Presentation

2019 Koski Lecture
Where is the coxswain?

FPMC2019
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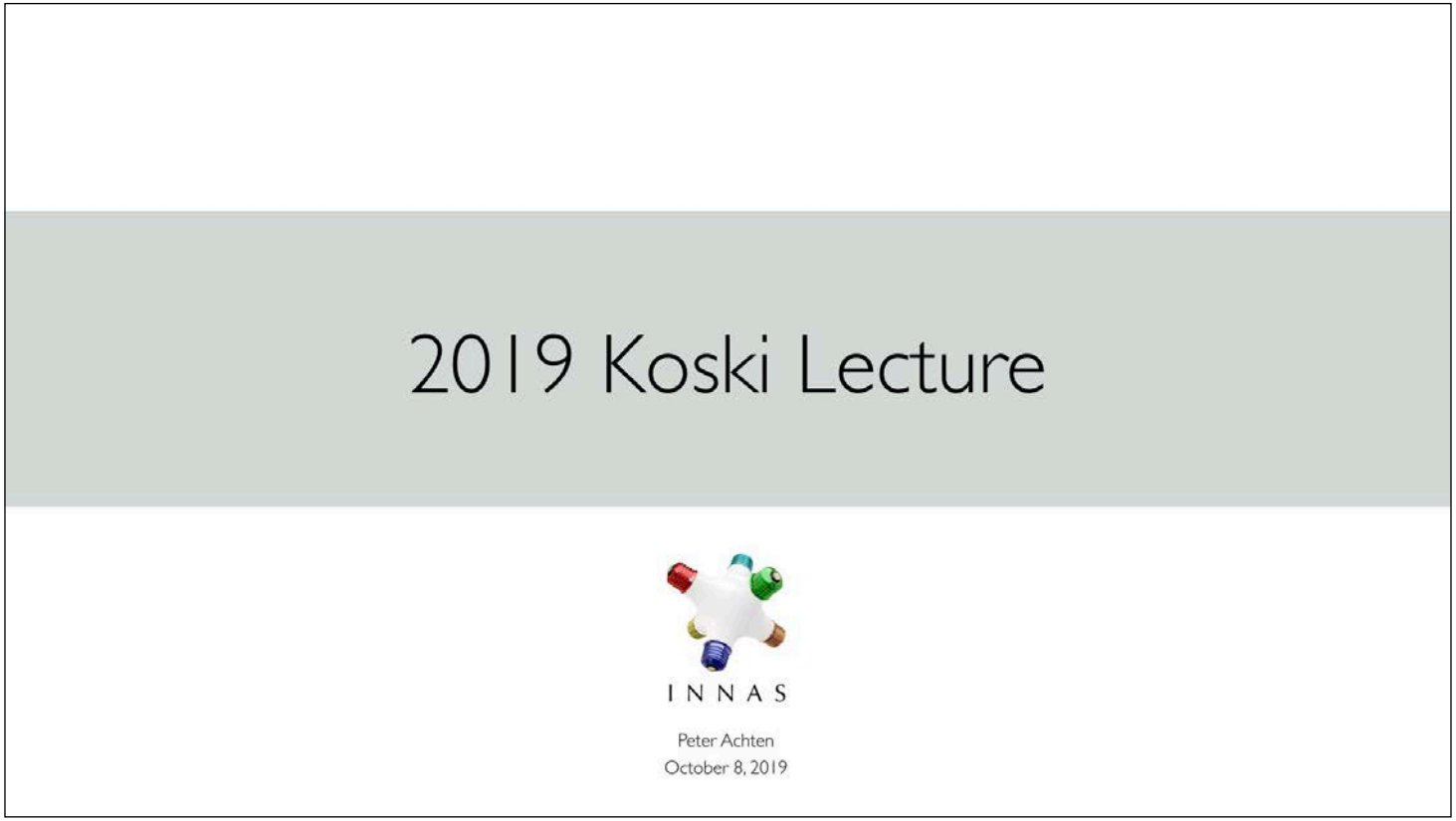


Thank you for the introduction. This is an incredible honour. But, much more than just an honour, it is my great pleasure to give the Koski Lecture this year. I hope you will enjoy it as much as I. I also hope you like roller coasters, because this presentation will be structured like a roller coaster.

The first part is a time line. That is the boring part of the roller coaster: you know the part in which the train of cars is climbing up the track. “Tak, tak, tak…”. After this, the fun part starts. You will be tossed around. So hold on, You are allowed to scream if you think it’s to nerve wrecking or exciting. This roller coaster has a name: it is called ‘innovation’.

Innovation is about change. And since the past can’t be changed, we talk about the future when we talk about innovation, right? Now, the problem with the future is that we can’t see it.

It is, as if we are walking or moving backwards into the future.

Like this young man in a rowing boat. He is also rowing with his back towards the future. Occasionally he looks over his shoulder to see where he is going.

But if this is a metaphor for leadership, then he will see that the future is dark. The further away he looks the darker it gets.

the coxswain

This is another photo of a rowing boat. This is a picture my wife likes: eight strong young men rowing like hell, and a small woman in the stern. She is the coxswain or just ‘the cox’.

She is controlling the boat's steering, speed, timing and fluidity. Coxswain’s are also responsible for the safety of the boat.

This photo is taken in full daylight, and the young woman in the stern, the coxswain, can clearly see where to go. But the coxswain’s in industry and academia have a much more difficult task. They have to lead, not knowing what the future will bring.

the coxswain

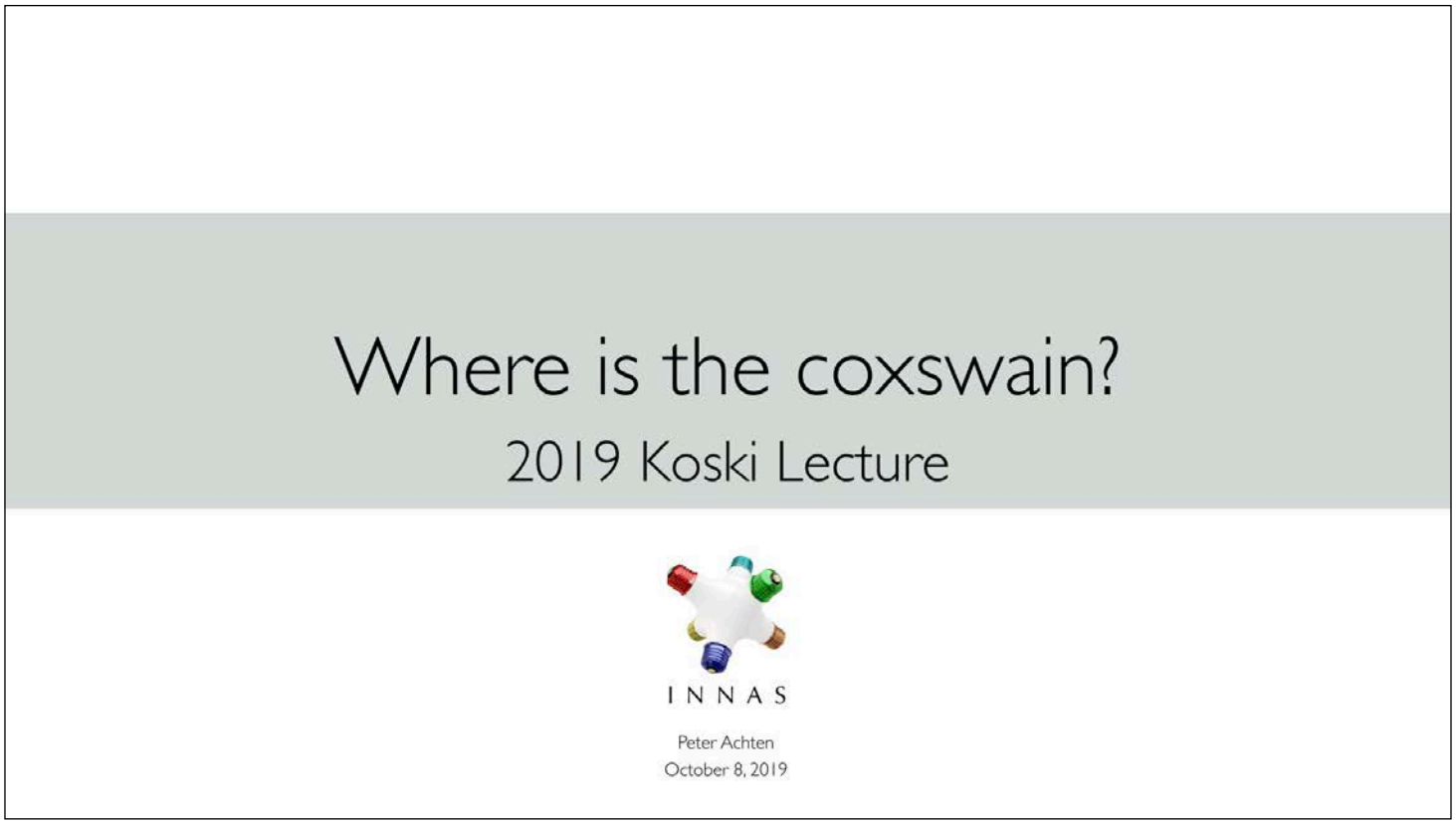
Also for them, the future is covered in darkness. Nevertheless, it is the task of the cox to see where to go.

The word coxswain is actually a combination of two words: the first part comes from the word ‘cockboat’, which is a small vessel kept aboard a ship.

The second part –swain– is derived from the Old Norse ‘sveinn’ meaning ‘servant’. So, being a leader and having control of the boat, the coxswain is also a boat servant.

For me, the coxswain is the ideal metaphor for leadership, also in innovation.

In this presentation, I will be looking for the next coxswains in our fluid power community.

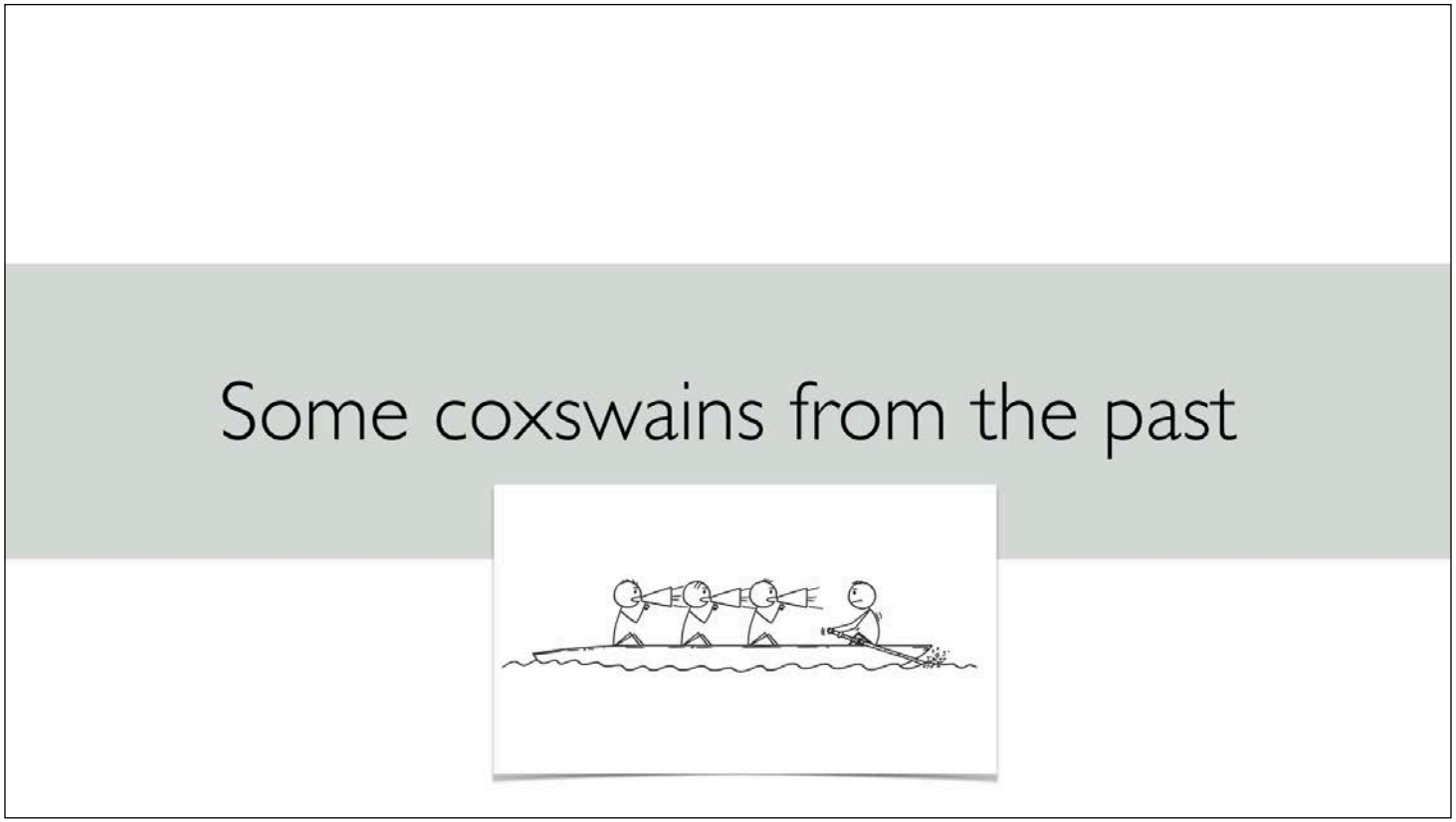


Which leads me to the formal title of this presentation:

“Where is the coxswain?”.

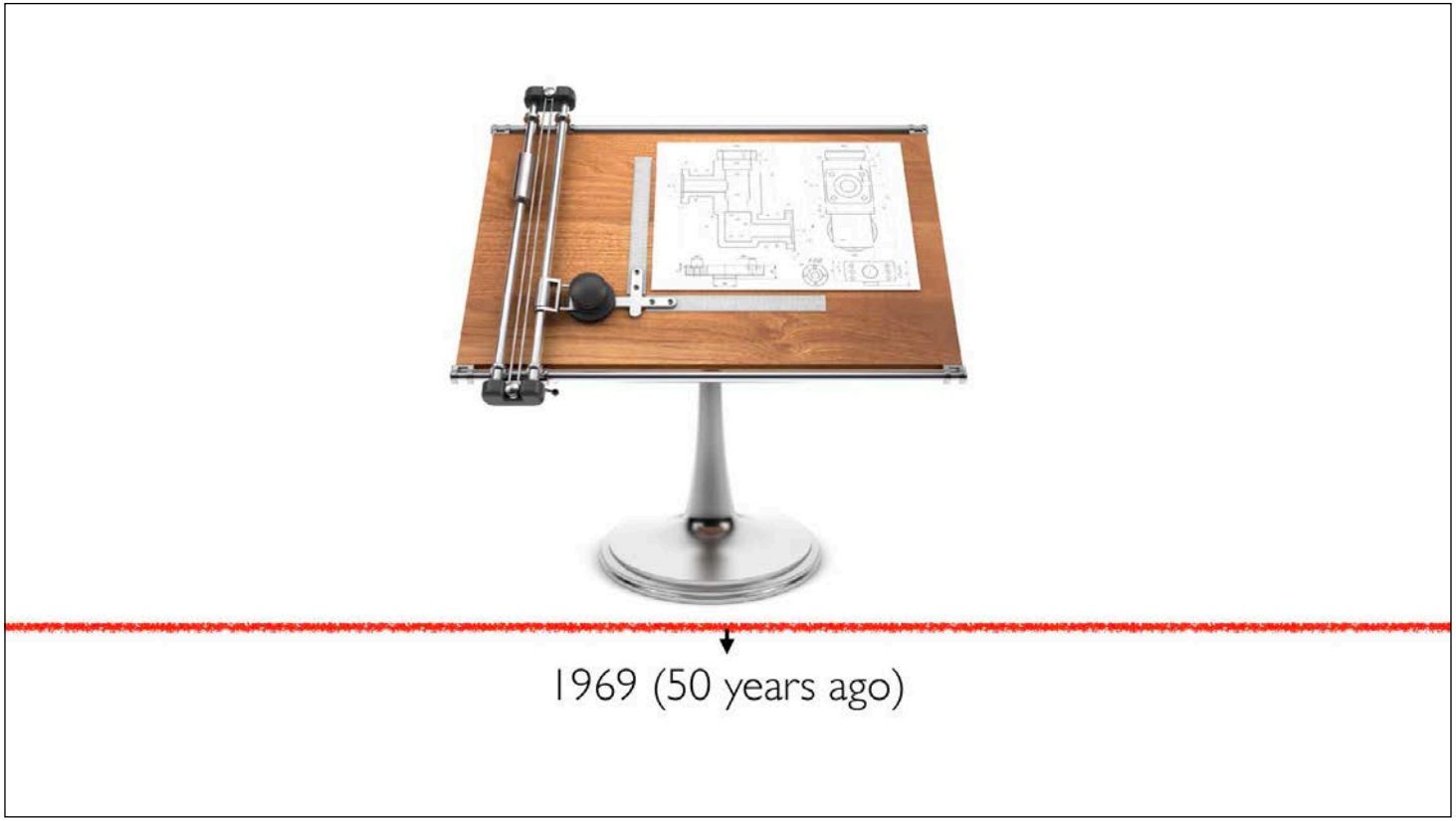
Where are the next coxswains to lead our fluid power community? And what should they do to make fluid power successful and alive? And, most and for all, to make it an innovative industry again. An industry that realises that there are big changes in society ahead of us.

I will be looking for coxswains that find new technologies and solutions, despite the future being shrouded in darkness.



