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New Catalysts for Change

THE NEW SOFTWARE DEFINED SUPPLY CHAIN: RETHINKING THE FUTURE OF PRODUCT DESIGN AND MANUFACTURING

Global Premiere of IBM Study

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Moderator:

Paul Brody, Global Industry Leader in Electronics, IBM

Panellists:

Hubertus von Grunberg, Chairman of the Board, ABB

Leonid Reyman, Chairman of Board of Directors, Angstrem

P. Brody:

What we are going to talk about today is truly a brand new analysis that no company and no organization has ever done before at this level of research into this new technology. I am going to share with you some really exciting conclusions. I hope you are excited. I am.

It is not possible to talk about manufacturing without talking about Henry Ford. If there is one thing that Henry Ford believed in, it was not customer service. Henry Ford is probably most famous for saying, “You can have any colour of car you want, as long as it is black.” But he was onto something. It was not about customer service. It was about standardization. The Model T was the first car to use interchangeable parts. It was the first car to be produced on a moving assembly line. It was the first car that went from being a product that was produced in hundreds or thousands, to something that was produced in its millions. In 1908, Henry Ford moved the Model T from fixed assembly to a moving production line. By 1914, what had taken 14 hours at the beginning was now down to just 90 minutes, to produce a whole Model T. As you can see, they were growing manufacturing at incredible rates.

Standardization was just one of three fundamental principles that guide product design and manufacturing. Standardization was the first. On top of standardization came modularization. As companies learned how to standardize products, they also started to think about how to modularize them. Modularization provided an increased level of flexibility. Standardization provided scale and low cost for a part. When you put a part into a modular subassembly, it costs even less to assemble the final product. The logical conclusion of this whole process is that we have products like the Boeing 787s, which may have millions of parts but they are snapped together from, what amounts to, less than a dozen modules.

Standardization and modularization were the foundation. More recently, we entered the era of digitization. At IBM, we love to talk about digitization. We love to talk about the smarter planet. But the truth is, in manufacturing digitization is mostly used for simplification. We take mechanically complex systems and we make them simpler, using electronics. If we think about the temperature sensor in your oven, the timer in your toaster, the fly-by-wire system on an airplane – all of these things took what was mechanically complex and made them electronically simple. That drove down cost and simplified the supply chain management proposition. When you add all of this up, what we ended up with was a very complex global supply chain.

Standardization gave us economies of scale. Three fundamental elements. We got economies of scale from standard parts. We learned from assembly that we should have subassembly partners, serving multiple companies. That gave us complexity. Now you were getting parts from one organization, were sending them over to an assembler for modularization and then, if you were doing manufacturing, you were going to search globally for a low-cost location. This resulted in big, complex and global supply chains. We have had a century of that.

Every single one of you has a mobile phone in your pocket, a cellphone, I am sure. The odds are that there are six little words on the back of that phone: “Designed in California, assembled in China.” This is the ultimate conclusion of a century of supply chain management. Sophisticated product is created in California; the design goes all the way to China where parts from all over the world converge. It is put together in volumes of millions and then shipped to destinations all over the world. It would have blown Henry Ford’s mind. Most importantly, not only is this a feat of engineering of supply chain management, you can also get it in two colours – black and white. That is progress.

These three rules of supply chain management – standardization, modularization and digitization – we are now going to throw them away because they are under transformation from three new technological revolutions. And that is what I really want to talk about today. These three technological revolutions are driven by emerging technologies including 3D Printing, Intelligent Robotics and Open Source Electronics. I will discuss each one of these individually.

First, let me tell you about 3D Printing. This is easily the most important of the technological revolutions that we are looking at. 3D Printing is amazing because it is just like two-dimensional printing. You design something online and then press ‘Print’. Just like for two-dimensional printing, you can put out a thousand pages that all have the same words on them, or you can put out a thousand pages that all have different words on them. It does not matter. There are no economies of scale. In this case, that is a good thing. We can forget everything we have learned about having standardized parts because we can now make a thousand parts that are different or a thousand parts that are the same, both at the same cost. This applies to everything, from shoes to hearing aids to aerospace parts.

