**((5. Kapitel))**

**What does the future hold?**

**Ten perspectives on future challenges and opportunities**

**A unique bridge between research and industry**

With a population of eight million – just 1,000th of the world’s population – the Swiss economy has been booming for years. This success comes in the context of a globalized world that has become complex and highly competitive. The key factor in this economic success has been our strong will to continue carving out new paths into the future together, and take on the changes and challenges it brings.

The main pillars of our economic performance are the many SMEs and large companies whose highly trained, dedicated employees are always willing to try new things and turn innovations into successful products. The challenges faced by SMEs in particular are huge; they are having to assert themselves in a global environment that is demanding in both market and monetary terms. Our structure is defined by SMEs, and more than ever before, it needs a strong bridge between academic research and industrial implementation.

In Switzerland, that bridge comes in the unique and outstanding form of Empa. It is a national research institute within the ETH Domain with sites in Dübendorf, St. Gallen and Thun that has earned the trust of industry clients, the academic community, the political world and society alike, and also enjoys an excellent reputation abroad. Empa always aims to stay one step ahead. It identifies new trends and helps to shape them, while remaining open to industry requirements. Empa is an indispensable Swiss research institute with specialized expertise in the fields of materials, technologies and digital networking. It is always breaking new ground, overcoming barriers and reinventing itself. It is a research institute that serves our economy, and is able to recognize and leverage opportunities and possibilities at an early stage.

We all rely on innovations that enable us to implement new products and services – in order for Switzerland to survive in the global market, to improve our prosperity and quality of life while keeping our environment intact, but also in order to help increase the quality of life of people around the world.

I would like to thank Empa and its employees for the dedication they bring to working at the interface of research and the market. We will continue to need Empa to drive innovation forward, in keeping with its identity as ‘the place where innovation starts’.

**Johann Schneider-Ammann, former Federal Councilor and head of the Federal Department of Economic Affairs, Education and Research**

**Scientific expertise and trust are the building blocks of a successful future**

*The future needs the past* is the title of a book by the German philosopher Odo Marquard. There’s no doubt that a 140-year-old institution has a rich past – as is clear from my mention of Empa as one of the six institutions in the ETH Domain. Hardly anyone has not heard of Empa, although the reaction is often, ‘Oh, really? Empa’s part of that, too?’

The general population is familiar with Empa’s past, and the institute enjoys great renown in addition to recognition from industry and business – in particular SMEs. This is an important building block for a successful future. A second building block is the quality of its research and the interdisciplinarity of Empa as a research institute for materials science and technology. Empa covers areas such as nanostructured materials and surfaces, environmental, energy and building technologies, and medical and biotechnologies, all of which are both essential and sensitive areas for industry, individuals and our society – and will remain so in the future.

When it comes to the successful future of Empa and its fundamental contribution to the prosperity of Swiss industry and society – which, in turn, contributes to the welfare of the country as a whole – a smart combination of these two buildings blocks is required. There is no doubt that Empa has high scientific standards and renowned research skills. Autonomy and intellectual freedom foster new ideas and products, especially in conjunction with free, spontaneous collaborations with companies and other institutions. This enables Empa to stay one step ahead and give our industry the leading edge. It also allows it to develop new ideas and products that might initially be met with skepticism by some, or by society as a whole.

This is where the second building block comes in: Empa’s past. It engenders trust and gives Empa the necessary credibility as a bearer of fresh, unusual and complex new ideas. Alongside its unquestionable scientific and technological prowess, Empa’s role as a trustworthy bringer of technological advancement that may meet with skepticism – because it is labelled as unusual and risky – should remain a hallmark of the organization in the future. Many institutions can learn about science and technology, but respecting and maintaining the implicit trust of the general public is one of the key challenges that Empa will increasingly have to face.

In addition to making important breakthroughs in science, research and development that promote the welfare of society and business, I hope Empa is able to successfully handle the huge trust that has been placed in it by the Swiss people.

**Dr Fritz Schiesser, president of the ETH Board (2008–2019)**

**The opportunities offered by medical technology and smart textiles**

When asked about their greatest desires, health is at the top of the list for people in Switzerland. The expectations placed on healthcare service providers are correspondingly high. We can’t predict the future. But it often announces itself in advance. Healthcare costs have been rising steadily for years. We are in urgent need of medical innovations to ensure we can continue to meet the population’s demands for better health in future while keeping prices reasonable. Empa researchers are called on to continue making innovative contributions in the areas of prevention and early diagnosis, establish more efficient treatments and increase the implementation of intelligent technologies.