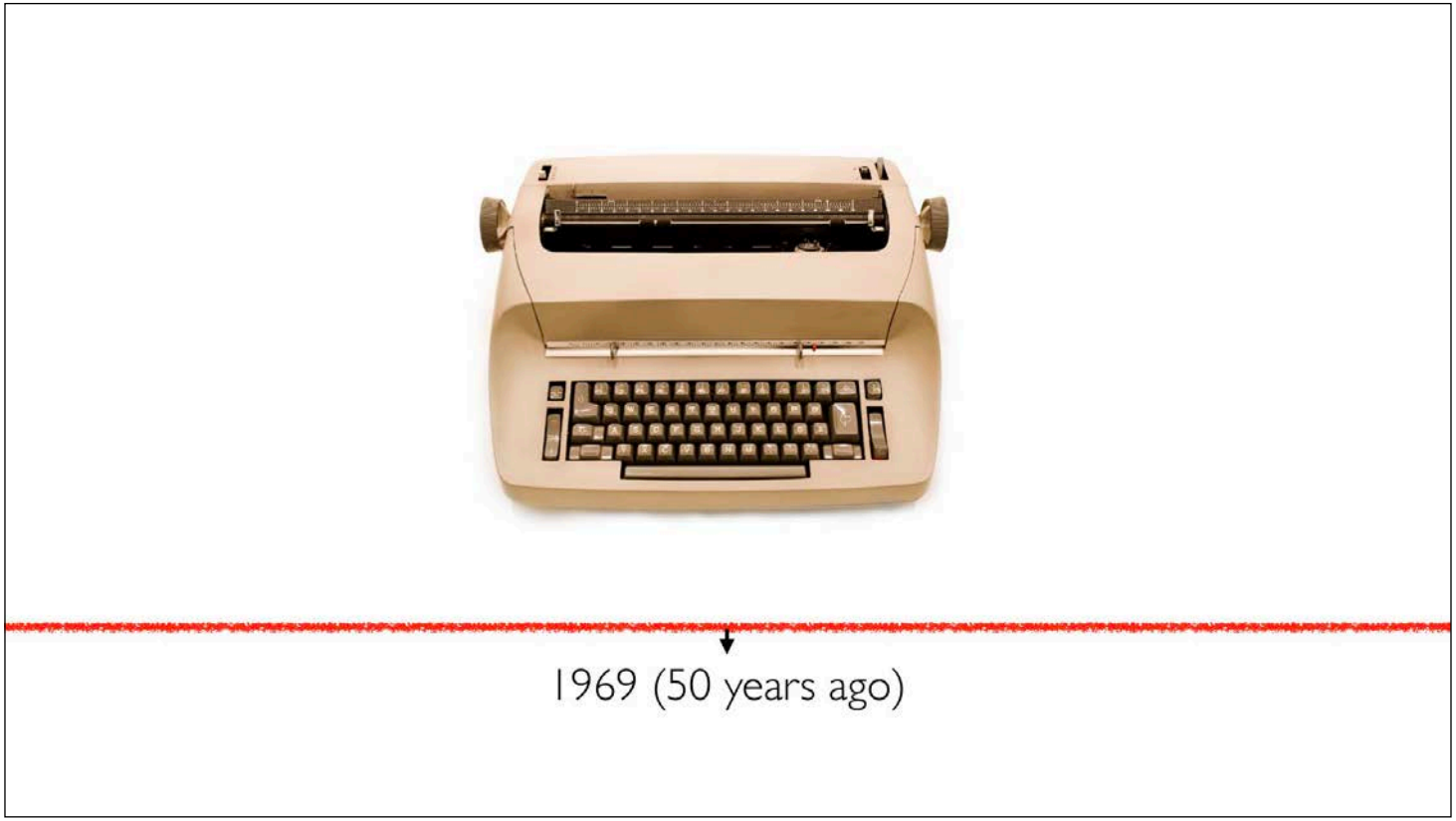
We had some coxswains in the past. Most of them you might know. Leaders who had a vision and made predictions about the future of fluid power.

Let me show you their visions in the past 50 years:



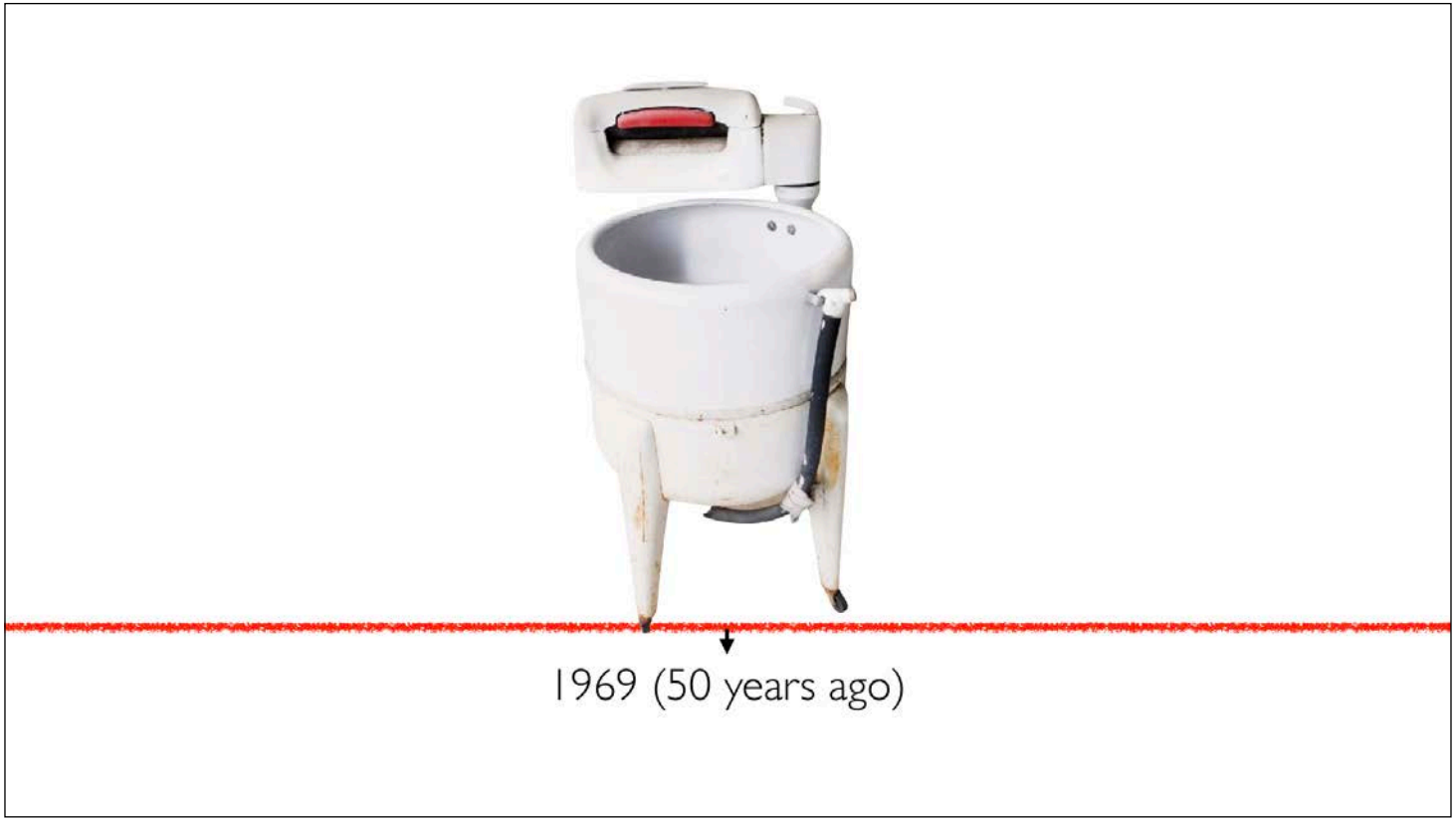
The next slides will all show a horizontal red line, which represents the time line. Let me take you back fifty years in time, to the year 1969.

Now, before going to the line of coxswains, I need to remind you that 50 year ago, the world looked different. We didn't have computers and CAD-programs to make our designs. Instead we designed them on drawing boards like these.

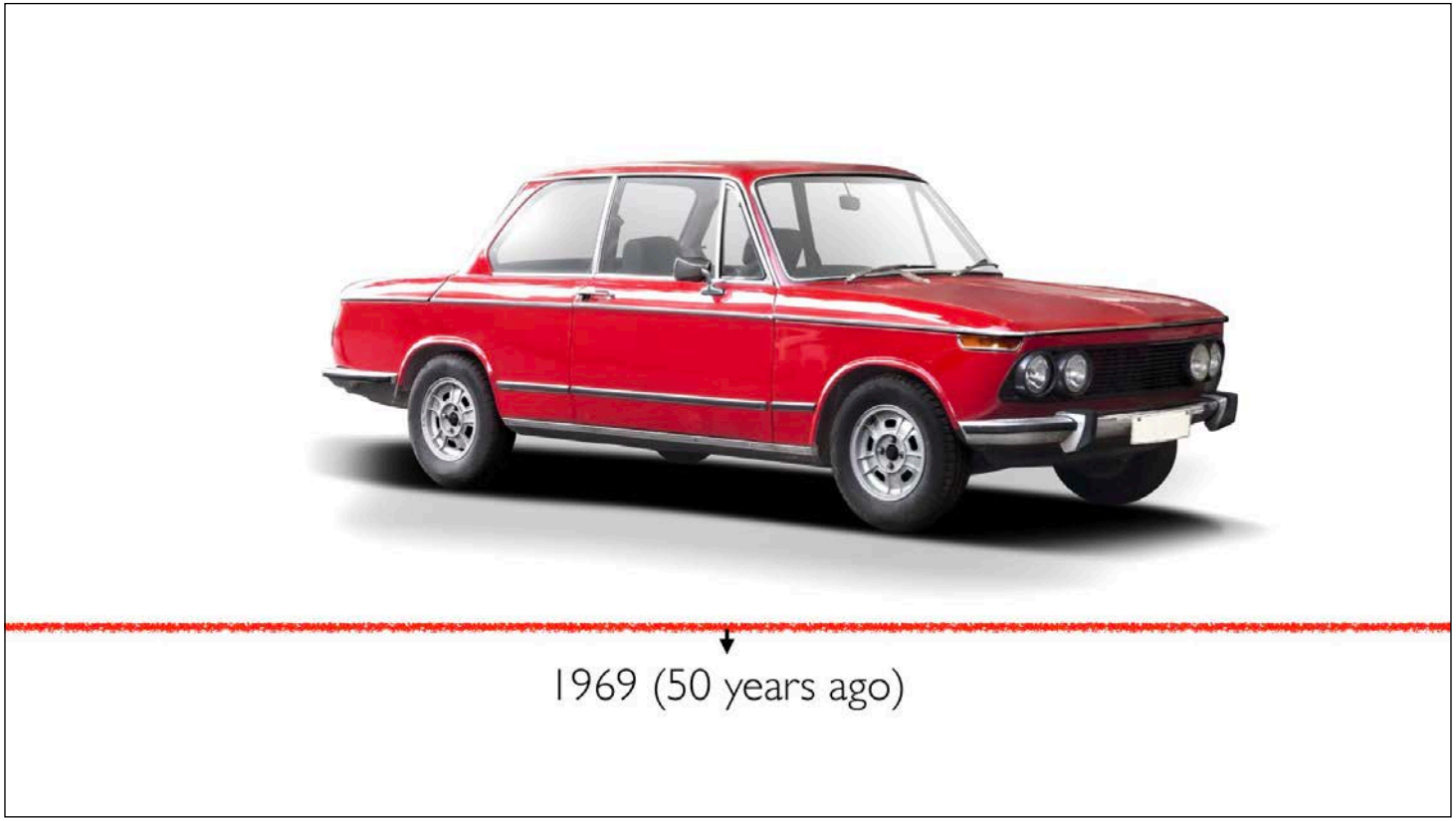


We also didn't have word processors. Instead we wrote our reports on paper, with a pen, after which they were typed. I wrote my master thesis on a type writer like this one.

Fifty years ago, TV-sets looked different, …



…washing machines looked different, …

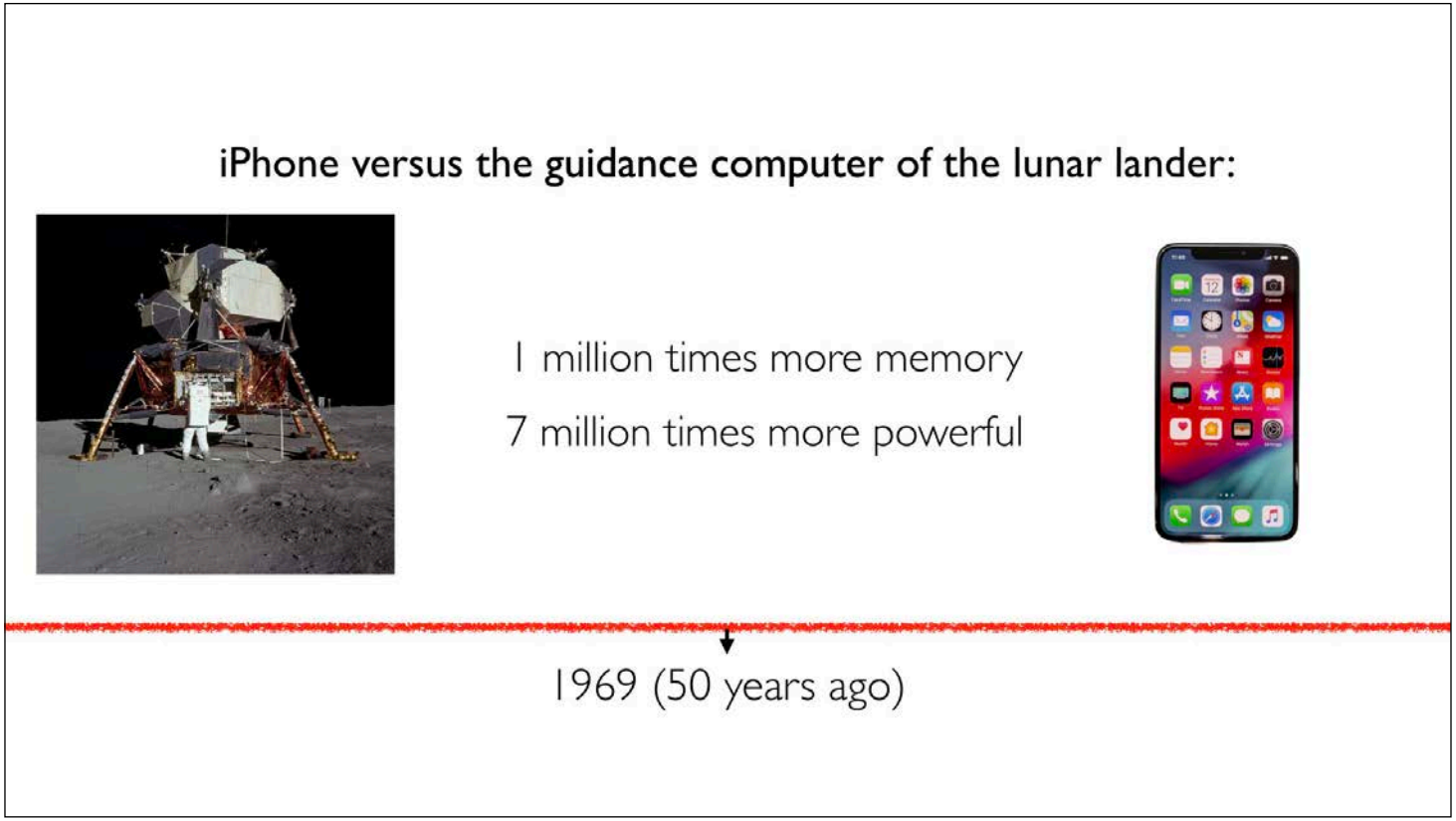


…cars looked different,…

…phones looked very different,…

…and pumps looked different.

Uhh, no, I'm sorry. That's my mistake. Pumps didn't look different.
They still look the same as fifty years ago.

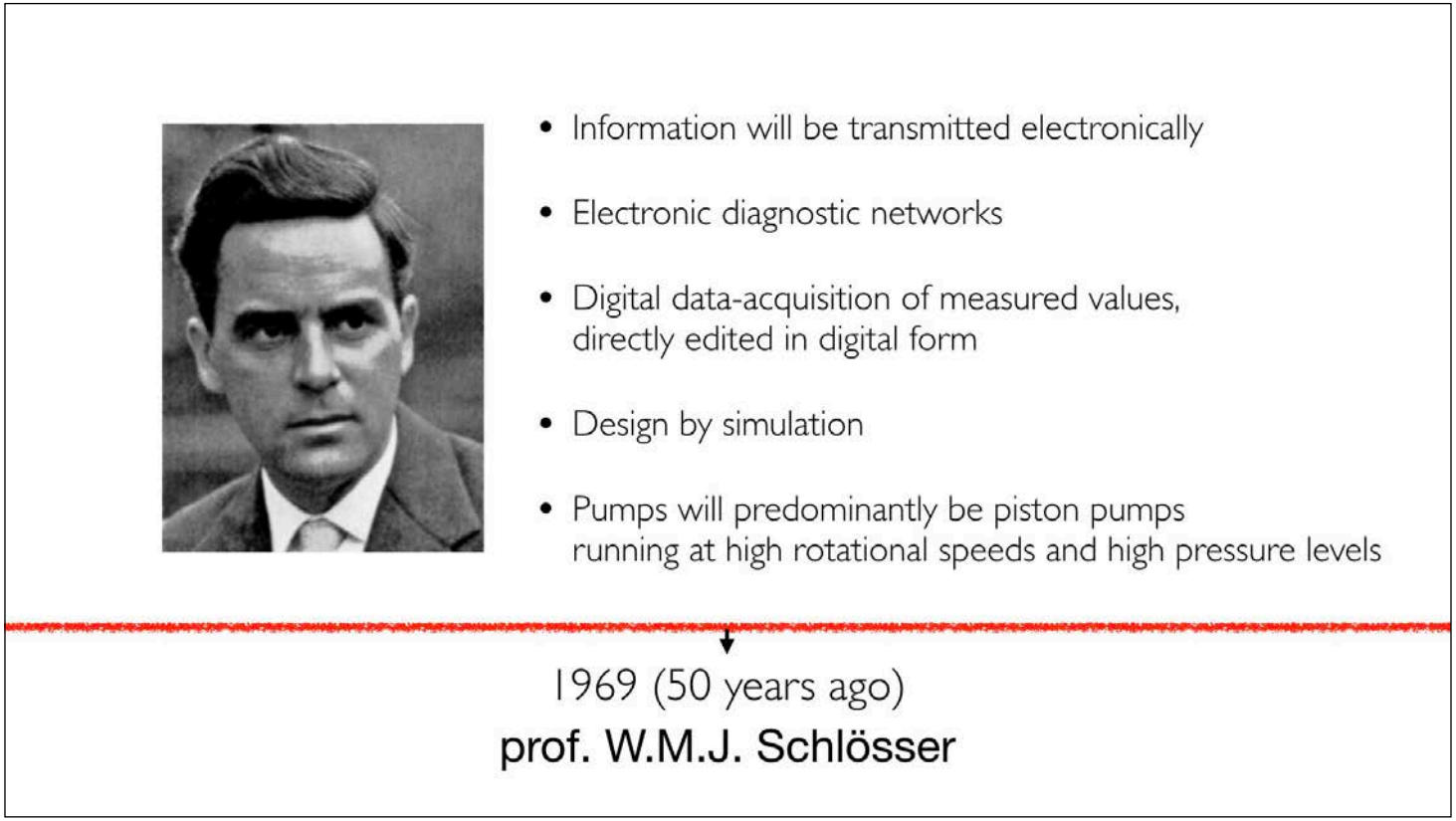


Now, the most important common factor in all these changes has been electronics. Let me explain this to you by means of a very simple example.

This year it was 50 years ago that a man landed on the moon. The Lunar Lander had a computer, called the guidance computer. Just to illustrate what has happened in the past 50 years:

This iPhone:

- has one million times more memory
- and is seven million times more powerful



So let me introduce to you the first 'cox' of fluid power: Professor Schlösser. He was my professor for hydraulics when I studied at the Technical University of Eindhoven.