Already, 3D Printing is inexpensive enough for consumers to afford it. What we found, after a significant amount of research, was that it is going to get much cheaper over the next ten years. Over the next five years, it is going to be 79% cheaper. In ten years from now, it is going to be 92% cheaper. This means that it is going to be not just a consumer curiosity, but an earthshaking manufacturing revolution. So that is, first and foremost, 3D Printing.

Secondly, Intelligent Robotics. Robotics is the technology that never fails to disappoint. We always thought that at this point of history, either robots would be working for us and doing amazing things for us, or we would all be working for them – one of those two. However, the reality is, while we were writing great science fiction about robots, actual robots were becoming much more productive. The early industrial robots cost millions of dollars, but the next generation of industrial robots started at much more reasonable prices. They cost around USD 250,000 to design and install. And that is just the beginning.

Today, we have the newest generations of robots, ‘intelligent robots’. They cost 90% less than the same robots that were available just three or four years ago. Not only are they much less expensive, they are also quick and easy to install. You can have them working in one day, and they can work on the assembly line next to people. They do not need to be cased away in any special environment. The first generation of robots we thought of as very sophisticated automation. The second generation we realized were flexible and could be redesigned and redeployed. But this third generation is truly intelligent. All of this effort that we have made to create a global supply chain, running around the world looking for low cost labour, we may not need nearly as much of that in the future. The first revolution was 3D Printing. The second one is Intelligent Robotics.

The third one is Open Source Electronics. We are used to talking about open source software. Every phone that we have, almost every product that we use today – if it is on the Web or on a mobile phone or a tablet – uses open source software. Yet, we have not thought much about Open Source Hardware. But it is coming. The reason it is coming is because of the way control systems are designed and managed, which has now been completely transformed by Moore's law. Originally, when we made a control system for a product, we used something called: embedded electronics. For all of us who are not electronics geeks, an embedded chip is basically a hardwire chip. It is not very smart. It is designed to be cheap and simple. If you have an embedded chip in your toaster, it knows timing. It does not know anything else. General purpose computers – the kind we have on our desk or in our pocket – those are really smart. They can be redesigned and reprogrammed very easily. It has got to the point where the room-sized computer of 1978, that fitted on your desk in 1989, now fits in your pocket. And for about USD 10, you can put it on anything. We can put an entire personal computer on a toothbrush, or on a doorknob. We can make every device intelligent. Because these things have been standardized, we can start to write open source software for them and develop multiple platforms. That is exactly what is happening.

Consumers and businesses are starting to create open source hardware platforms. They are starting to share physical product designs online. Just to give you one example, we looked at one website called *Thingiverse* (www.thingiverse.com). It is a website for sharing product designs. Four years ago, on average, people were sharing 20 to 30 designs every month. Today, they are sharing on the order of 30,000 new product designs every single month. This is the kind of exponential curve that we are used to seeing and thinking about when we talk about software or social networking. The only difference is that it is all about hardware. That is the third revolution, Open Source Electronics.

Each one of these things is quite substantial by itself. However, fact is, they are actually working in harmony with each other. What is going on is that we are in an era of transition, from an era defined by manual labour and physical strength to one that is defined by software. Take, for example, the making of a physical part today. We build a mould or a cast, which takes time. It can take weeks and they can be large or small in actual physical size. In the future, after you have designed the part, you print it. Today, if we want to have a hardwire production line, it takes weeks or months to set up a manufacturing environment. In the future, if we want to reconfigure our whole assembly line, we can do it online. Today, if we spend weeks or months developing a customized embedded chip, in the future it will only take a standard platform and writing a little bit of new software for it. All of these fundamental rules, about how to do things and how to make them, that we learned for a century, are going away. This new environment is something that we call a Software-Defined Supply Chain. It is exciting.