Combining biological knowledge with technological knowledge at an early stage will be a key factor in Empa’s success, as will access to high-quality clinical and pre-clinical trials. Empa is already working closely with the Kantonsspital St.Gallen to achieve this. Their collaboration spans a broad range of areas. An innovative treatment for life-threatening blood poisoning is just one example of the discoveries made through the partnership between researchers at Empa and the physicians at Kantonsspital St.Gallen over the last four years. As a former doctor at the hospital, I have been following the partnership closely. I also consider the collaboration between Empa and the University of St. Gallen in the field of personalized medicine and body function monitoring a very important endeavor. Digitalization in the medical field has inspired high hopes of more efficient and increasingly high-quality medicine in many circles.

Smart textiles have not yet met with such widespread acceptance. Their development is highly complex and requires collaboration between very different members of the value creation chain with research partners from a variety of disciplines. The right combination of new technology platforms (such as technology for integrating sensors into textile structures, including durable integration technology and energy management) and traditional technologies and methods will result in innovative products. The large number of textiles specialists hired by multinational companies like Logitech, Google, Apple, Microsoft and Samsung is an indication of the significance of the smart textiles field. With Empa and the local industry presence, eastern Switzerland is ideally placed to take on a leading role in this pioneering, highly profitable market segment. Let’s seize this opportunity! On that note, I would like to congratulate Empa on its 140th anniversary.

**Cantonal Councilor Bruno Damann, head of the Department of Economic Affairs of the canton of St. Gallen**

**Making space for inspiration – enabling ideas**

Innovation is the key to our prosperity. Innovation creates new products and services, promotes competitiveness and optimizes processes. Only an innovative country can provide its population with prosperity and a high standard of living. Switzerland is a pioneer of innovation on the international stage. This is first and foremost thanks to its strong educational and research landscape. This success is neither God-given nor set in stone, however; it is based on strategic decisions taken at past junctures. The effects of most educational decisions on a political level are only felt after a few years have passed. Our future prosperity thus depends directly on the decisions we make today.

As a small country, it is especially important that Switzerland benefit from foreign knowledge capital. This means our research institutions need to be open and have good international networks. Universities and research institutions are best placed to achieve this when they are given the greatest possible degree of autonomy. They need to be able to define their own specializations and become involved in independent collaborations. Openness and freedom are what allow ideas to take shape.

Furthermore, Switzerland needs to make sure it remains a country that is open to technology and continues to be an attractive business location. The broad scope of this includes, among other things, an advantageous tax system, provision of modern infrastructure, protection of intellectual property rights and limited regulations. It is equally important that Switzerland remain international: our borders need to be open to the best specialists and researchers, as well as to innovative products and services.

For 140 years, Empa has been a beacon of Swiss research and innovation and has played a significant role in our country’s success. In 2018 alone, Empa released over 700 scientific publications and registered 14 patents. In the same year, it also supported 94 start-ups and spin-offs which employ a total of around 800 people. This innovative momentum is driven in particular by the more than 350 multi-year projects that are currently underway between Empa and Swiss companies, many of them SMEs. These kinds of projects are an important factor in Switzerland’s innovative capabilities. I am convinced that Empa will continue to contribute to Switzerland’s prosperity in future, and I hope it retains its innovative drive!

**Monika Rühl, Chairwoman of the Executive Board of economiesuisse**

**Power-to-gas: the first step towards a new key technology?**

Empa’s reorientation as an organization with an increased focus on research activities has earned it a central place in the Swiss scientific landscape. Its traditional proximity to business has made it a forerunner in terms of practical implementation, in particular when it comes to the development of new technologies. This makes Empa a truly unique player in the local research community. As a potential driver of innovation, in particular in the field of energy, Empa has the opportunity to address urgent global challenges, not only with Swiss businesses but as part of an international network.

As a result of the shift towards renewable energy, a whole branch of industry in the energy sector is facing huge technological challenges. Renewable energy sources such as wind, hydropower and solar energy pose the question of how to store energy that is not immediately required. The complexity of decentralized energy systems also requires new networking concepts that increasingly make use of direct current lines.