In the time of the Lunar Lander he predicted:

- Information will be transmitted electronically
- There will be electronic diagnostic networks
- and digital data acquisition of test data
- Instead of building prototypes, design will be done by means of simulations.
- He also predicted in 1969 that in the future pumps will predominantly be piston pumps, running at high rotational speeds and high pressure levels

Source: Ölhydraulik und Pneumatik 13 (1969, nr. 9) p. 464

- Extensive use of computers
- Controls will be fully digitized
- Electrohydraulic axis drives with bus interface
- Components and systems will become more **efficient**

1993 (26 years ago)

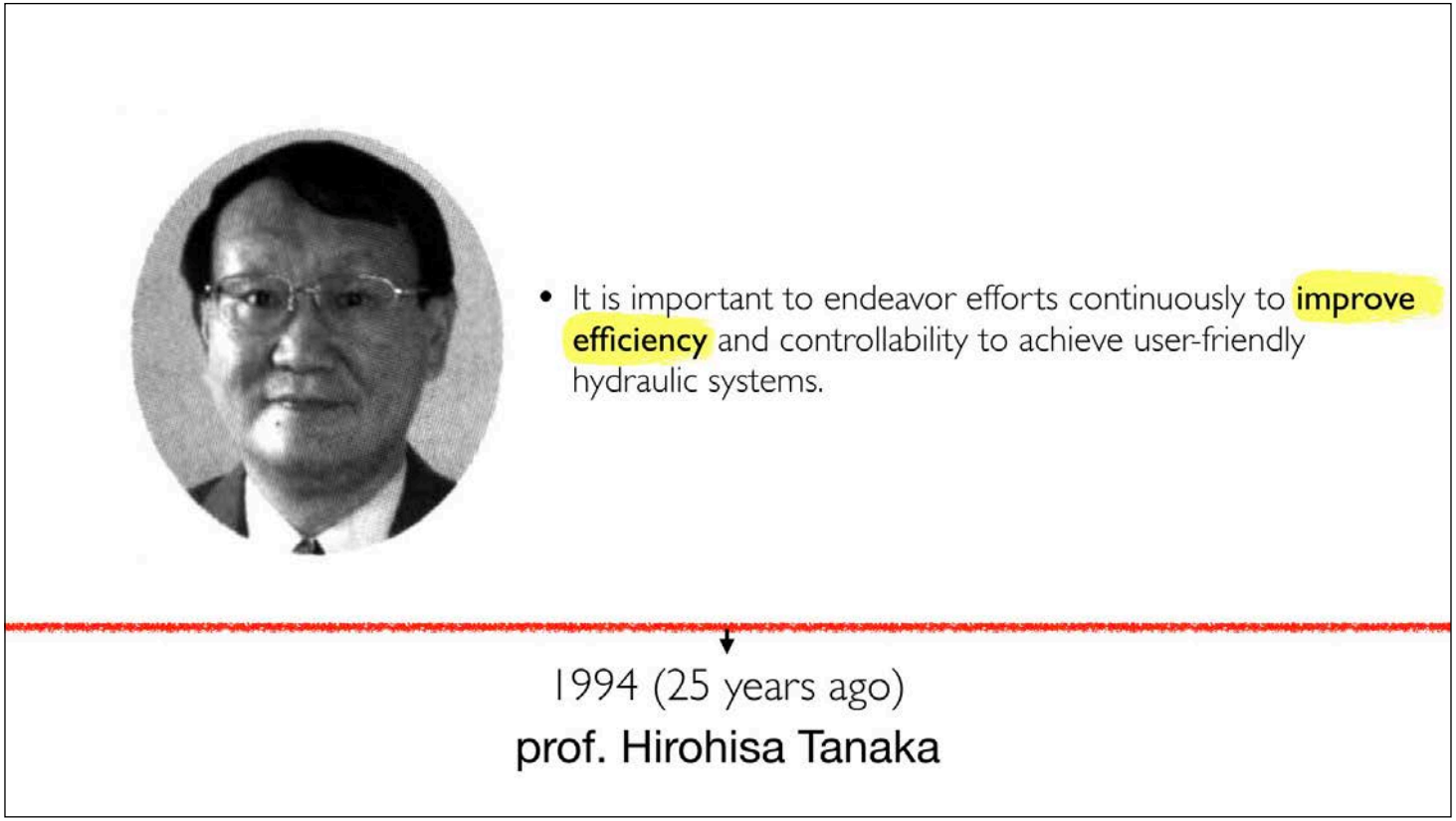
prof. Wolfgang Backé

In 1993, professor Backé wrote an article about the present and future of fluid power. He was the 1st recipient of the Koski medal.

Like Schlösser, he also predicted an extensive use of computers. In that time, in 1993, we were still making designs on the drawing board. He also foretold that hydraulic systems and components would become more efficient.

As you can see, the word ‘efficient’ is printed in bold. I did this on purpose. You will later see why.

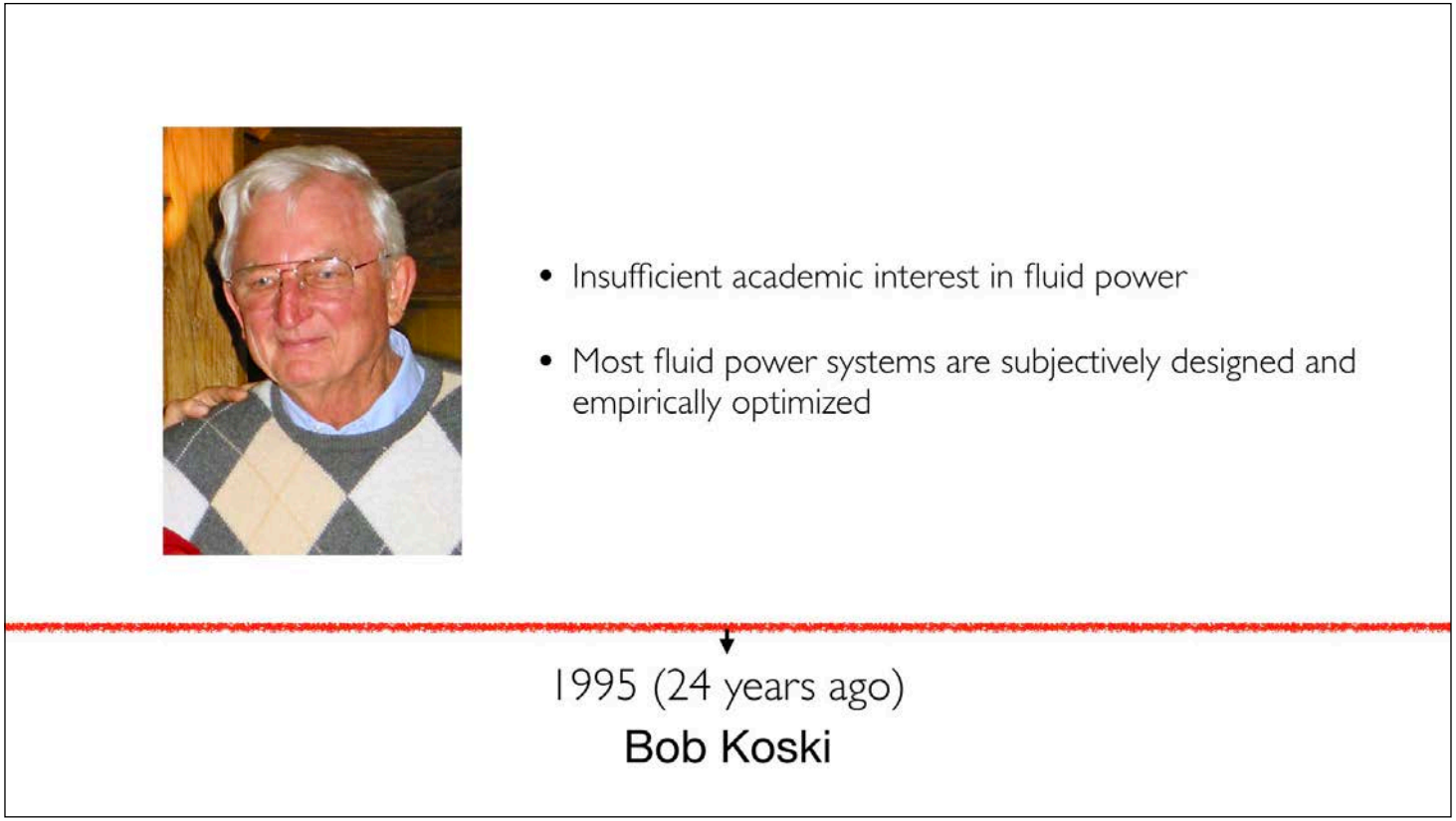
Source: Backé (1993) The present and Future of Fluid Power, Proc. of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering 1993 207:193, DOI: 10.1243/PIME_PROC_1993_207_343_02, http://pii.sagepub.com/content/207/4/193



One year later, in 1994, Professor Tanaka from Yokohama University emphasized the need for a continuous improvement of the efficiency of hydraulic systems.

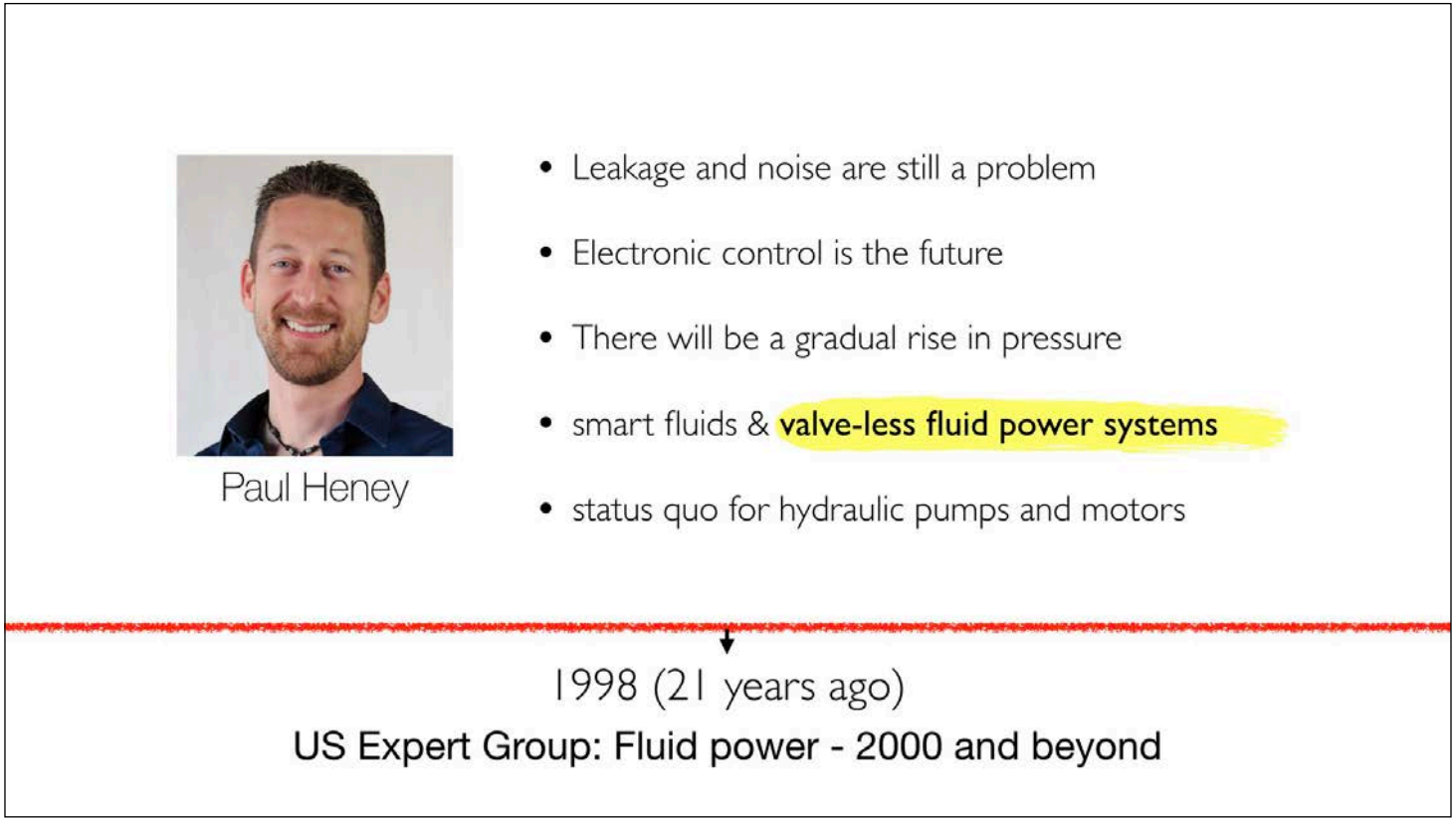
Please note that I marked the words “improve efficiency” again.

Source: Tanaka (1994) Fluid Power control technology: present and near future, JSME international journal. Ser. C, Dynamics, control, robotics, design and manufacturing, 1994, Volume 37, Issue 4, Pages 629-637, https://doi.org/10.1299/jsmec1993.37.629



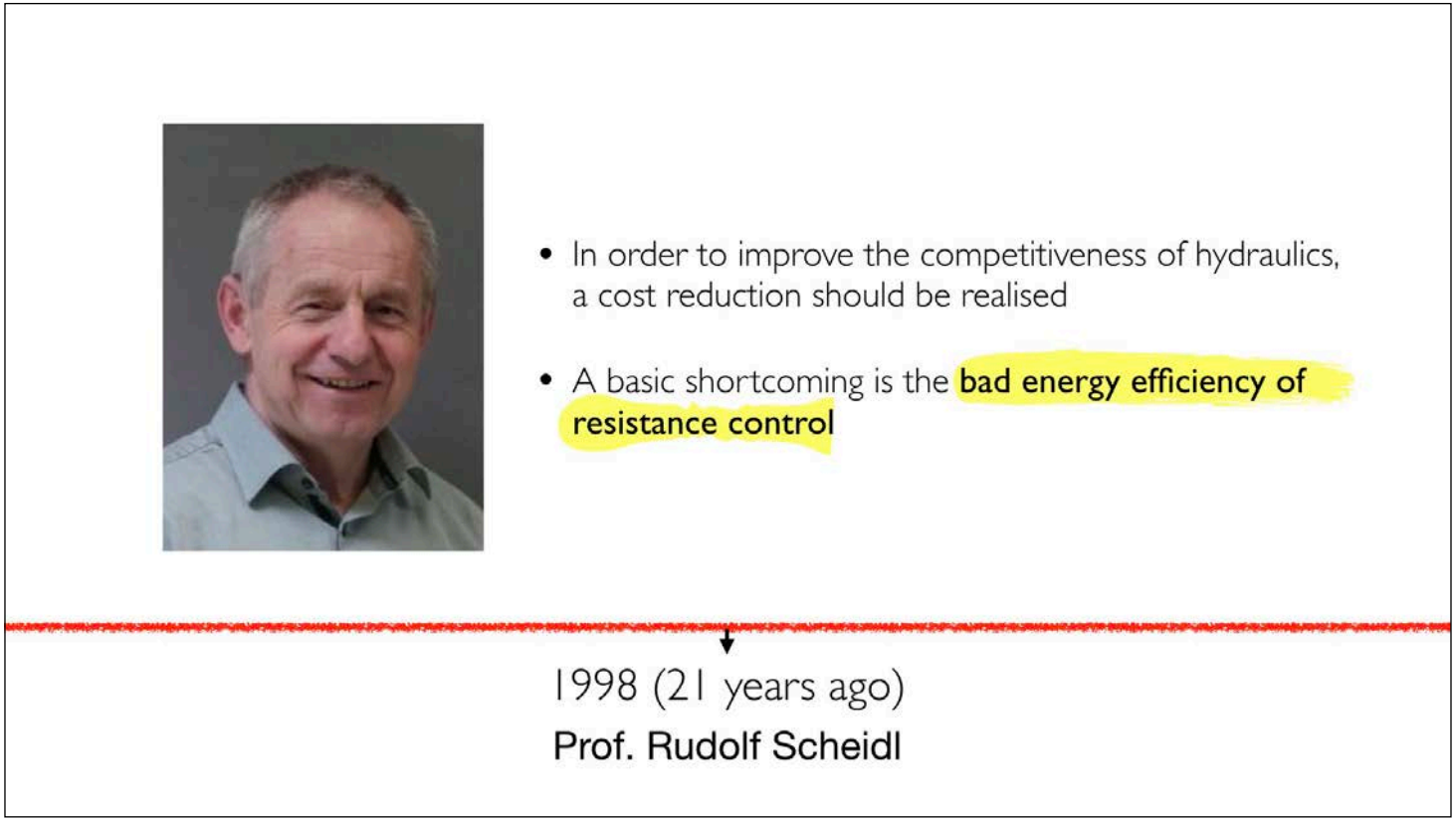
24 years ago, at a conference in Linköping, Sweden, Bob Koski made an urgent call to improve and professionalize research and education in fluid power. We need better ways to design and optimise designs of fluid power systems.

source: Koski R.E., Fluid Power Education - What went wrong? Proc. 4th SICFP, Tampere, 26-29 September 1995, pp 71-92



Three years later, in 1998, there was a meeting of experts here in the US. The motto was: “Fluid power - the year 2000 and beyond. It was lead by Paul Heney. One of the important conclusions of that meeting was, that the industry needed ‘valve-less fluid power systems’: systems with a much higher energy efficiency.

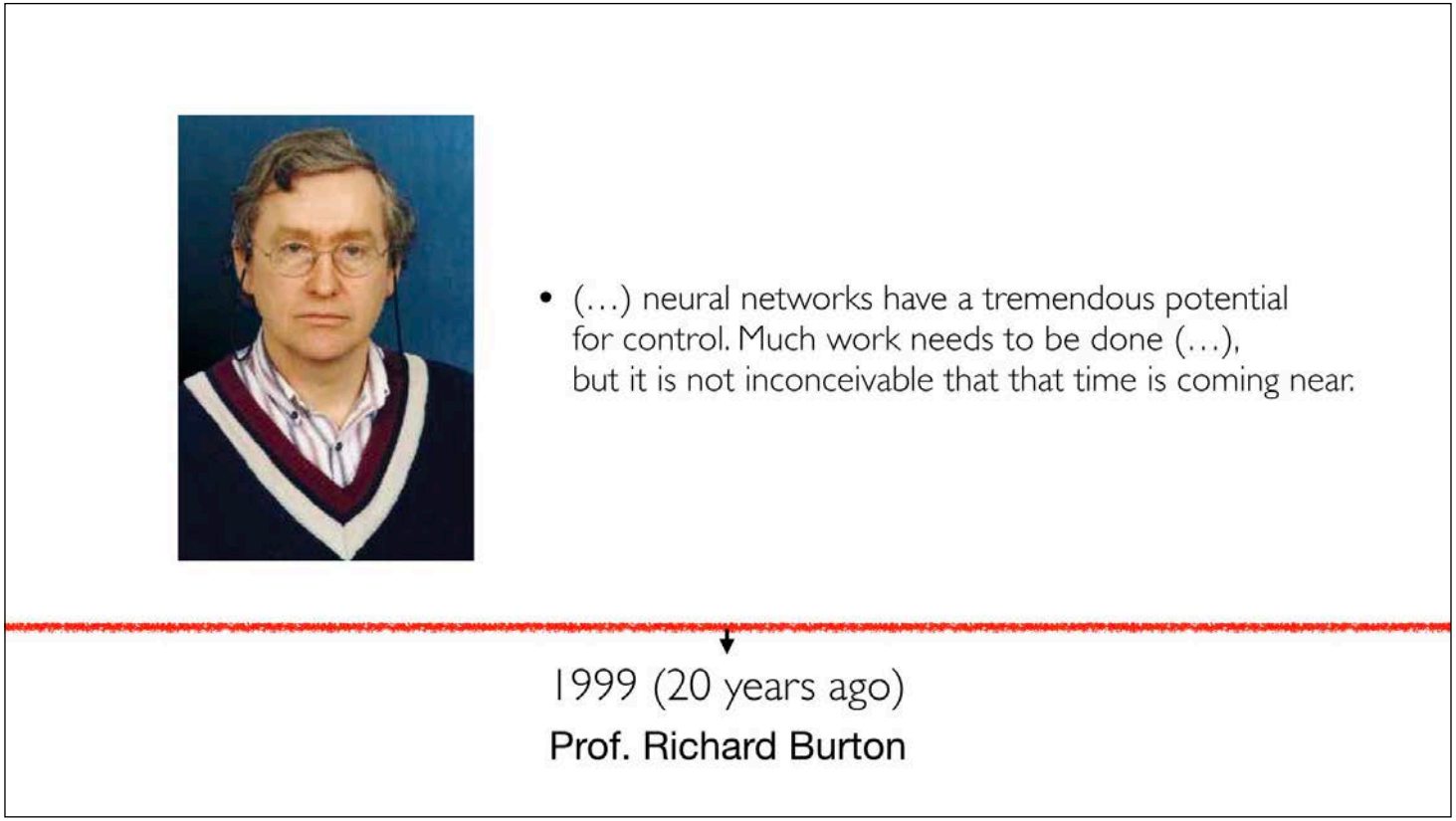
source: Fluid power: 2000 and beyond—a blueprint for the future
Heney, Paul J., Hydraulics & Pneumatics; Cleveland Vol. 51, Iss. 3, (Mar 1998): 68.