In this era, of the software-defined supply chain, if you are a smart, rational, level-headed business person – and I assume that all of you are – you should be asking a simple question. When is this going to happen? To be honest, when somebody from any kind of technology company gets up on stage and starts telling you about some incredible, amazing technological revolution that is coming, you should be sceptical because if every technological prediction had come true then we would have all come here on our own jetpacks. But we did not. In addition to the question of when, other questions that we should absolutely be asking are: if this is true, where should we put all our manufacturing facilities? Which companies will be most affected? What kind of strategies can we pursue in order to take advantage of these changes? And, ultimately, why is this really so important? We spent a year trying to answer those questions and the results are amazing.

If you are a rational, level-headed, reasonable person, the first thing you want to know is: how did we do our research? We did three things. First of all, we wanted to be very specific. Instead of talking about 3D Printing and Robotics in the aggregate, we decided to take four products that are completely different in cost, volume, complexity and personalization, and look at each individual product by itself. We analysed a hearing aid, a mobile phone, an industrial display that tells you that your session has been rescheduled or your flight is late, and a washing machine. From the small and incredibly personal, all the way up to a large mechanical device. I do not know if anybody will ever need a personalized washing machine, but it might be possible now. We literally bought these. And by the way, I had the most wonderful conversation in my entire life with IBM Procurement, trying to explain why I would like to buy a washing machine so I can destroy it. I eventually got the answer I wanted. They let us tear apart these machines and analyse each part in each piece of assembly.

The second thing we did was to assemble a global team of experts. It may shock you to you hear this but not every single one of these experts is employed at IBM, but we got some. We had the IBM Research team, of course. We also have a special team at IBM called Plant Location International. What they do is advise companies on the best places to put factories, based on labour cost, tax rates and infrastructure. We wanted to make sure that, when we thought about the whole supply chain design, we were actually using the most appropriate questions and the right data. In addition to that, we received help from an organization called Sourcemap, a spin-off company out of MIT. They focus on identifying product sources in global supply chains. We also received help from organization in United Kingdom, a spin-off out of the University of Nottingham. They are the world's top experts on 3D Printing. They take parts, analyse them and estimate their cost, both now and in the future, using 3D Printing.

We took all of that data and gave it to two of the world's top experts in linear programming and supply chain modelling from Northwestern University and Pennsylvania State University, with the instructions to create a real-time model that we can put all these data in and to then tell us what the optimal supply chain would be for each product, how we should go about finding and setting up the right supply chain for our products. We also wanted to know where should we put our products and whether they would cost more, or less, using 3D Printing and Robotics and Open Source Hardware than they do today.

Now we are getting to the exciting part – we are going to tell you the big results of our study. The first amazing result was production cost. It was our most fervent hope that the cost of making things with the software-defined supply chain would be cheaper than the cost of making them in a traditional supply chain. The answer was in the affirmative. It was cheaper. In fact, the answer was a 23% decrease in cost.

We looked at four points for each and every one of these products. First, the product's cost of production today, the current cost of making the items. Secondly, we asked ourselves what the cost of that product would be today if we manufactured it using the software-defined supply chain. What would the cost be in five years' time? What would it be in ten years' time? The answer was that already today, it was cheaper to make products like a hearing aid using a software-defined supply chain. Five years from now, every single product that we analysed will be significantly cheaper to make. In ten years from now – no contest. It absolutely will be cheaper to use these new technologies.

However, if you go away from this discussion today thinking that it is all about cost, you have missed the point. Cost is a secondary factor. It is necessary but no one will adopt these technologies if the cost of upgrading to these technologies are higher than the savings they will produce in product manufacturing. It is the scale which is the real amazing result. Today, if you need a manufacturing facility, you have to have a certain level of scale in order to be cost competitive. These new technologies do away with many of the traditional requirements for achieving high volumes of economies of scale in order to be cost competitive. So much so that by the year 2017 you will require about 75% less scale. By 2022, less than ten years from now, it will be about 90%. In other words, if you needed to manufacture a million units a year today to turn a profit, you will only need a hundred thousand units in the future. Or, in the case of hearing aids, it is 98% less volume. The business model that supported one or two companies in the market today, might in the future support ten, twenty or thirty new competitors.