When it comes to energy supply for urban areas, a paradigm shift is taking place towards an energy supply that calls for current above voltage. This method achieves high energy densities using high currents rather than high voltages. There is a lot of potential for innovation when it comes to the development of new technologies in the field of energy.

With its research on power-to-gas systems, Empa has taken the first step towards a hydrogen-based society in which hydrogen serves not only as a method of energy storage for carbon-neutral systems, but is itself becoming a significant future energy source. This calls for the development of optimal energy storage and distribution solutions. The use of liquid hydrogen at a temperature of -250°C is a natural choice: it is safe to handle at normal pressures, and demonstrates higher storage capacities under high pressure compared to H2 in gas form. The development of an efficient hydrogen infrastructure is also conceivable, using a liquid gas grid of the kind that has been used for industrial purposes for decades. In addition to the transmission of chemical energy, the use of liquid gas as a cooling agent also offers a loss-free transportation option for electrical energy via superconducting cables with hitherto unseen energy densities. By taking advantage of these synergies, an environmentally friendly, reliable, modern energy infrastructure could be achieved featuring compact routing and high gigawatt levels.

Whether it addresses the whole system or just specific areas, striving for a solution to the question of energy and the development of a new key technology is exactly the kind of outstanding work we expect from a research and innovation institution like Empa, and an innovative country like Switzerland.

I hope Empa and its employees maintain their pioneering spirit and I wish them the best of success when it comes to selecting their future projects.

**Dr J. Georg Bednorz, IBM Fellow Emeritus, winner of the Nobel Prize in Physics**

**Swiss? Absolutely!**

Ever since I got to know Empa a little from the inside, I like to tell people at every possible opportunity – appropriate or inappropriate – that Empa embodies the attitude that has made Switzerland so successful.

It embodies the spirit of knowing we are still climbing the mountain; we have not yet reached the summit. Mother nature gave us a breathtaking landscape – but there wasn’t anything very valuable hidden underneath. We had to learn early on to fend for ourselves. The harsh life in the foothills of the Alps made our forefathers hardy, tenacious and smart. They used this intelligence to overcome the poverty and inertia they were born into. They began to build their future: tunnels, bridges, machines. The Gotthard Tunnel is a case in point; it demonstrates how ingenuity and engineering skill can flourish in the face of adversity. The Swiss people embody the principle of homo faber: they are go-getters, pioneers, problem-solvers, developers, and insatiably curious. They are not simply stuffed full of abstract knowledge; they are hungry for better, more intelligent solutions. Switzerland doesn’t live inside its comfort zone – it is a laboratory for a brighter, freer, better future.

For me, this is what Empa is all about.

It’s not about the supremacy of knowledge over raw materials. Empa is more than just a well-oiled knowledge machine. NEST, for example, is not just peddling knowledge; it wants to gain practical intelligence. Plain knowledge is just that: something we already know. NEST wants to gain new knowledge by confronting it with practical implementation on a trial-and-error basis. This calls for people who see the opportunities of tomorrow in the technology of today. People who see the same things everyone sees but come up with ideas that no one else has had. People who don’t get from A to C via B, but take a detour via Q or X. That calls for courage. And courage calls for character. Character is an essential virtue for researchers, inventors and explorers.

These are the kinds of people I meet at Empa.

Unlike at other large-scale research institutes, at Empa, the spirit of engineering reigns. It wants to make people smarter – not just AI.

**Ludwig Hasler, journalist, philosopher and physicist**

**A pioneering spirit working on the solutions of tomorrow**

Empa has a long, impressive history. It has become so much more than the federal institution for the testing of construction materials that started out in 1880 in the basement of what was then the polytechnic – and is now ETH Zurich. Not even the new title of Swiss Federal Laboratories for Materials Science and Technology that was introduced in 1988 truly reflects what Empa does for Switzerland. It is a world-class interdisciplinary research institute.

More than 1,000 highly intelligent researchers carry out their work in Dübendorf, St. Gallen and Thun every day. They are changing our world by triggering important new discoveries, impacting business and society with fresh ideas and bringing new perspectives to our everyday lives. They recognize demands and challenges and tackle them with expertise and a pioneering spirit. As the President of the Cantonal Council, I am proud to have Empa as part of Zurich’s innovation ecosystem. I am also delighted that groundbreaking projects like the NEST building are taking shape here in Zurich.