In the same year, in 1998, Rudolf Scheidl wrote that the hydraulic industry has two shortcomings:

- high cost
- and a bad energy efficiency

Source: Some comments and suggestions on the future development of oil-hydraulics
Developments in Fluid Power Control of Machinery and Manipulators, 1998 FPNI Forum, Cracow

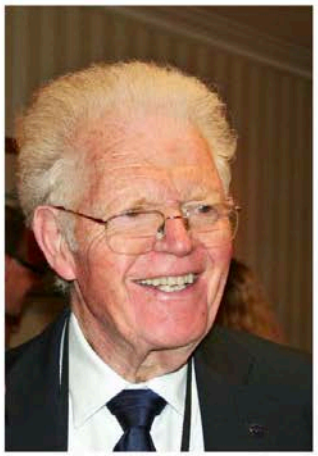


Then, Richard Burton. Sorry I couldn't find a better picture of you Richard.

20 years ago, Richard thought it was not inconceivable that we will have adopted neural networks in fluid power.

"not inconceivable". That is a very cautious prediction. Something like: 'it is not unthinkable that we might be pregnant'

source: Burton (1999) Neural networks and hydraulic control—from simple to complex applications, Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 213(5), 349–358. https://doi.org/10.1243/0959651991540205



- "…because resistance to change will hasten a decline towards the status of a niche technology."
- "There is an ongoing requirement to overcome the inherent disadvantages of fluid power associated with leakage, noise and **inefficiency**."

2002 (17 years ago)

prof. Cliff Burrows

17 years ago in 2002, professor Cliff Burrows uttered his concern about the general resistance to change in the fluid power industry.

He urged the community to overcome the inherent disadvantages of fluid power, especially leakage, noise and inefficiency.

Source: Burrows (2002) Some challenges facing fluid power technology, opportunities for international collaboration and progress to date, Proc. of the JFPS International Symposium on Fluid Power, 2002, Volume 2002, Issue 5-1, Pages 107-112, https://doi.org/10.5739/isfp.2002.107

- Use of the flow control valve has to stop;
- New approaches to flow modulation must be attempted if we want to be competitive.

2005 (14 years ago)

Prof. Richard Burton

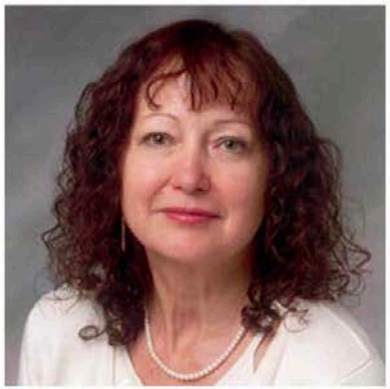
Here you are again Richard. After all I did find a better picture.

In 2005 there was another expert group in the US talking about the future of fluid power. In this meeting Richard said:

‘The use of flow control valve has to stop’.

We have to find other ways to control our hydraulic systems.

Source: Paul Heney (2005) Fluid power 20/20, https://www.hydraulicspneumatics.com/200/TechZone/HydraulicValves/Article/False/9464/TechZone-HydraulicValves



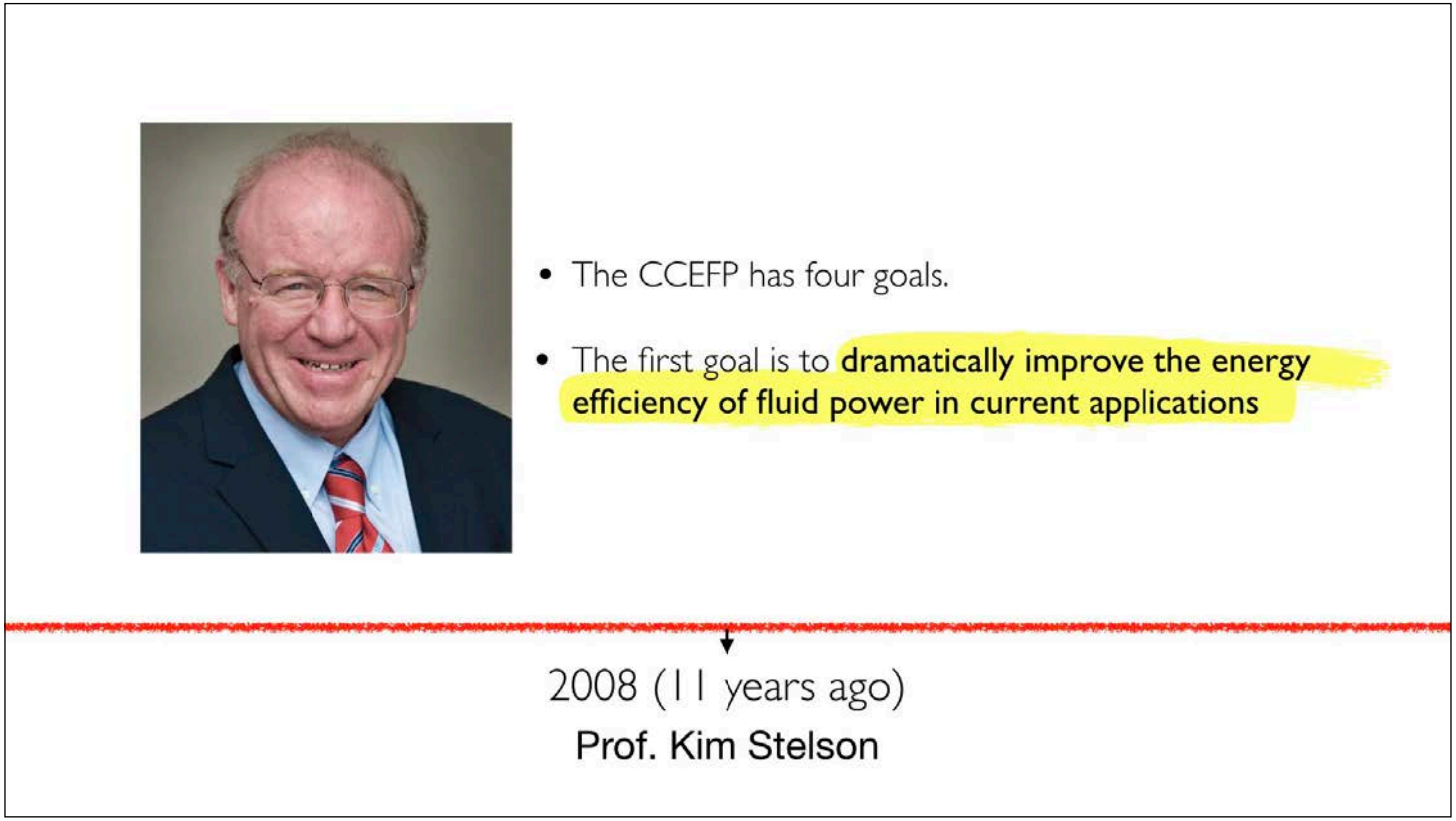
- Displacement control instead of resistance control
- Variable pumps and motors must be used as the final control element of fluid power actuators and drives

2005 (14 years ago)

Prof. Monika Ivantysynova

Also Monika Ivantysynova was convinced that we needed to go away from valve-control. She strongly advocated the concept of displacement control, in which every cylinder or group of cylinders are individually controlled by means of a variable displacement pump. “Variable pumps and motors must be used as the final control element of fluid power actuators and drives” she said.

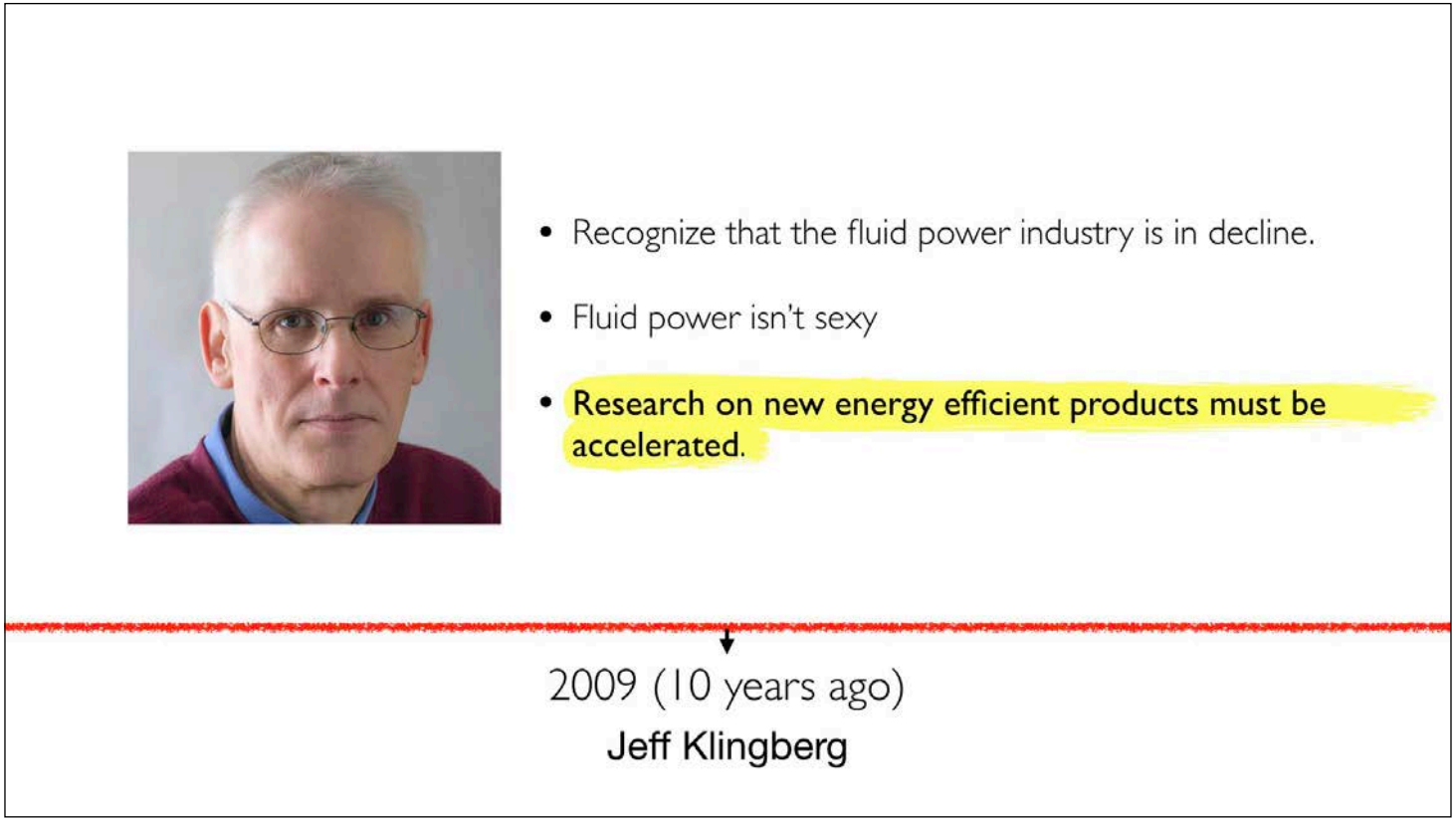
Source: Paul Heney (2005) Fluid power 20/20, https://www.hydraulicspneumatics.com/200/TechZone/HydraulicValves/Article/False/9464/TechZone-HydraulicValves



11 years ago, Kim Stelson talked about the main goals of the newly founded CCEFP.

The first goal, he mentioned, is to improve the energy efficiency. Not just a small improvement, but a dramatic improvement is needed.

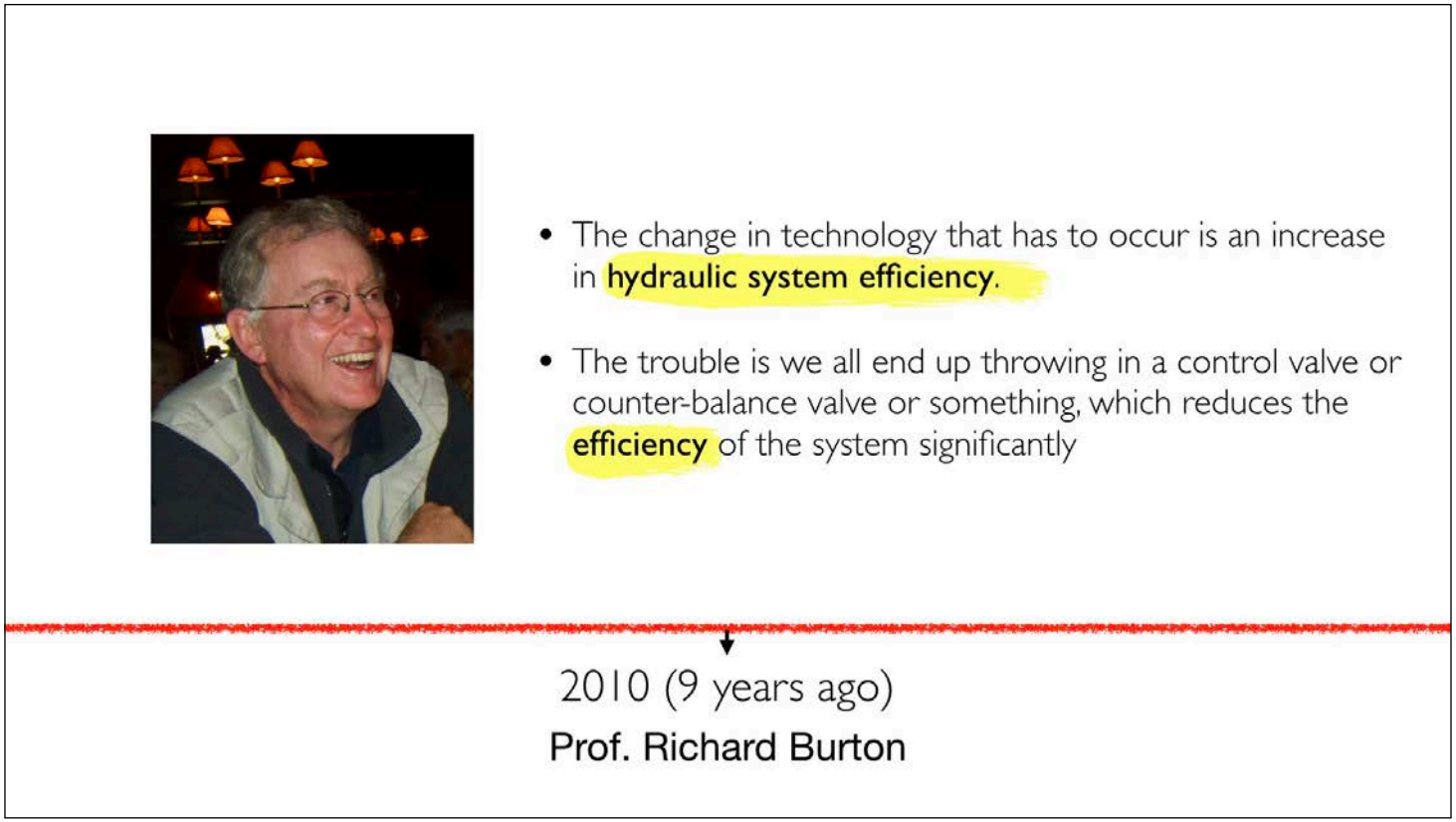
Source: Stelson (2008) The Center for Compact and Efficient Fluid Power, FPMC2008, Bath, http://www.bath.ac.uk/mech-eng/research/ptmc/files/2008_FPMC_proceedings.pdf



Ten years ago, the former President of Fluid Power Technologies International, Jeff Klingberg, wrote an article in 'Product Design & Development'. The title of the paper was "Wake up fluid power industry, or prepare for extinction."

He didn't say that the fluid power industry might be facing a decline. The industry is already in decline he wrote. He concluded that 'Fluid power isn't sexy'. His first concern was the energy efficiency. We need to accelerate research on new energy efficient products.

Source: Klingberg (2009) Wake Up Fluid Power Industry Or Prepare For Extinction (This article was first published in the September 2009 issue of the now defunct Today's Fluid Power magazine)



Nine years ago, Richard Burton warned again that we needed to increase the hydraulic system efficiency.

“The trouble is we all end up throwing in a control valve or counter-balance valve or something, which reduces the efficiency of the system significantly.”

Source: Fluid Power Roundtable ’10 (2010)

Yes, I also had my contribution as a coxswain, or should I say ‘prophet’, as Bob Koski preferred to call me?

9 years ago I mentioned two problems: Costs and efficiency.

Source: Achten (2010) Convicted to innovation in fluid power, DOI: 10.1243/09596518JSCE1026

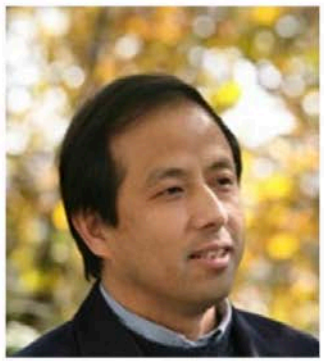
Then, in 2012, professor Murrenhoff also made a call for more efficient system solutions. As a solution he mentioned:

- hydraulic transformers
- discontinuously adjustable cylinders
- and multiple pressure networks

Source: Murrenhoff (2012) Zukunft der Mobilhydraulik, ATZ Off Highway, April 2012

In 2014, five years ago, professor Yongxiang Lu addressed the fluid power conference in Hanzhou. He strongly encouraged the participants to do more in innovation. Instead of 'made in China', the future motto should be 'create in China'. The new products, he said, must be energy efficient and sustainable.