How does this all add up? If you recall, when I started the conversation, we were talking about big, complex and global supply chains. We worry a lot about things like ‘green footprint’ or ‘carbon footprint’. Looking at a product from that angle, when you purchase your phone or your washing machine, it already has significant frequent flyer miles. It has a significant carbon footprint. We believed that 3D Printing and Advanced Robotics would always be cheaper in terms of green, in terms of carbon footprint, because we were replacing inventory and physical facilities with information. That was wrong. It turns out that in some cases, especially in the larger products, you can actually end up consuming more energy in a 3D printed, robot-assembled world than you do today. Now, do we think of this as a show stopper? Absolutely not. What it does do, however, is it reminds us that we cannot assume just because it seems less wasteful, that it necessarily is less wasteful in every aspect.

Let us add all these pieces together. What does the world look like in the era of the software-defined supply chain? It is coming very quickly. We started talking about big, complex and global. We believe we are headed towards something entirely different – small, simple and local. I would like to take, very specifically, the example of a hearing aid, because this is already the best one in terms of cost and efficiency. We will show you what happens in the optimal supply chain.

Today, it is already a little bit cheaper to make a hearing aid from a digital model. Within ten years, it will be dramatically cheaper – 65%. However, the impact of scale means that, today, when we talk about the optimal supply chain, it is about one or two locations in a market the size of the United States. Within ten years, though, instead of being national, it goes to regional. Eventually, the optimal supply is one that is almost entirely local. Every town and city would have their own manufacturing facility for hearing aids. That is the most extreme example. Yet the pattern is the same for every single product that we looked at. That means that we are going to have industrial disruption in every single major manufacturing industry.

I have talked about the good news, that there is so much opportunity here. The fact is, though, most industry leaders are not prepared for this new era. We went out and talked to fifty of the world's top supply chain executives, at the world's leading manufacturing companies. Seventy percent of them said that they were somewhat aware, or had no awareness at all, of how these new technologies would drive their systems. When we asked them what their plans are for the next ten years, in terms of activity and development, it gets even worse. It turns out they are planning more of the same things that we already know are kind of obsolete – more standardization and more modularization. There is a great management philosopher, named Dilbert, who can explain this result. He said, "Change is good. You go first." That is exactly what we see – a lot of discomfort around change.

As part of our discussion, we prepared some recommendations on how to think about the world. The first set of recommendations is for industry leaders; we are also going to talk about recommendations for public policy makers. One of the starting points is thinking about personalization. We are going to end up in an era where not everything is standardized anymore. If we do not have any requirement to make some things standardized, people will want to have them customized. We are also going to have to think about a competitive environment. Today, we might have one or two companies in the industry. In the future, the same business might have ten, or twenty.

Lastly, we have to think about how we are investing in supply chains. In a business that requires 90% less scale, how do we choose to deploy our capital? Many of these businesses will be much less capital-intensive than they are today. If you are building a big factory right now, with the previous generation of technology, it may never produce a great return on investment. From a capital planning perspective alone, you have to take these new technologies into account. Our recommendations tell you exactly what to expect.

First of all, change how you design and manufacture products. Secondly, prepare for this new landscape. You will not be competing against the same companies. Lastly, build your supply chain for flexibility. There is a similar set of recommendations that apply to policymakers, but they are somewhat different in that respect. Policymakers are going to face interesting challenges. First and foremost – competitive advantage. If your country is hoping to build its process of industrialization based on low-cost labour, this strategy might not be viable anymore. The other thing, that we are going to see as a big challenge, is intellectual property rights. We have had moderate success in controlling music and movies online, but once you can define an entire product online, you will be able to send a new pair of shoes to your friends as easily as you can send a new piece of music. We are used to defining our tax and operational metrospace on sending physical products. But if we do not have physical products to track, how will we do any of those things?