Empa has achieved a huge amount over the past 140 years. We are facing major changes across all areas of life in the coming years: our world is becoming even more face-paced, even more digital and even more interconnected. At the same time, the pressure of international competition and environmental requirements are increasing. In short, we are facing huge challenges that we can only face by uniting forces. If we want to find solutions to the urgent problems facing industry and society, we need the driving forces in research, politics and private business to work even more closely together.

Empa is already playing a major role in this network through its active support of the development of Zurich’s Innovation Park. This project aims to provide a source of inspiration for the development of the ideas and solutions of tomorrow. Empa is at the forefront of efforts to ensure that this research and innovation center gets off the ground. And its dedication will be worth it: the Innovation Park promotes interdisciplinary collaboration between science and business, meaning that discoveries resulting from basic research can be transformed into marketable projects more quickly. This, in turn, benefits society as a whole.

I would like to thank Empa and all of its employees for their dedication to Swiss innovation. I look forward to the seeing the groundbreaking new discoveries they make in the decades to come.

**Cantonal Councilor Carmen Walker Späh, Director of Economic Affairs of the Canton of Zurich**

**Materials as a challenge and an opportunity**

Materials can mean resources or raw materials. There is a world of meaning behind the term. The ability to manage the available or acquired materials carefully is essential for the success of a country with few raw materials of its own. Processing materials, making them useful and creating value are among the most noble tasks that businesses and politicians undertake. Both create the foundations that allow material processing to contribute to national prosperity. These foundations range from human resources to data resources and cannot be described in a linear way. The interaction between brain and body, between wrought iron and *quantum dots*, and between printed and virtual material, has formed part of the paradigm and reputation of *engineering* throughout the ages.

What has remained unchanged throughout history is what I would call the mystery of the materials themselves. The essence of this mystery is the association of materials with a particular essence. This is something we experience every day. We have no trouble identifying something as ‘wood’. The object feels wooden (in a figurative or literal sense), it (generally) floats and it (generally) burns. The result of the analysis is a combination of individual characteristics that make up a whole. And we’re usually right. It’s a classic mereological approach. If you follow this line of reasoning through, as Hilary Putnam did, the conclusion is that our world is definitively describable in terms of a finite number of parts that come together in different combinations to create the diversity we find, which we identify, for example, as ‘materials’. Are we living in a LEGO world? Yes and no. We live in a LEGO world whose building system we understand more and more, but with which we have been building since the beginning of human history without having understood it. (All other living creatures started building even earlier.) How does this work? We use formulas. Following a strict set of tried-and-tested steps for processing a material always produces the same result. Or rather, a result that is similar enough to ensure the necessary continuity when it comes to building a house, writing a piece of software, creating an antibiotic or baking a cake.

But does this conventional approach tell us anything about the material used – or give us instructions for one we should use in future? The mystery remains: what is ‘similar enough’? How closely do we need to follow the individual steps – this is where the problem of measurement comes in – and is it logical to following them in the exact same order? Does a particularly high resolution help when it comes to testing and measuring? Maybe. Charles Eames created wonderfully functional furniture without any knowledge of – or interest in – the hydrogen bonds in the upholstery of his desk chairs. Clearly, rituals and conventions are enough to ensure quality and functionality, as they did for the early guilds.

The same mystery also opens the door to an entirely new world: the future of ‘new’ materials. One of the properties of a mysterious substance is that it allows for the unexpected – while full transparency does not. Changing a step in the formula, or not being able to measure something about the material you are starting with, often produces an entirely different result – one that is usually disappointing, but is sometimes the first step towards disruption. In our LEGO world, this is hard to achieve without tools. *Right for the wrong reasons*, *serendipity* and all the other attempts at explanation – correctly or incorrectly applied – all point to one of the most challenging and extraordinary phenomena that scientists, engineers and philosophers can consider: ‘material’.

**Prof Gerd Folkers,** president of the Swiss Science Council

**Empa in Thun – a beacon in the Bern innovation landscape**

From recycling solutions for electric car batteries to turmeric foam for treating wounds, Empa has repeatedly earned attention for its applied, innovative research. 140 years after its founding, the former materials testing institute is now a cutting-edge, interdisciplinary research institution with strong industry ties and an international reach.