Source: Seventh Congress of China Hydraulics Pneumatics & Seals Association hydraulic hydraulic and pneumatic sealing industry work conference was held in Hangzhou, December 2-3, 2013



- There are still many challenges in fluid power and motion control areas. The main challenges include its **efficiency**, compactness, and environmental impact.
- Novel fluid power control methods are also needed to **improve system efficiency**

2015 (4 years ago)

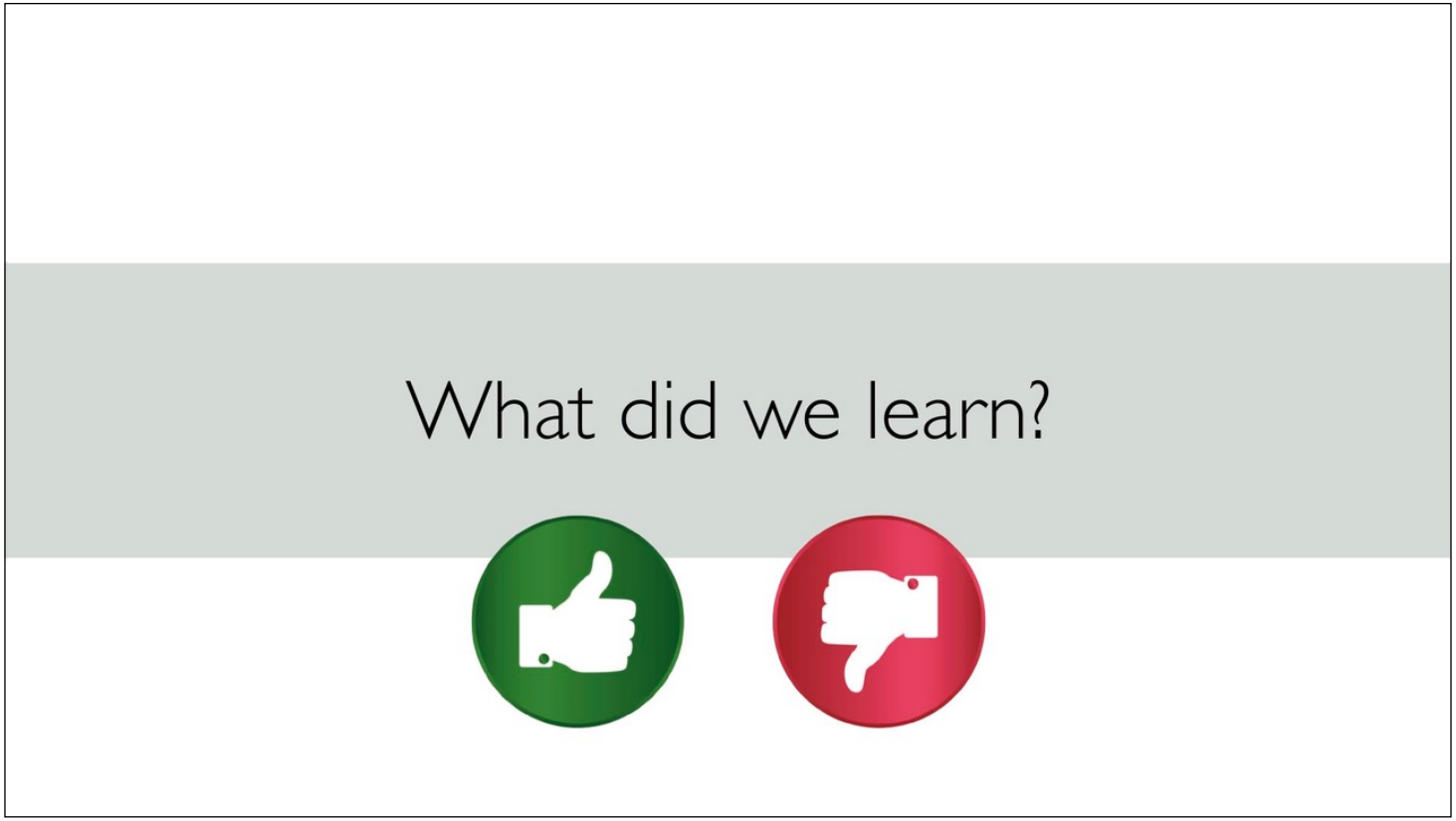
Prof. Huayong Yang

Also professor Yang mentioned energy efficiency as being the first challenge for fluid power. We need new fluid power control methods, he wrote.

Source: Yang (2015) Engineering research in fluid power: a review, J Zhejiang Univ-Sci A (Appl Phys & Eng) 2015 16(6):427-442

Finally, last year, Andrea Vacca also concluded in an editorial article the fluid power drives are indeed inefficient. But he also mentioned that there is a tremendous opportunity to improve the efficiency and reduce energy demands of fluid power systems.

Source: Vacca (2018) Energy Efficiency and Controllability of Fluid Power Systems, Energies 2018, 11, 1169; doi:10.3390/en11051169



So, here we are. We just arrived at the summit, the highest point of our roller coaster. On the way up we have listened to what the leaders in our community had to say: Sixteen coxswains that made predictions and uttered their concerns in the past.

What did they tell us? And what did we learn from their forecasts and prophecies? Looking back, what has been good and what is wrong?

What's good?

- Education has improved, especially in China and the US
- Schlösser was right:
  - *Digital diagnostics & data-acquisition*
  - *Design by simulation*
- Leakage has become less of an issue

First of all, let's see what we have changed in the past decades, for the better:

Education has strongly improved, especially in the US and in China.

Furthermore, the predictions from Schlösser and others were right: Electronics have also changed our hydraulic systems, and design by simulation has been completely integrated in our way of designing, although prototypes and measurements still remain necessary.

Finally, I believe we can conclude that leakage has become less of an issue.

What's wrong?

- Fluid power is not sexy
- Resistance to change
- Risk adverse
- **Fluid power isn't efficient (and too expensive)**

So far the good. But what have we failed to do.?

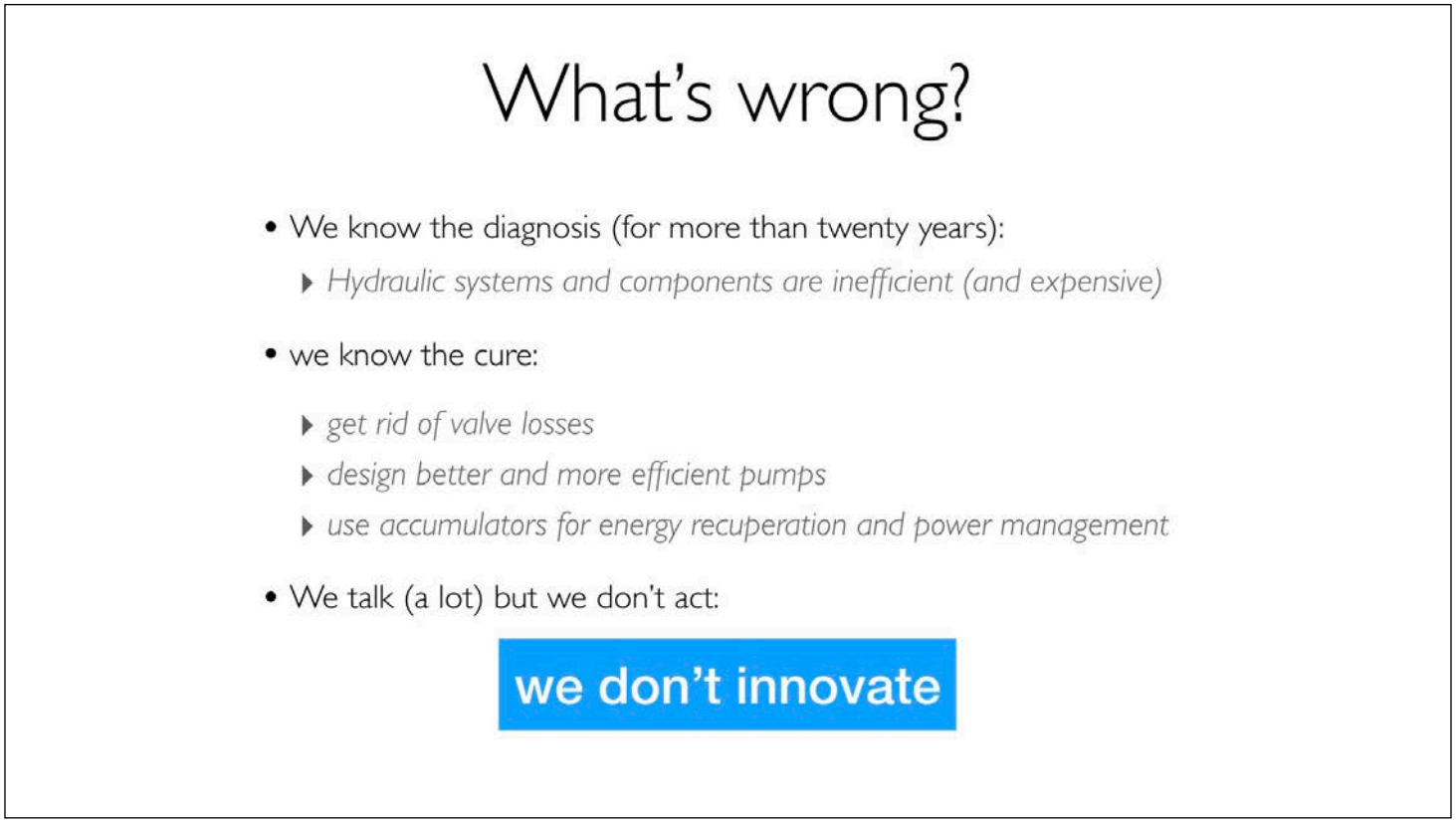
Especially in the last 10 years, leaders in our community have expressed their concerns about the strength of our industry and academia.

Fluid power isn't sexy, certainly not as the appealing electronic industry. There is resistance to change and the industry is risk adverse.

But the overruling warning is that fluid power isn't efficient.

Now you know why I emphasized the word 'efficiency' in the previous slides, by making the words bold.

I addition I would like to stress that hydraulic systems and components are too expensive to be competitive.



For more than 20 years we know the diagnosis: hydraulic systems and components are inefficient and expensive

We know the cure

- we have to find a better solution than dissipative control
- we urgently need pumps and motors with a higher efficiency
- and we should use accumulators for energy recuperation and power management

Yes, we talk about these concerns, a lot, but we don't act. We don't innovate.

some promising developments

Yes, I know, we did make some changes. We added sensors and other electronics on our valves and other components.

But you can also make a cuckoo clock electronic. That's perfectly alright, as long as you don't believe it will make a big difference in the market.

One thing is sure, it will make the thing more expensive. This electronic cuckoo clock you can buy for $531.74.

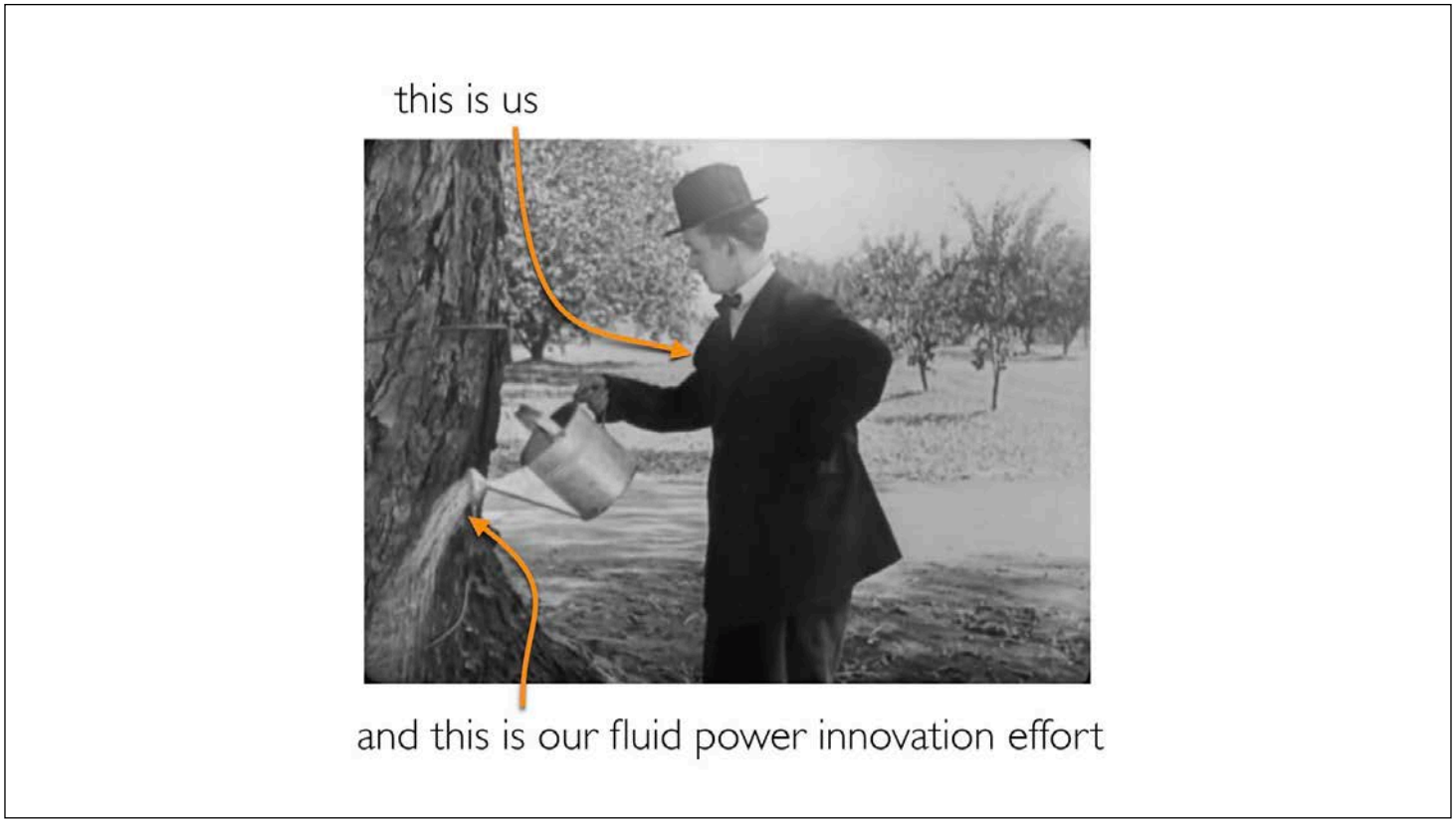
Furthermore, adding electronics to valves won't improve the efficiency of our hydraulic systems.

It is not that we don't do anything. There are some promising developments such as

- independent metering…
- multi-chamber hydraulic cylinders
- I am also very pleased that Danfoss has decided to take the digital displacement pumps from Artemis into production
- and that Bucher Hydraulics is now producing floating cup pumps and motors
- but… it's not enough.

To illustrate what I mean, I want you to look at a small movie:

Movie ‘Detained’ 1924 with Stan Laurel



This, ladies and gentleman, this is you and me, this is us.

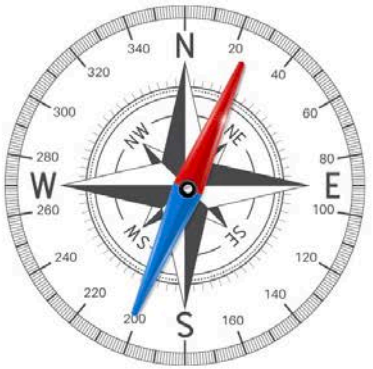
And this is our fluid power innovation effort.

… it's not enough

It's not enough.

2019 NFPA Technology Roadmap

96 research targets



A few weeks ago, the NFPA published their latest technology roadmap, for ‘improving the design, manufacture and function of fluid power components and systems’.

The report ends with a long list of so called research targets. Like: “Connect real-time and big data feedback to the Cloud for rapid utilization” and “Develop methods for stress relief, flaw detection, and distortion correction”

96 in total. 96 different directions. Like Jack Sparrow’s compass not showing any clear direction.

Source: 2019 NFPA Technology Roadmap: Improving the Design, Manufacture and Function of Fluid Power Components and Systems. https://www.nfpa.com/home/workforce/Fluid-Power-Industry-Roadmap.htm

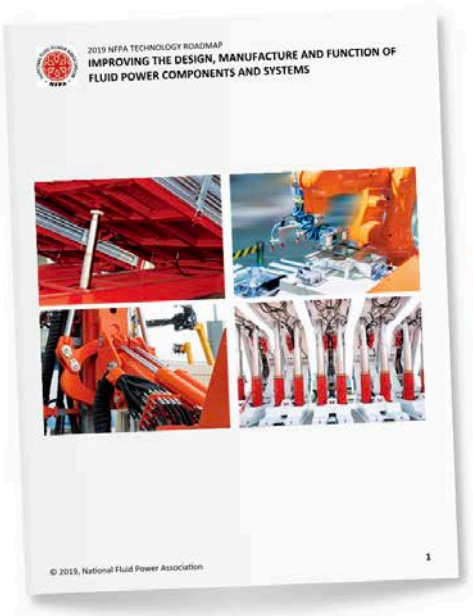
2019 NFPA Technology Roadmap

Don’t get me wrong: it is an impressive document.