Recommendations for policymakers are, first and foremost, new sources of competitive advantage. We believe that you will be driven around entrepreneurship. Secondly, new thinking about intellectual property management. And when I say 'new thinking', I do not mean repeating what has gone on in other industries. Lastly, let us think about taxing value add instead of physical trade, because we are going to find physical trade disappear quite quickly. Those are the key conclusions in our recommendations.

Before we go any further, what I would like to do is have a thoughtful discussion about this. It may shock you, but consultants do not know everything. We have invited two of the world's top experts in manufacturing and technology for a panel discussion, I would like to welcome them to join me now. Dr. Hubertus von Grünberg, Independent and Non-Executive Chairman of the Board of ABB Ltd. Welcome. And Dr. Leonid Reyman, Chairman of the Board of Directors of Angstrem. Welcome. Thank you for joining us today.

I have some questions prepared for both of you. Before we get started, I would like to ask each one of you to give your initial reactions on what I have spoken about. If I may start with you, Dr. von Grünberg. And if I may, before we go ahead, I would just like to extend a sincere thank you. ABB is one of the world's leading makers of robots and ABB was instrumental in helping IBM with some our research and our analysis. This is therefore an excellent time for you to tell me how we got it all wrong.

Dr. H. von Grünberg:

Thank you, Mr. Brody. First of all, I must be a little cautious. I have a huge business to protect. We have USD 40 billion in annual sales and 150,000 employees. Every day, they sell the product for today's world – robots for today's assembly lines, and make automation equipment for today's factories. If I am too overwhelmingly positive in supporting you, Mr. Brody, I offend many of my customers, and we want to still be alive when this, if this, finally happens. So I have to be cautious.

Before I get started, may propose a question? Why are you so generous and so friendly and get me to sit on a panel to discuss a vision of the future that still includes the need for robots? Why would you not – if you can – simply print any one part of a washer or any one part of an automobile? The assumption being that if you can be competitive on washers, then you should also be able to be competitive on automobiles. While automobiles are a different size and a different weight, they are not fundamentally different, they are still machines. Why would you assume there is still a place for a robot? Why would you not 3D print all the pieces in the right sequence coming from the printer already in place and eliminate the robot industry all together? Why are you so nice to us? Why do we not appear in your vision? Why are you still accepting us?

P. Brody:

I have to say, this is the most unexpected thing. I have never been on a panel posing a question only to get one back. First of all, I should say, I was not successful in convincing IBM Procurement to buy me a car to take apart. That is one reason I did not comment on the automobile industry. The second thing, though, was that we realized, when we 3D print and manufacture products, they still have to be assembled. We were very mindful to evaluate the limit of some of these technologies. Parts are individually printed, but they still require assembly. When we created our model, we knew that if there was no robotic assembly, 3D print and manufacture would not be quite as transformational. We looked at that very carefully and came to the conclusion that there was no way to go forward without a significant element of robotic assembly.

Dr. H. von Grünberg:

You requested some initial remarks from me about this entire situation. ABB is a diversified company, but the issue in question today is the robotics area of ABB. You received some input from ABB. We have been responsive and appreciate the cooperation. There is a lot of learning for us, which keeps us on our toes. We will be ready by the time the market is, I promise you. We are always looking out and we will not be the last to make these changes.

In the past, when you wanted to robotize an assembly line to take labour out, as the standard of living increased, you had to wait for a new generation of products to come along because ‘robotizing’ an existing double-belted, typical automotive assembly line was difficult to do, from a hardware point of view, or for mobile devices. You had to wait for the next product generation and then design a new, totally robotic assembly line for that product from the outset. You could not simply take the labour off and put the robot in on the existing product and its manufacturing process.

