplace. How we were going to have a strategy. What we were going to do… [what] were the different pieces of our strategy. He did a really good job of writing that and communicating that.

Then, J was the overall engineering lead, platform architect bringing together the software, and the hardware and the live experiences that we had. So he was responsible for the 30 pages. And he would work with the team on-- With J, everything that should be 30 ends up being a little longer if you know J. But he ended up with a document that described in more detail what we were going to deliver and put more specifics behind the three pages that Robbie had developed.

And then the 300 was the rest of the team coming together and putting all the technical specs. And of course, it ended up being more than 300 [pages]. But it was really a good way to talk about the planning of the program and getting the team set up. And to this day, you hear people talking about it.

Spicer: Let's move onto the Xbox One. And just a couple of questions about it because it's a new product. And we don't actually consider things history until they're 10-years-old here at the Museum. But tell us about the marketing goals and the differences between 360 and One.

Penello: Well, I had moved over onto the planning for Xbox One. So I guess I can kind of speak to it. But it was another iteration of learning and our desire to expand on what had been successful and learn and grow that area. And so Xbox is a gaming brand. And it's always been gaming first. And if you think about, the original Xbox was about establishing credibility. Xbox 360 was about sort of winning in gaming and starting to bring in the other parts of Microsoft.

And I think what we had learned is that probably the world changed more since we launched the 360 then I can think of in any time. And I'm sure it's always-- there's always a time in history when there was a huge step change. But so much has changed from 2005 or 2002 and '03 when these guys were developing the Box to today in terms of computing power, performance in your hand, multi-function Boxes, the consumer's ability to have one device that does more than one thing.

It was-- in fact, if you actually even go back and look at some of the early criticisms of Apple, they were reflecting a very similar idea that, why would I want a Swiss Army knife computing device. I want a phone, and I want a laptop, and I want this. But customers chase change and how they were consuming computing devices. All kinds of new things, like TV and videos, there was no streaming video. There was no HD video. HDMI wasn't even out. There was no smartphones. I mean, so much has changed.

And one of the great things about the Xbox 360 is, it was powerful enough to adapt to those changes. The Box that we're shipping today almost 100% looks nothing like the Box we shipped in 2005. The operating system's different. The functionality's different. The way people use it is different. And so we were able to take those learnings with Xbox One and say, wow. If we could go back and had known all of the things that was going to be different, what were some of the challenges that we faced in that development, from an operating system perspective, from an architectural perspective, and from a customer perspective.

What are they actually, really, doing on gaming? So where 360 was about being around you, Xbox One was the one device that does everything in your home.

Baker: And I think those from early on it became obvious that the whole concept of about being able to multitask was going to be an important aspect. If you-- not that I endorse this kind of usage. But you certainly look at kids and everybody today. It's everything's up on the screen at once. They're switching between windows so very rapidly. And on the 360, you're playing a game. And you want to go out and check your Facebook feed or something like that, that's a very huge context switch … you have to exit the game.

And you have to launch back into the game at the end. So from the outset, one of the design goals was to be able to allow that seamless, alt-tab we started calling it at the start. I'm not sure that's the right marketing terminology now. But really that concept of quickly being able to switch between tasks.

And if you look at a game console that is designed to provide a stable platform to a developer and not necessarily have all these other intrusions coming in, taking resources away in an unpredictable way, we had to-- a lot of the hardware and operating system decisions were actually influenced by that very simple, very simple concept, trying to take the ability to multitask at the user interface level and take that into, what does that really mean for the operating system and the hardware. It was actually a lot that we had to plan for to be able to enable that.

Spicer: Anything else you'd like to say about Xbox One or Xbox in general? This is where you get to make statements for the ages.

Holmdahl:. Well, I think that Xbox One, one of the things that we have found out is that this is a marathon. These console life cycles last a long time. And I think we really set up a good foundation with the Xbox One product allowing us to be able to work in the cloud and allow us to have all sorts of natural user interfaces and to be able to interact with the computing device. To continue to live off of the foundation that we developed with Kinect and the 360 and the Xbox.

With respect to the future, I will say that-- and I'm sure a lot of product developers say this in their time but-- --we're at really interesting inflection time. And it's exciting to be in this space. There's all sorts of stuff going on with sensors that are out there. And you saw a bunch of that with what we did with Kinect. And being able to take sensors and create virtual skeletons. And there's a lot going on in machine learning. You're starting to see the rise of AI.

And Kinect is a perfect example of that. We were able to actually use machine learning to be able to determine the probability that a depth pixel was your arm versus your leg versus your head. It was only the combination of the sensors and machine learning that we could make that happen.

Then, the third thing is services are really predominant. Everybody has compute in the cloud. They have storage in the cloud. And as you go forward, I think you're going to see that those three things- the sensors, the machine learning, the services, coupled to the continual drive of silicon to do more and more things at lower and lower power. You're going to get a whole set of experiences that are going to make a good story 10 years from now.

Spicer: Albert, anything you'd like to say?

Penello: Yeah. I think, for me, if I'm thinking about the history of Xbox, the thing that I'm always reminded about is, the people are the most important part. I think so many people think and so many entrants have come and gone that if I just bolt some pieces together and build it and ship some games, I'm going to have a game platform. And it doesn't work that way. I mean, when I think about the fact that you've got people at this table who have been there since the beginning, who have gone from a very small organization to a huge organization, three console transitions, unbelievable changes in the computing landscape and customer landscape.

Competitors have come and gone. But it really takes special people to not only have the passion to maintain the thread of the brand throughout all three generations, but also not so caught up in how things used to be that they can't look forward into the future. I mean that's just an unbelievable skill that it takes, I think, great people to be able build the types of products. I mean, the fact, we all still love it. And we've been doing it for, just this product, for now 12, 14 years, and we're still innovating, we're still-- we're never looking back and just trying to do [what] we did before. We're always trying to innovate across the line. It really is the people, I think, that have made the product super successful.

Spicer: Nick?

Baker: Yeah. I think in terms of the investments we've made into the architecture on the platform. I think as Todd said, there's a lot that you have only started-- haven't even started scraping the surface on. And you couple that with the power of the cloud. I think that has got some very interesting years ahead.

Spicer: And when do you start beginning your new, your next console?

Baker: Well, that's funny because you always-- we're always thinking about what's next. On the architecture side, we're always-- our heavy lifting, so to say, was done many years ago, even on the Xbox One. And so has a tendency for an architect say, OK. What's the next big thing? And so that's always in our minds.

Spicer: Right. Well, I'd like to thank you all very much for coming today. Albert Penello and Todd Holmdahl and Nick Baker of the Xbox team at Microsoft. This was a great interview. Thanks so much.

Baker: Thank you.

Holmdahl: Thank you.

Penello: Yep. Thank you.

END OF INTERVIEW