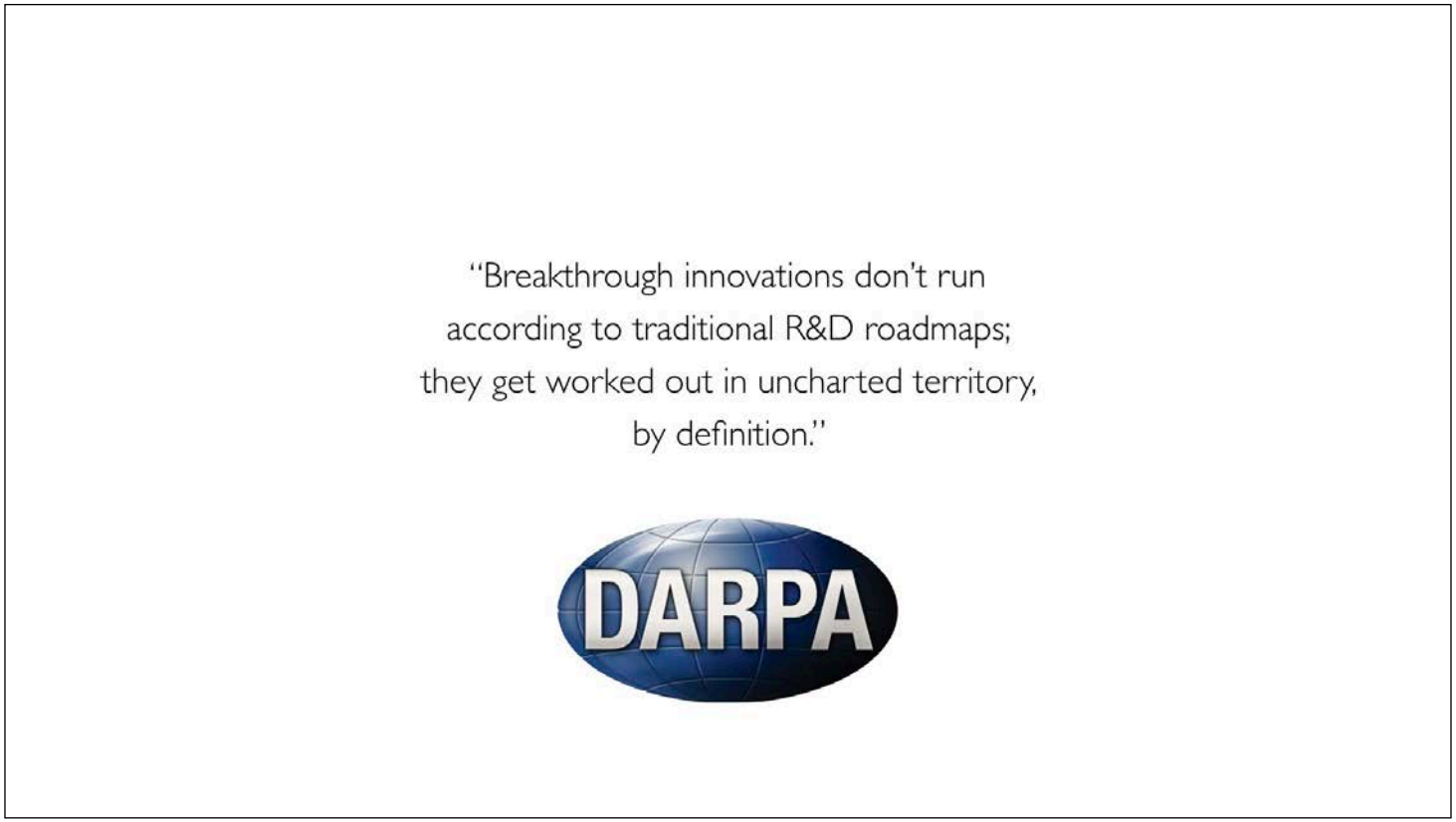
But, in my opinion, the big mistake of the technology roadmap is, that it is a roadmap.

For where we should be going, or where we need to be going, there simply are no roads, there is no map.

2019 NFPA Technology Roadmap



We are going into unknown and uncharted territory. Our map is like this world map from 1664, showing large parts of the US being unknown. We are going to terra incognita.

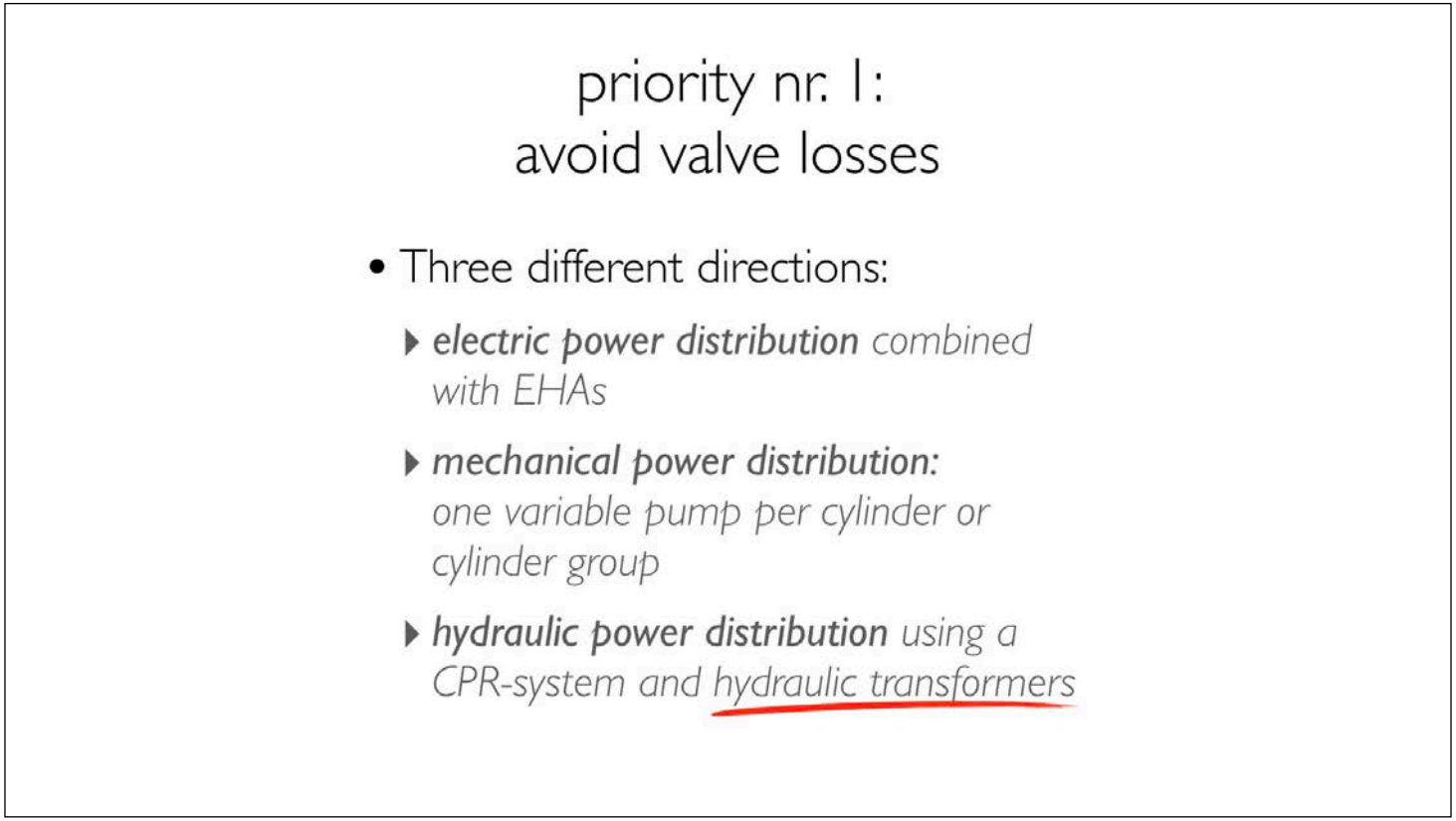


"Breakthrough innovations don't run according to traditional R&D roadmaps; they get worked out in uncharted territory, by definition."

This is a quote from a well known and respected organization called DARPA: The US Defense Advance Research Projects Agency

The most important thing you need when there is no roadmap, is a direction. Leadership is to tell the people where to go, not how to get there.

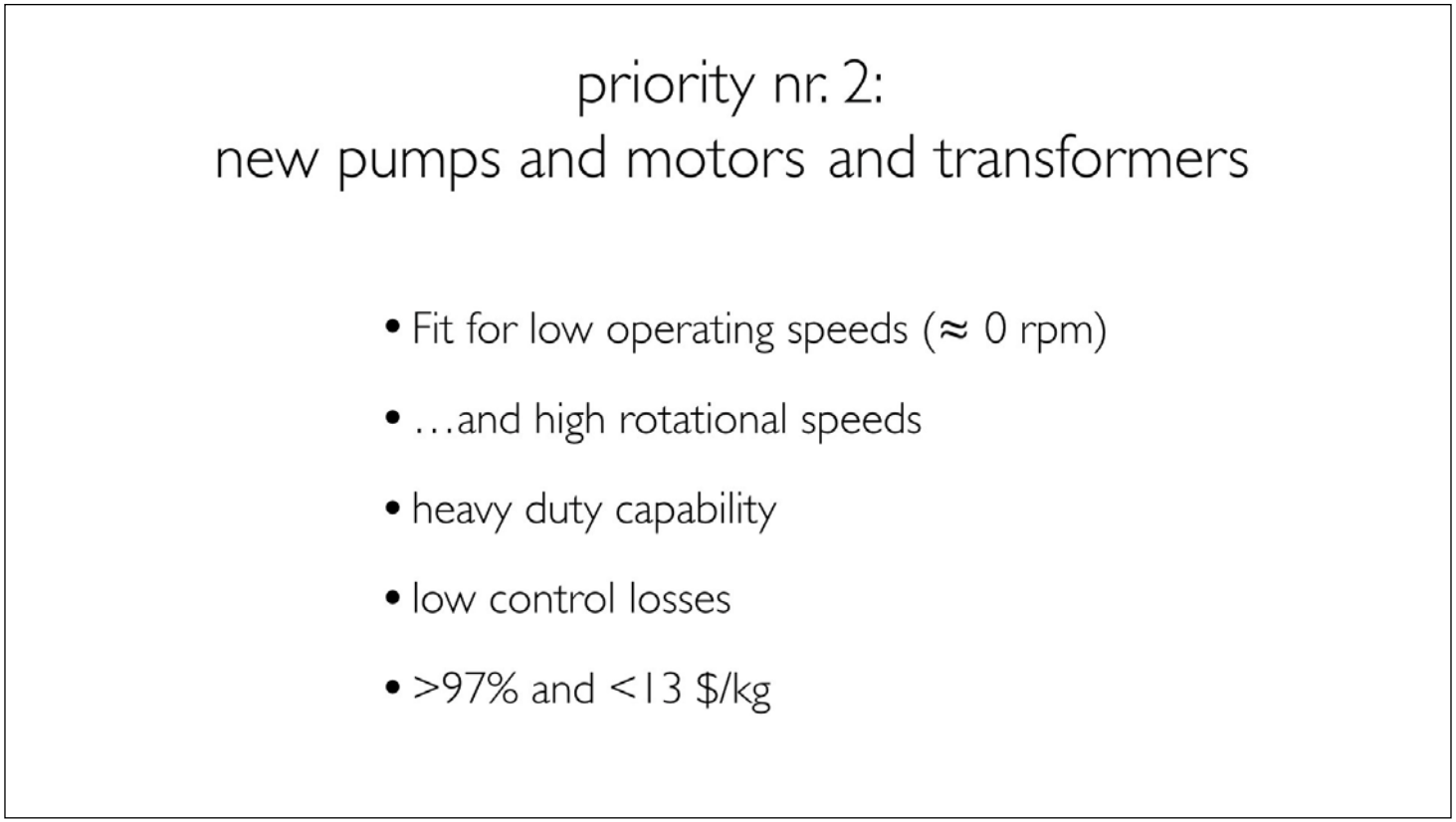
Let me show you where we, as a fluid power community, need to go.
Allow me to be your coxswain, for the next five minutes.



There is absolutely no doubt about the first research priority: We have to get rid of the valve losses in our systems. We have three different solutions, three different ways of distributing power to our loads:

- Electric power distribution, combined with Electro-Hydraulic Actuators or EHAs;
- Mechanical power distribution, in which each hydraulic cylinder or group of cylinders is controlled by means of individual variabel displacement pumps;
- Hydraulic power distribution, by means of a common pressure rail or CPR, in combination with hydraulic transformers.

The last solution is my favourite. It is not only the best system solution, but also the best way to stay in control of fluid power systems and to secure a growth, both in turnover as in profitability.

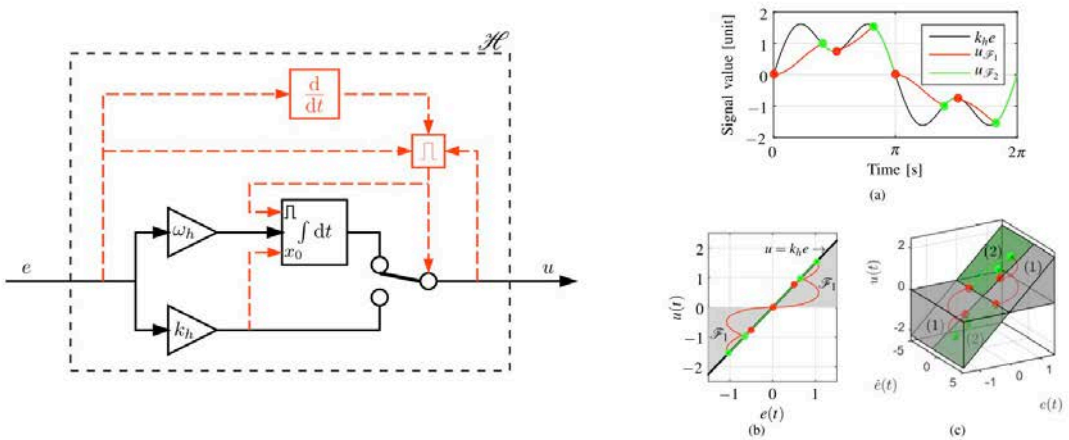


The second priority is to develop completely new hydrostatic machines: pumps, motors and hydraulic transformers.

Machines that are capable of running in a large speed range, at close to zero rotational speeds, as well at very high speeds, such higher than today. It should also be possible to run the new hydrostatic machines at high pressure levels.

But, most and for all, then new machines need to have a high overall peak efficiency, including low control losses, and need to have low manufacturing costs. In order to become competitive we have to reduce the production costs to the automotive level of below 13 dollar or 13 Euro per kilogram. There is no reason why pumps and motors should have a specific cost of 40-100 $/kg or 40-100 €/kg as is now the situation.

priority nr. 3:
advanced controls

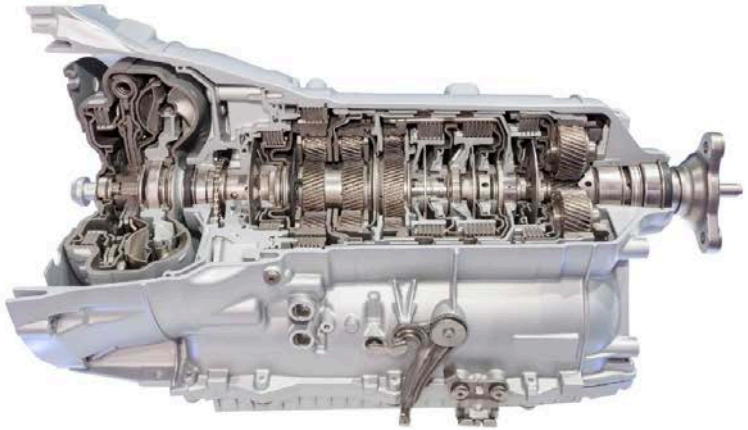


Hybrid Integrator-Gain Switched (HIGS) control

The third priority is that we have to learn more about modern control theory. We need to find new control solutions because we now profit from the strong damping characteristics of our control valves. As soon as we start to develop efficient systems –the first priority– then we end up with systems which are much more prone to oscillations.

We complain that hydraulic systems are different form other technologies because we suffer from strong non-linear behaviour, and large dead bands. But, also in other technologies they have to deal with non-linearities and dead-bands, and they found solutions. Like this hybrid integrator-gain switched control, which I would love to see tested in a hydraulic control system.

priority nr. 4:
reduce costs of systems & components

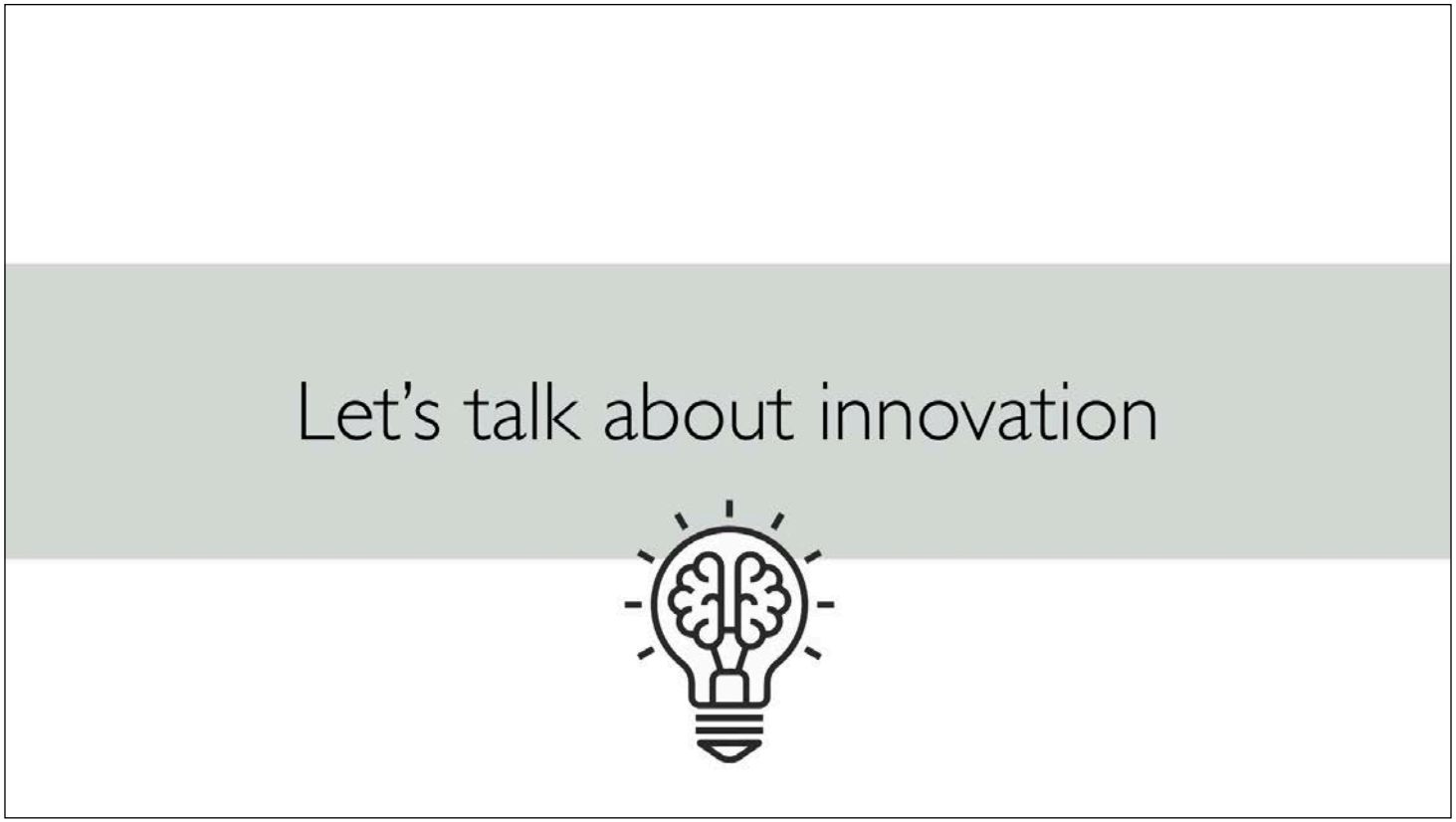


compete with mechanical transmissions

Finally, we have to find a way to reduce the costs of both our components and our systems. We have to compete with mechanical transmissions. There is no reason why we can't.