The robot was also dangerous. It had to be kept in cages, like a wild animal, because it had the potential to physically harm humans. The new robots are no longer in cages. They are small; they are light; they are fast. The plastics – in spite of the metal – may make the engineer in you wonder how the precision of final location can be achieved, with the flexibility of plastics. Through smartness. They sense position; we have the motor calibrating the vibrations of the softer and lighter plastics. These light, two-armed robots –visual and tactile – are not in a cage and are not dangerous to humans. They have sensors that detect an approaching human. They have redundant proximity sensation that does not let them get too close to a human, minimizing the risk of physically hurting a human. They replace existing manual labour jobs. This new generation is on the verge of coming to market. So a lot has been going on in our industry, on our side, as well. We are a little farther from your vision though. I have different customers for my hardware than IBM has for their software. Thank you.

P. Brody:

Thank you very much, Dr. von Grünberg. By the way, your question about 'When?' is very relevant. We are not only going to talk about this model we created. One of the things that we are going to do is to release the entire model as an open source application, with all of the data. Your folks, and anybody who wants to, will be able to download this model, do their own analysis, change the assumptions, and see how it looks. Thank you for your comments, Dr. von Grünberg.

Before I pose any specific questions, let me turn to Dr. Leonid Reyman. You are obviously extremely knowledgeable about communications and advanced technology here in Russia, as well as globally. I would love to get your reactions.

L. Reyman:

I represent a company which deals with the production of microelectronics, the production of chips. It was very interesting for me to hear from Mr. Brody because the processes described in the IBM report are very relevant to the production of microelectronics.

In recent times, we have witnessed rapid growth in the production of Field-Programmable Gate Array (FPGA) chips compared with chips with pre-set parameters. They are used everywhere, from washing machines to toasters.

Drawing conclusions from 2012, the company Polilife conducted an analysis and came to the conclusion that the number of new designs of PLD chips created before 2012 was nine times higher than the number of new designs of application-specific integrated circuit chips (ASIC). This once again confirms the theory that we are now experiencing a third industrial revolution. Not long ago, *The Economist* published a front-page article about how the world was experiencing an industrial revolution. This revolution is defined by the fact that people are prepared to pay more for faster access to the market, for more flexible approaches. For example, those same PLD chips sometimes lose out to the ASIC chips in terms of their commercial and price parameters; nevertheless, they enjoy a high level of demand on the market. This is practical confirmation of those conclusions which Mr. Brody so interestingly formulated today.

P. Brody:

Allow me to ask one follow-up question to you, if I may. We talked a lot about the wide use of microelectronics and making even the smallest products very intelligent. How do you think that would present new opportunities for small- and medium-sized fast-growth companies in Russia?

L. Reyman:

Today, chips with open code are more expensive from the use perspective, from the perspective of their commercial attributes (I am thinking of energy efficiency and speed) than chips which have specific functions and are programmed for a specific product. Nevertheless, they are much more attractive because the release of chips such as ASIC requires a design to be created, which sometimes takes more than a year, and production processes to be rearranged. It may even require a production line to be built for that particular chip. In this time, the project requiring the use of this kind of chip will have fallen behind on the market. This is why flexible chips with open code are preferred today.

Despite the fact that in our country, there are many creative people who would be delighted to innovate, to develop chips, we still do not have a well-developed microelectronics industry and in this case, Angstrem, which I represent, is one of the exceptions.

Universal chips, which can be used for various purposes and various devices, will be the most in demand. Their use will encourage small and medium-sized enterprises to develop very interesting solutions, devices, and end products which, I hope, will be in demand not only here, but throughout the world.

P. Brody:

I agree. I hope that the price will create opportunities for new companies in Russia. Now, Dr. von Grünberg, may I ask you one question. You mentioned at the beginning of your talk that ABB is a large and diversified company. Robotics, of course, is one part of the total picture of ABB. How do you picture using these elements, of both Intelligent Robotics and 3D Printing, in other parts of ABB's business to stay competitive?