As Director of Economic Affairs, I am proud that this research institute belonging to the ETH Domain is also represented in the canton of Bern. Alongside the translational center sitem-insel in Bern and the Switzerland Innovation Park in Biel/Bienne, Empa in Thun is a beacon of the canton’s innovation policy. The three institutions at the intersection between Thun, Bern and Biel/Bienne complement one another’s areas of expertise and work closely together. They share the same ambitious goal: to turn technical scientific discoveries into practical industrial applications that can survive on the market. They enable innovation, attract companies to the area and provide fertile ground for start-ups. All of this is why the canton of Bern supports the expansion of Empa in Thun and the development of the center for excellence for metals and process research in 3D printing. The results of this research are particularly important for our core industries – medical technology, high-precision industry and watch manufacturing. We are convinced that the investment will pay off.

Innovation will continue to be one of the most important drivers for our economy and society in future. Empa as an institution is a leading example of this. Over the past 140 years, it has consistently adapted to changing circumstances and successfully developed from a classic testing institute into a renowned research institution. Innovation is part of Empa’s DNA, so to speak. The fact that Empa focuses not only on excellence and profitability, but also on sustainability makes me feel optimistic about the future.

None of us know what the world will look like in another 140 years. The only thing we can be sure of is that digitalization will have a long-term impact on research and development – and it will do so at high speed. In an increasingly complex, globalized and digitalized work, intermediaries and bridge-builders like Empa will be more important than ever.

The canton of Bern will remain dedicated to enabling Empa in Thun to develop and continue its contribution to the prosperity of Swiss industry and society as a beacon of the canton’s innovative economic policy.

**President of the Cantonal Council Christoph Ammann, Director of Economic Affairs of the Canton of Bern**

**Problem-solving is in our nature**

When I speak about the world in 2040 and the problems facing future generations, I counter the widespread pessimism on the subject by talking about the huge reduction in child mortality, the increase in life expectancy thanks to medical advancement, and the future possibilities offered by inexhaustible natural energy reserves. People sometimes respond by saying, ‘I don’t like how much faith you put in technology.’ Is it technology I put my faith in? What even is technology? Behind this response is the idea that technology is in some way the opposite of humanity. But is it?

Humans are a successful species in evolutionary terms. Why else would there be over seven billion of us on earth? We are a successful species despite having far less well-developed instinctive responses than other species that have also survived successfully, such as crocodiles or rats. Instead, human beings are equipped with intelligence and the unique ability to anticipate future events.

I see technology as the combination of intelligence and creativity – which are among humanity’s most prominent characteristics. These gifts are what gave us the wheel, penicillin and the space shuttle, and will soon give us artificial intelligence. Technology has allowed the human race to survive. So do I have faith in it? Yes, I do. When it comes to finding solutions to the challenges the future brings, I have faith in intelligence, creativity and – last but not least – our adaptability.

The challenges we face are significant. Global warming, for example, is threatening to radically change our habitat. Population growth indicates that there will be over nine billion people on earth by 2050. This growth throws the problem of our dwindling resources into even sharper relief – Earth Overshoot Day is getting earlier and earlier every year. And there are still many more challenges.

It has also become an incontestable fact that the survival of our species has become a threat in itself – the collateral damage is increasing. Technology itself has had undesired side-effects that have caused new problems while trying to solve others. There is also the threat of technology being used to restrict our freedom, as China is demonstrating.

How can we overcome these challenges? We need to anticipate the dangers – which, incidentally, it is possible to do without immediately invoking the horsemen of the apocalypse. The next steps are the same ones that have brought us to where we are today: we need to seek out intelligent, creative solutions. Of course, this does not just mean developing new technologies. It’s also about adapting our lifestyles, establishing political systems and pursuing just, sustainable values. But new, more efficient, sustainable technologies and materials are also a part of this.

They alone will not be able to conjure up paradise on earth – there’s no such thing as paradise, and there never will be. For every solution we find, there are new problems we face. Tomorrow’s world won’t simply be better – or worse – than the one we have today. It will be *both* at the same time – some things will improve, others will get worse. And do you know what? I look forward to it. I wouldn’t want us to reach a standstill. I welcome the fact that we will still be required to use our intelligence, creativity and adaptability in future. Because there is something else special about our species: human beings are problem-solvers. Solving problems is what drives us. To all the curious, creative, adventurous people out there – let your voices be heard!

**Georges T. Roos, futurologist**