INNOVATION

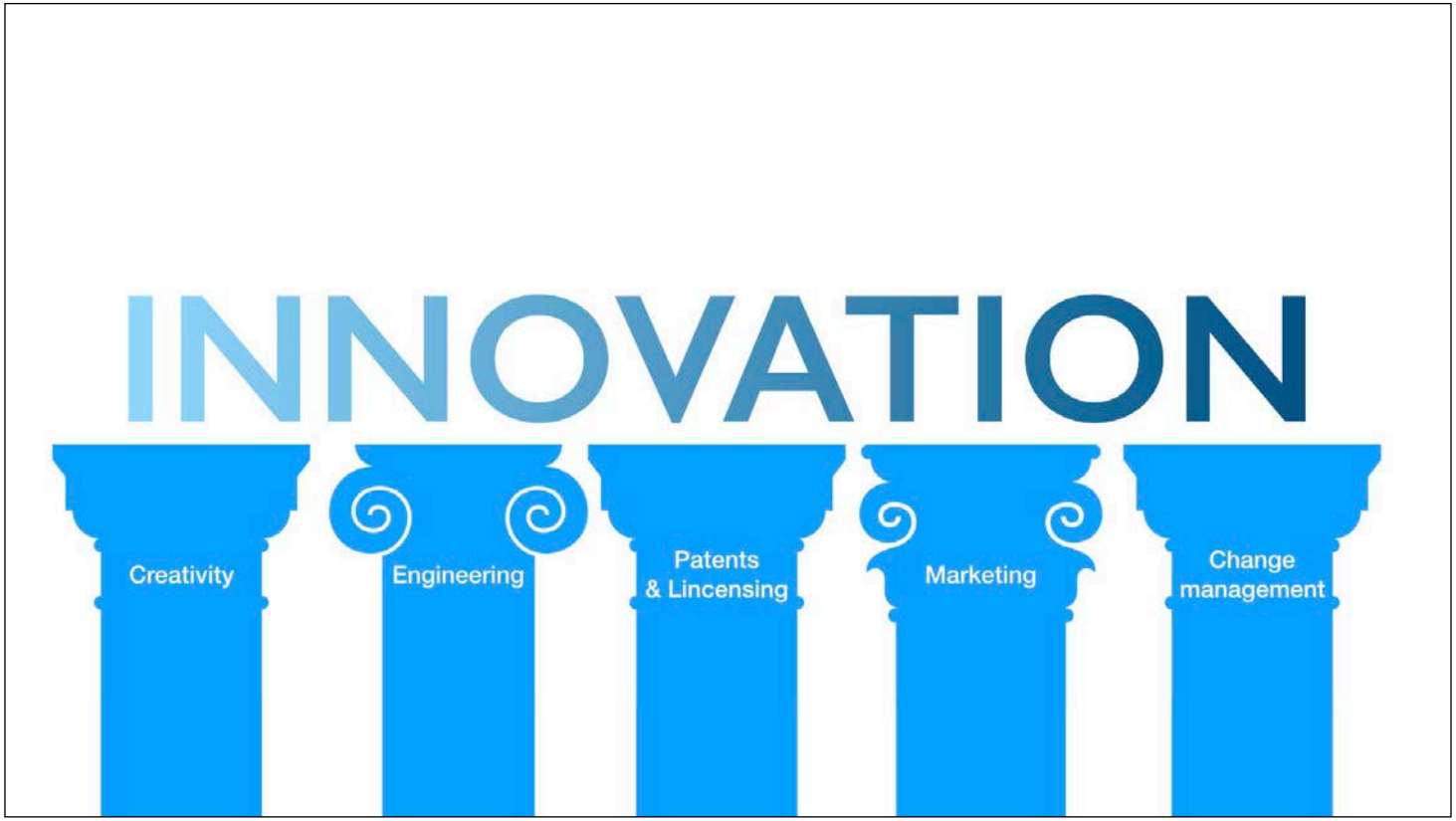
We can’t achieve these combined goals and priorities with just a single invention: we need many ground breaking solutions. We desperately need real innovation.



So, let's talk about innovation. Let's go on an adventure into uncharted territory.

First of all, let me take away some misconceptions about innovation:

- It is often said that innovation is too expensive. But there is a complete library of books that proof the opposite. A recent research showed that companies, that fail to innovate, generate 12% less revenue, are 32% less profitable, and are worth 17% less
- The second misconception is that innovation can simply be solved by means of a brainstorms. Let me free you from this delusion: brainstorms don't work
- Another delusion is that computers can invent. They can't come up with fundamental disruptive innovations. At least, not yet.

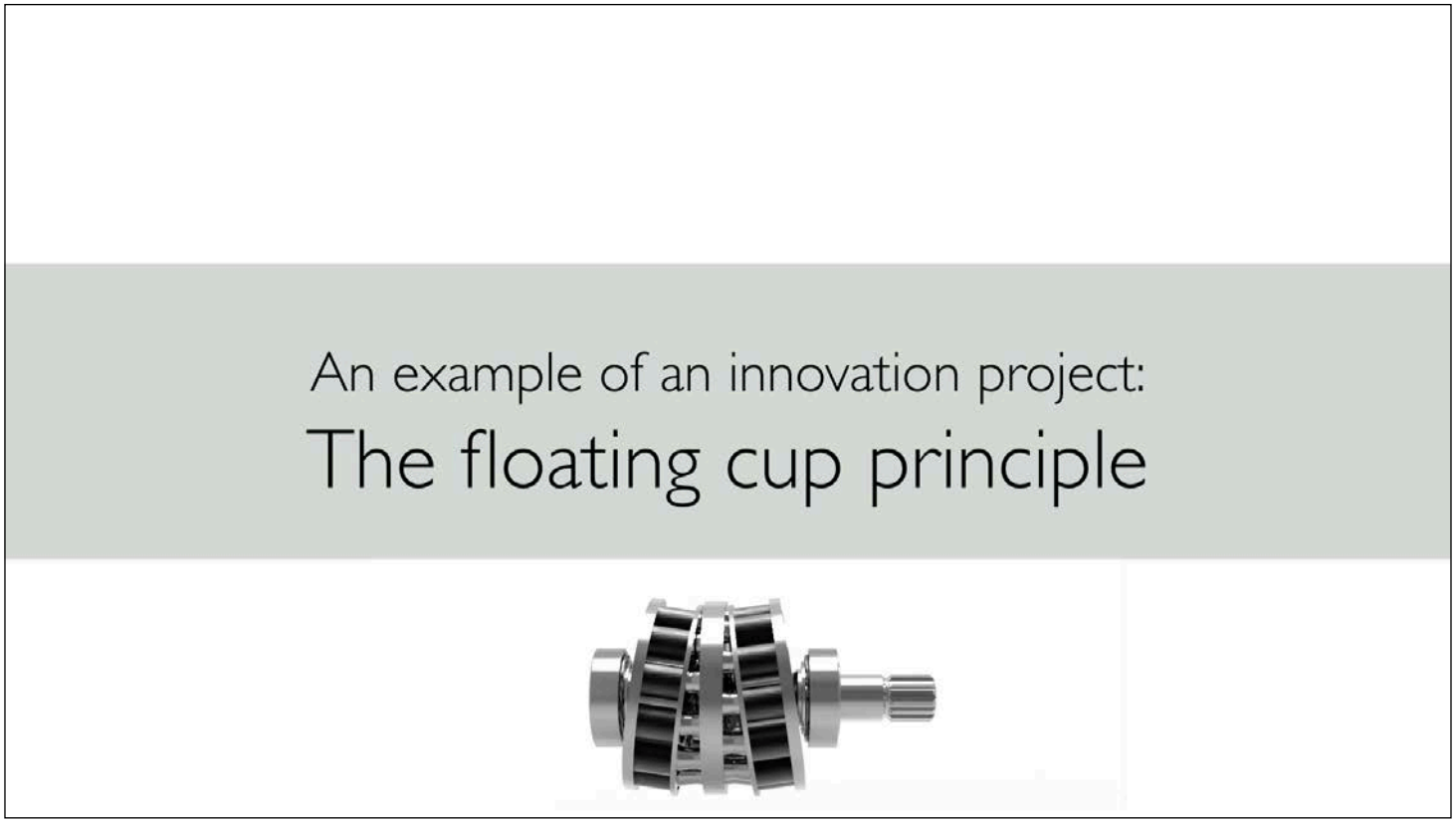


So if brainstorms don't work, and computers can't invent, what does work to make innovation successful?

We, at INNAS, do innovation for more than thirty years. And we learned that five elements are needed. Five innovation pillars:

- Creativity
- Engineering
- Patents and licensing
- Marketing
- and, Change management.

In the next part of my presentation, I will talk about explaining these five pillars by means of an example:

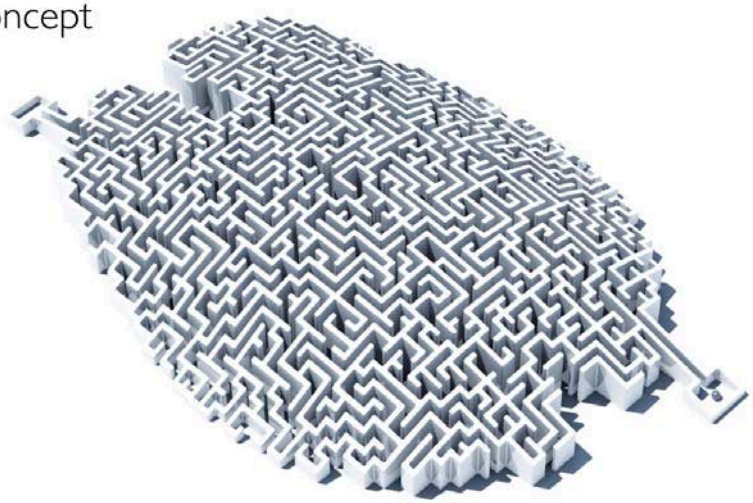


The floating cup principle. I have chosen for this example because I can't speak for other innovations at other companies. I also can't tell you about other developments for which we have signed non-disclosure agreements. But I can tell you, to a certain degree, about the way we found to make the innovation of the floating cup principle successful.

Let's start with the first innovation pillar: creativity.

First steps

- throw the computer out of the window
- find a first concept



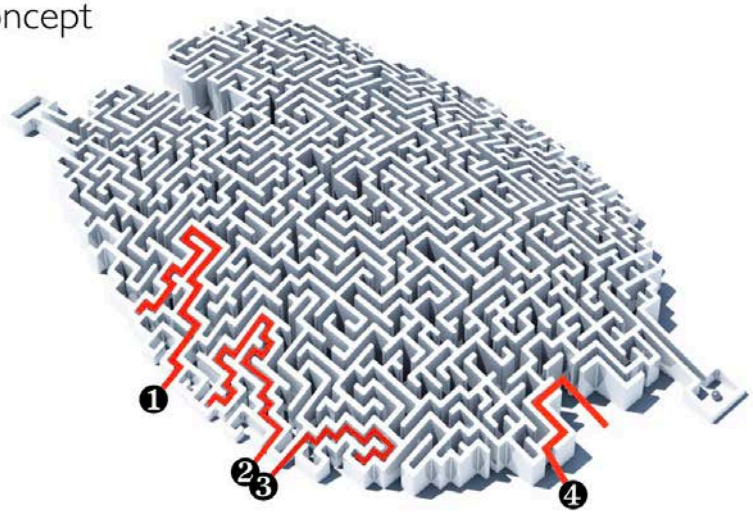
The first step, in any innovation project, is to throw the computer out of the window.

Set yourself a design problem, and try to find a first concept, a first idea of a solution.

At this point you can go in many, almost infinite directions. Like you are looking at a multi-dimensional complex maze.

First steps

- throw the computer out of the window
- find a first concept



There are many entrances to this maze, and most of them end up nowhere, or in a dead end.

Here I show to you four of these wrong entrances, four wrong first concepts.

Look at path number 4. It is going nowhere. It is coming back to the place you started.

From a mental point of view, finding a first concept is the point of maximum uncertainty. And since engineers are like real people, they don't like uncertainty, and try to avoid it.

As a result, engineers try to stay close to what already exists. As a result, they find the same concept. They end up where they started. That is path number 4.

You have to force yourself away from this path. By defining an impossible task. In the example of finding a new pump principle, the task I set myself was to develop a pump which could run 60.000 rpm. Not with the goal to find a principle which could run 60.000 rpm, but it was an effective design challenge to force myself away from the beaten track.

First steps

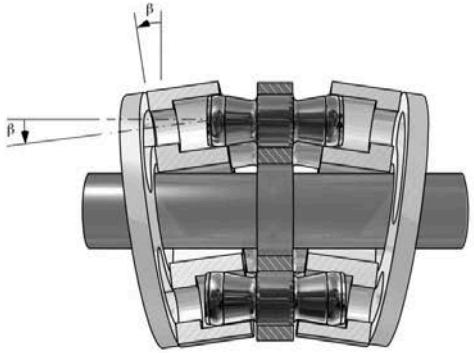
- throw the computer out of the window
- find a first concept

small tilt angle

multi piston

mirrored design

pistons are fixed



no floating cups

piston rings can move

And this was the result. It looks like a floating cup.

- it has a small tilt angle
- it is a mirrored, multi-piston design
- …having the pistons locked into the rotor

As I said: it looks like a floating cup. But it's not.

The cylinders are just bores in a cylinder block. Like in an ordinary axial piston pump.

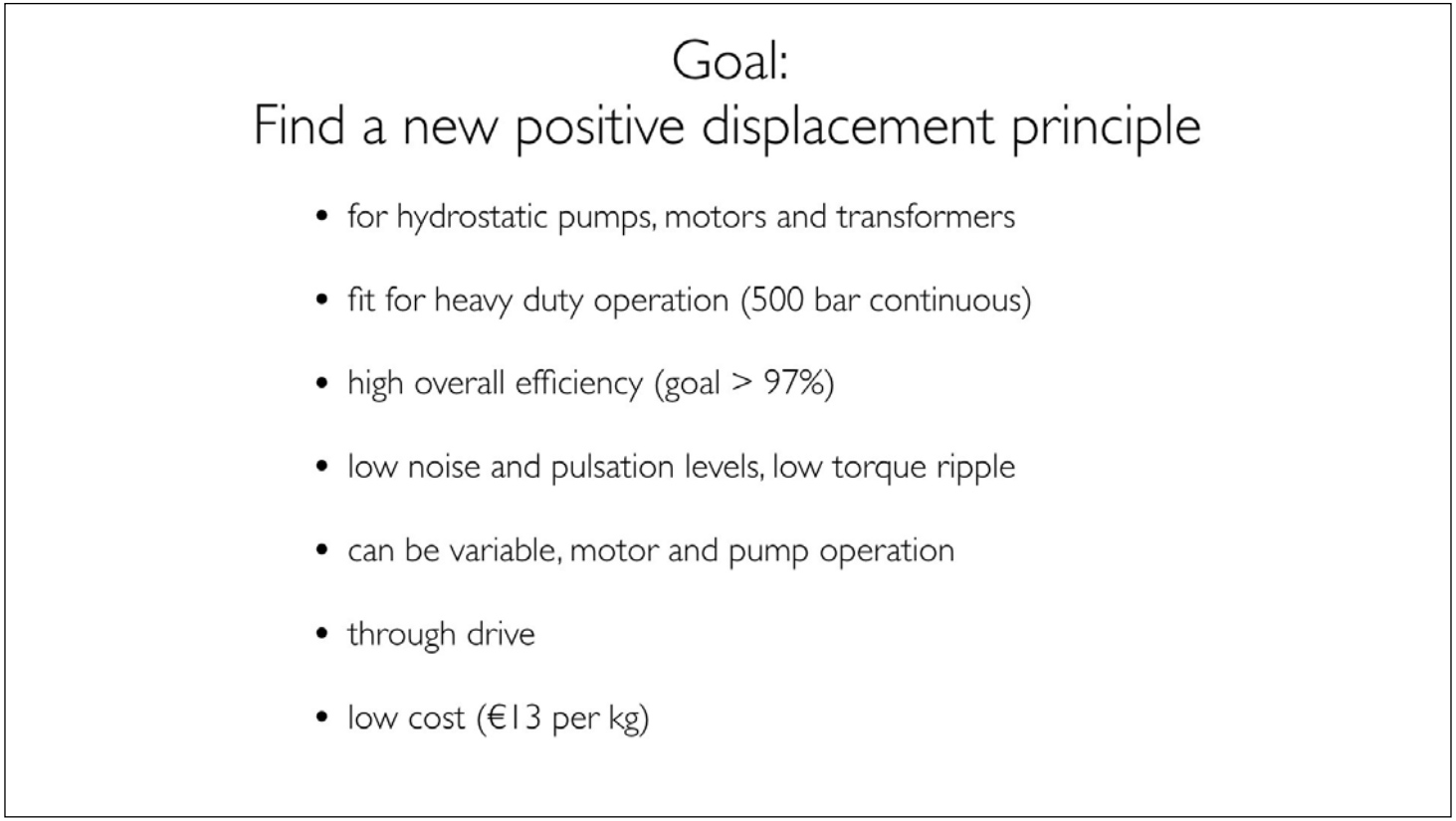
In order to avoid a kinematic conflict between the circular movement from the pistons and the elliptical trajectory they would need to make in the barrel, the piston rings could move.

First steps

- throw the computer out of the window
- find a first concept
- make a team of your best engineers (max. 9 persons)
- get the computers back in
- define a clear goal of the project

Now that you have a first concept, you can set the team to work.

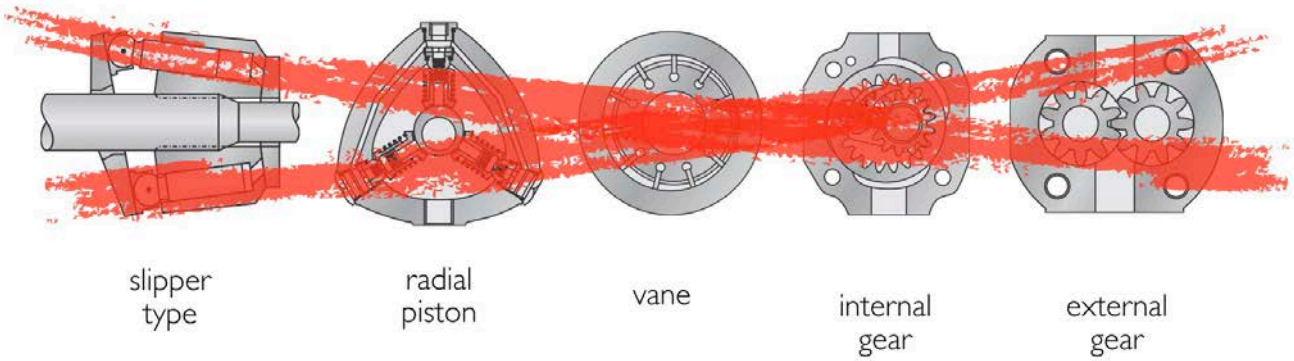
- Select a team of your best engineers, but don't make the team bigger than 9 persons. If you need more disciplines, make the team dynamic or split it in two or three teams;
- Next you have to get the computers back in. They should be the most capable and strongest computers you can get, because you will need to go to the frontier of computing technology;
- Finally, you need to define a clear goal of the project.