Dr. H. von Grünberg:

If it happens and fast enough, it would open a totally new business. I would like to suggest just one potential business. With the flexibility of individual, one-piece manufacture, there would then be a whole new meaning to computer simulation models. While making a million identical cars and washers, there would be recourse to the classical prototyping and testing, after some superficial simulation, which does not have to be totally accurate. You could build the 10 prototypes, and physically test them in the lab, because you know that if those 10 prototypes produced exactly to the specification drawings, if they are perfect, then the next one thousand will likely also be perfect because they are identical by design.

With this technology then, you want to be able to make a one-of-a-kind product. This one-of-a-kind product may have a behaviour that is different from its sister-product, to accommodate an especially demanding customer who wants a different version. Now, especially if the product is a safety product, or in product liability countries, such the United States where you had better not fail and had better not disappoint a customer, with any change you make you must be sure that this one change will please the customer and will not fail. If you cannot prototype it to this 3D printer and test it in a physical laboratory first, then the entire economy is gone. It needs to be validated by software. That is the long view. What Mr. Brody has demonstrated is that there will be a whole new industry to make this viable. This is the tip of the iceberg; what is under the water is just humongous. It is a different road.

If I may add one follow-up thought. You spoke about new entrepreneurial possibilities for small-sized companies in Russia, based on this model. In Russia, you may consider it to be a fortunate advantage not to have the majority of your economy based on high-volume and on mass-manufacturing. Of course, Russia is an automobile manufacturer, and has white goods. Yet, I would say, without being in any way critical, that China makes more of these. Also, in proportion to Germany's small geographical size, it produces more cars than Russia, which is a big country. In this world, you would not be at all unhappy about that fact. You might think about attributing this to your brilliant software capability in Russia, to leapfrog Germany, France and Italy and go with this generation of product manufacturing right away; illuminating and jumping over the enormous, endless car factories, saying that they are useless because this is what comes after. We do some other intelligent business in between. When it comes to the new world, this world that Mr. Brody described, the Germans and the Americans and the Chinese – endless, devastating rivals. We will not be rivals anymore because we are embarking now on the generation after. Is that a thought, Mr. Brody?

P. Brody:

Not only is it a thought, but I need to come with you, and you need to come with us on tour, to spread this message because you have really thought about this in an amazing way. I could not agree with you more!

When we sat down and really thought about all the implications, you are exactly right. We are in complete agreement. It is not just the physical capability. We will have to simulate everything, and it will change the process of designing products. It will also change even the process of selling them. The customer will have some role in designing his or her own products. We think that the manufacturing world is truly going to change.

Now, in a moment, I am going to open up the floor to questions from the audience. Before I do that, however, I would like to ask Dr. Reyman about communications.

This will give the audience some time to think about brilliant and challenging questions to Dr. von Grünberg and Dr. Reyman.

At IBM, we talk a lot about making a smarter planet, and we think a lot about how the open source electronic environment will not only improve ease of customization and development but how it may start to make products truly, exceptionally 'smart'. When you can put the equivalent of an entire personal computer on a doorknob or a toothbrush, it is going to make that product smart. And these 'smartproducts' are going to be networked, connected by a network. What kind of an impact do you think billions and billions of smartproducts will have on national communications infrastructure, among other things?

L. Reyman:

I would like to comment on what Mr. von Grünberg said. He touched upon a very interesting topic. It is true that for Russia, the development of new approaches, the development of the three most important key principles that Mr. Brody was talking about, including 3D printing and 3D technologies, is highly significant.

Not long ago, at a forum in Moscow, an interesting fact was demonstrated: a chip produced according to 65-nanometre technological standards using 3D technology is equivalent to a chip produced according to 32-nanometre technological standards without the use of 3D technology. Meanwhile, a production line of 32-nanometre chips is many times more expensive than a production line of 65-nanometre chips. This means that the use of innovative technology on a not very complex and not very expensive production line allows us to produce chips which are in no way inferior to the latest technologies. We will be able to use this kind of product in equipment that is produced by small and medium-sized enterprises.

I will return to the question of connectedness. This is a very interesting topic that began with the idea of the cloud and is an inherent element of the cloud. Today we are constantly in collaboration with each other. It is difficult to imagine someone without a mobile phone. Mobile phones are also equipped with a system for determining their location. Your friends, and also your enemies, can know where your telephone is. This raises a whole series of questions about privacy, but on the other hand, it offers people a huge number of opportunities to save time and improve their lives.

Today I walked by the Sberbank stand. They have some rather interesting software: they set up an application on your phone, which allows you to see the whole infrastructure of Sberbank around you. You can see where the cash machines are, the deposit machines, branches; you can see the schedules of these branches, you can see which of them are closed for technical reasons, which cash machine has run out of money, which one still has plenty. This means you are constantly kept up-to-date. Everything around you, starting from the telephone, the washing machine, the Volvo car which tells you how much petrol it has left, and the toothbrush which tells you when you need to throw it away and buy a new one – all of these things update the situation around you and make your life entirely different.

P. Brody:

You have described the dream of every electronics company – to have a product that sells its replacement. An electronics product that convinces its user to 'throw me out now' and 'here is the new one of me that you need'. This is actually the dream of all of my clients – to have products that literally sell themselves. With that, I would like to open the floor to questions.

H. von Grünberg:

I will give all the difficult and nasty ones to Paul. I am a little shy and timid.

P. Brody:

I have had special media training on how not to answer difficult questions.

From the floor:

When you were talking about how effective production will become, the prognoses for telephones and for hearing aids were extremely different for some reason. Why?

Surely they are similar? What is so particular in the technology that one does well in the figures and the other slightly worse?

P. Brody:

We wanted to be very specific. When we set about this analysis, we knew that some things would be ready for 3D Printing and robotic assembly sooner than others. That is why we picked specific products. The hearing aid was first on the list, but by the end of the time span that we looked at, every single product – even a washing machine – was cheaper and more efficient to produce in its new environment. Does that answer your question? No? We need to do it right.

L. Reyman:

I will add my own personal viewpoint on this situation to the question you have asked. It seems to me that the more innovative a device, the less this percentage changes. That is, the telephone today is a relatively innovative device; it is equipped not only with modern technology, but also modern principles of design, assembly etcetera. This is precisely the reason why that column is so high. Whereas a hearing aid is relatively simple; there is a huge amount of room for optimization, for innovation, etcetera.

From the floor:

That seems paradoxical. Does that mean that a square-faced shovel should only be made digitally?

L. Reyman:

Of course, every genius idea is simple.

From the floor:

But why digitize it? It is already simple to make.

P. Brody:

That it is a possibility. One of our observations is that for products that have changed very quickly, and if it is very dependent on cutting-edge technology, it might be harder to simulate. However, we also expect that the products have value added by personalization. A hearing aid, for example, made exactly for your ear is much more valuable than one that is not. Obviously, it is the same with things like shoes, or other items that have to fit the human body. I have to admit, I do not know how I would personalize a washing machine but I am confident that somebody will figure out a way to personalize a washing machine and charge a premium for it.

Do we have other questions from the audience? If not, then what I would like to do is bring our discussion to a close. Before I do that, however, I would like to tell you that the information that we handed out today – on your chair – is a copy of our executive summary. We are going to issue a full report, with all the data in it. You will be able to download the entire electronic supply chain model and analyse it for yourself, when we publish it in July. Simply visit our website, or leave us your business card and we will send it to you at the time of publication. You can take one of my business cards when you leave the room, from myself or my colleagues. I would also, in conclusion, like to thank Dr. Reyman and Dr. von Grünberg very much for their amazing participation and for sharing their expertise. Thank you. Finally, I would like to thank all of you for attending here today. Thank you very much.