This was the outline of the goal of the project which let to the development of the floating cup principle (which didn't have this name at that point):

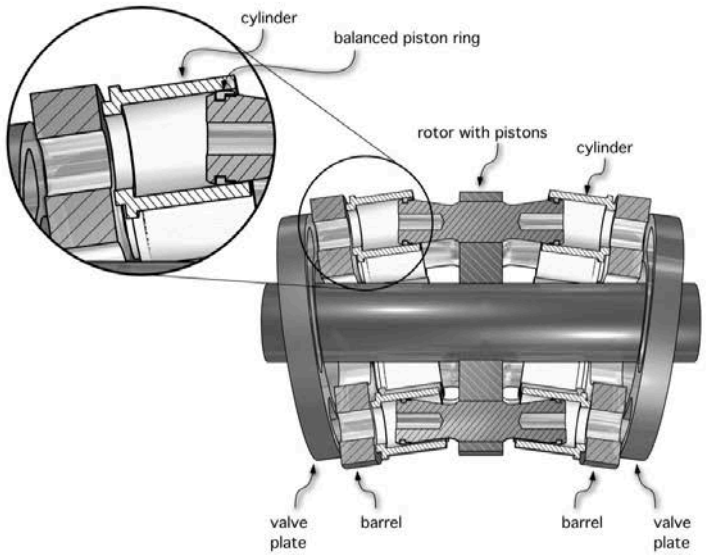
- The new principle should be a solution for pumps, motors and hydraulic transformers;
- It should be possible to run the machines at high operating pressures;
- The overall efficiency should de higher than 97% in the best point;
- Furthermore, the new principle should result in low noise and pulsation levels as well as in a small torque ripple;
- It should be possible to make a variable displacement version;
- The new principle should also have the ability of a through drive;
- Finally, the new principle should have specific manufacturing cost which was and is on par with automotive components, that is a specific production cost of less than 13 Dollar or Euro per kilogram.

Be ambitious



Finally, it is important to be ambitious in this phase of the project. It was our ambition to make all other existing positive displacement principles obsolete and superfluous.

The result



small tilt angle (≈8°)

multi piston

mirrored design

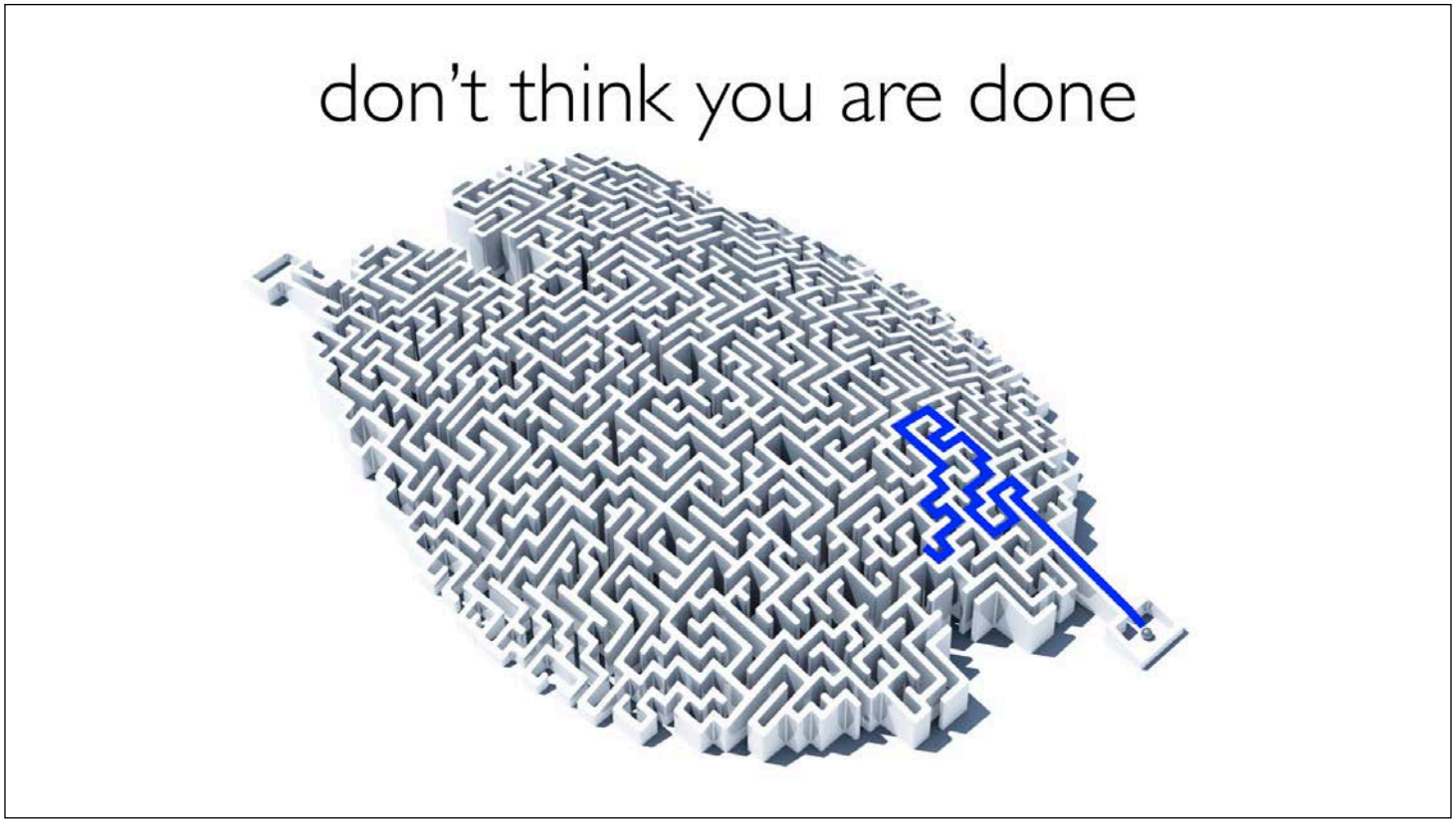
pistons are fixed

floating cups

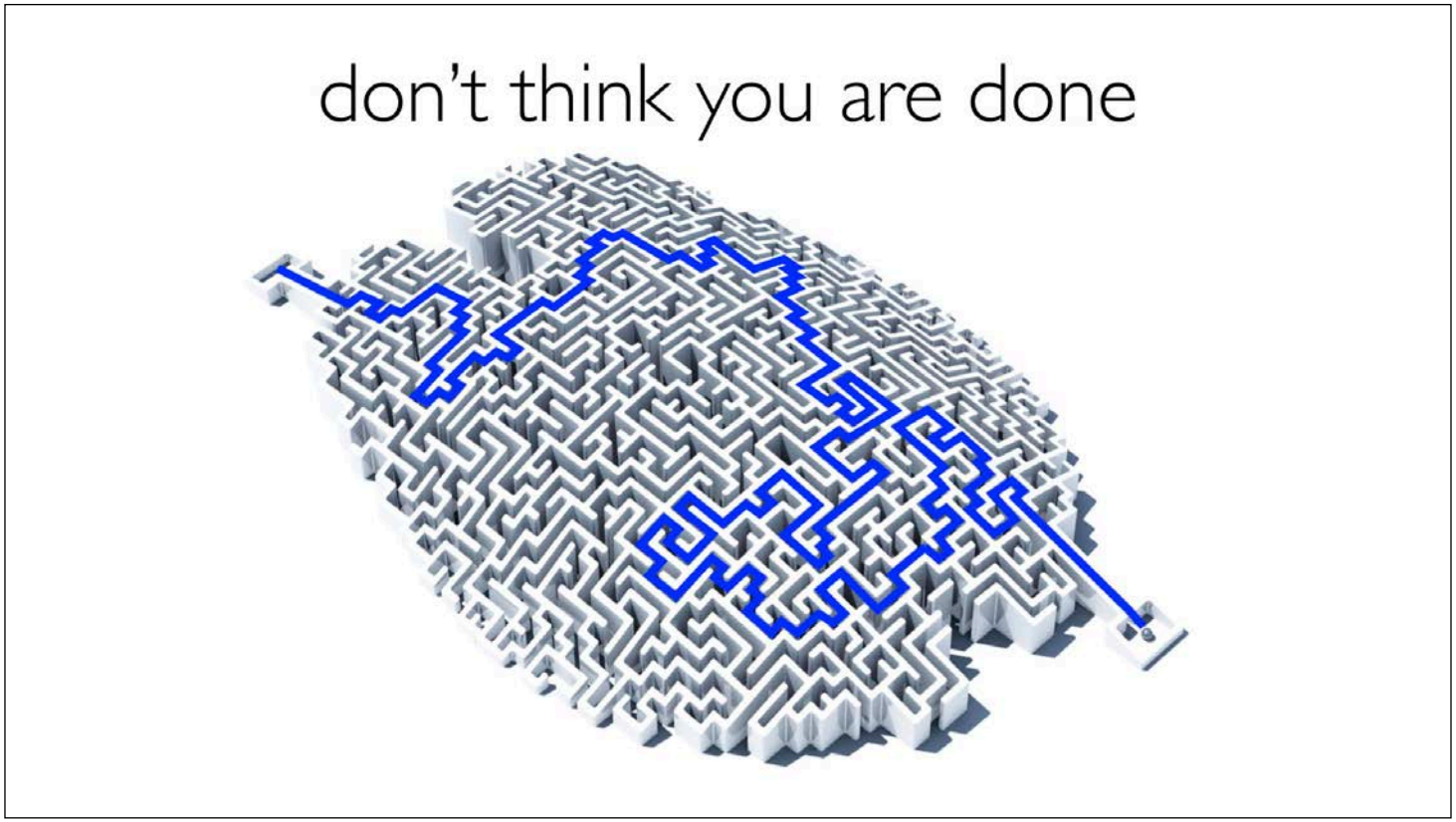
piston rings

And this was the results after many month of hard working and engineering:

It looked like the first concept, with one important difference: this design had cylinders that were disengaged and taken apart from the cylinder barrels. This design had floating cups. It also had pistons rings, which we later on removed.



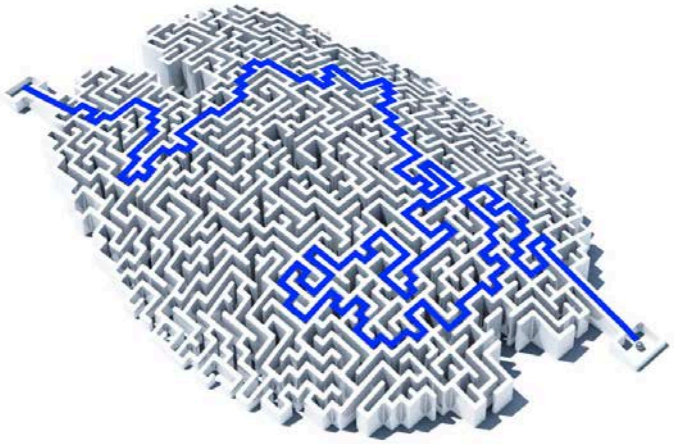
When you arrive at this point, you shouldn’t think you are done. You are not even halfway.



You have to prove the value of your new invention. Which means you have to build prototypes. In our case it meant building pumps, first fixed displacement, and later also variable. In addition, we also build motors.

don't think you are done

- many more design challenges
- many more inventions
- many more patents
- the project takes longer…
- …and the costs increase
- but the value increases as well

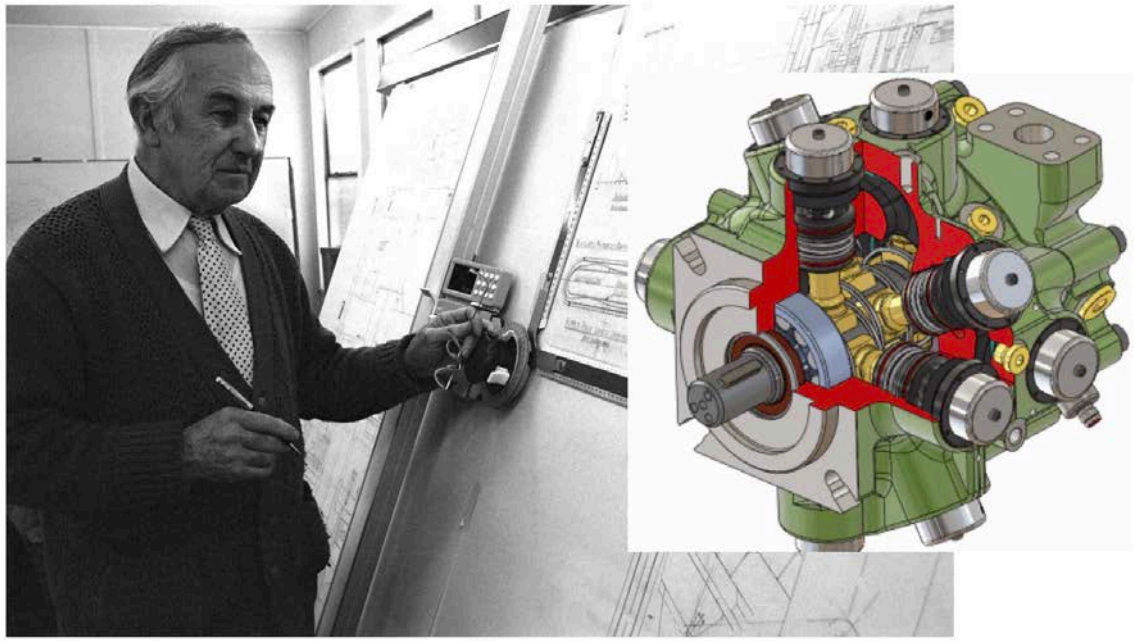


You will have to deal with many more design challenges, which results in many more inventions and innovations. If you are lucky you can get these new ideas being patented.

But, for solving all these issues, the project takes longer and costs more than expected. But the value increases as well. To get to this point, you need strong and mandated management support. Without this support, the project will certainly fail.

Meanwhile, your initial design is being transformed. The end-product can look quite different form the first prototypes.

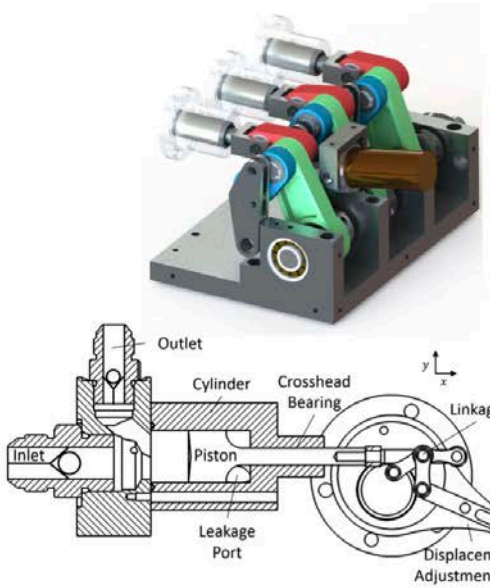
Artemis Digital Displacement

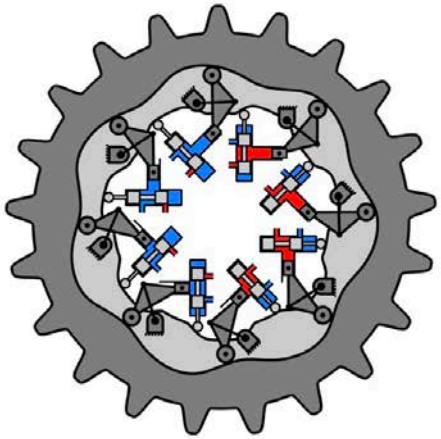


This also happend to the initial design of the Artemis Digital Displacement pump. Here you see a photo from 1985 showing Robert Clerk behind a drawing board. Robert Clerk designed the original Clerk Tri-link, which later on was transformed to a radial piston design.

source: patent WO9105163 (A1)

Adjustable linkage pump





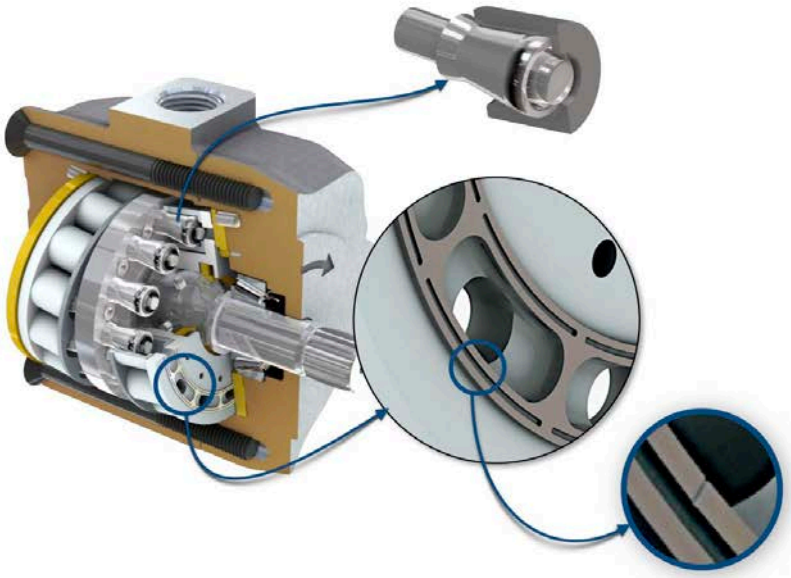
And also the adjustable linkage pump, from Minnesota University, has been transformed. The check valves are gone, it has transformed from an in-line principle to kind of radial piston principle, and it is not even a pump anymore, but a motor.

floating cup

floating cups

no piston rings

new axial bearing



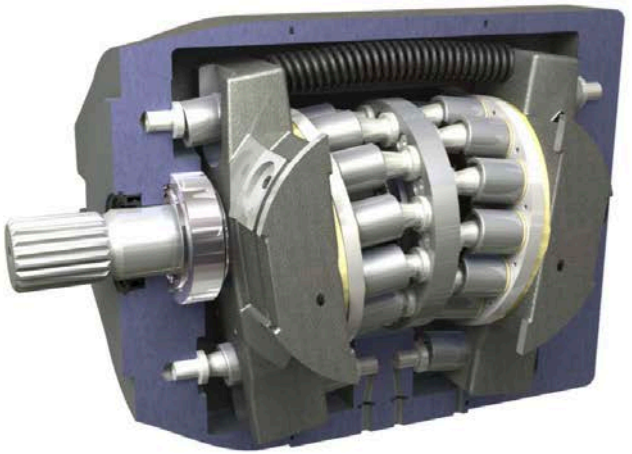
Also the floating cup principle needed to be refined. We eliminated the piston rings to avoid the losses and costs of these rings. Furthermore we developed an efficient solution for the axial hydrostatic bearing between the barrels and the port plates.

floating cup

variable displacement

new control

new oscillation damping



We also had to prove that the principle was viable as a variable displacement pump, for which we had to find new solutions to control the pump and achieve a better way of damping the oscillations of the swash plates.

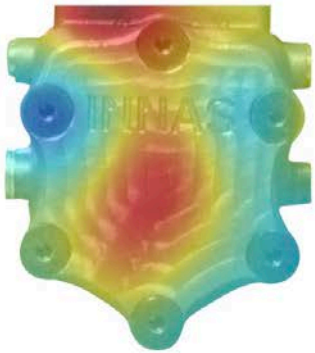
floating cup

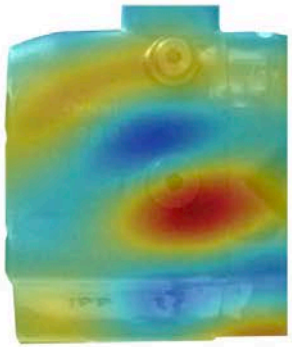
reduce noise levels

reduce pulsations

durability tests

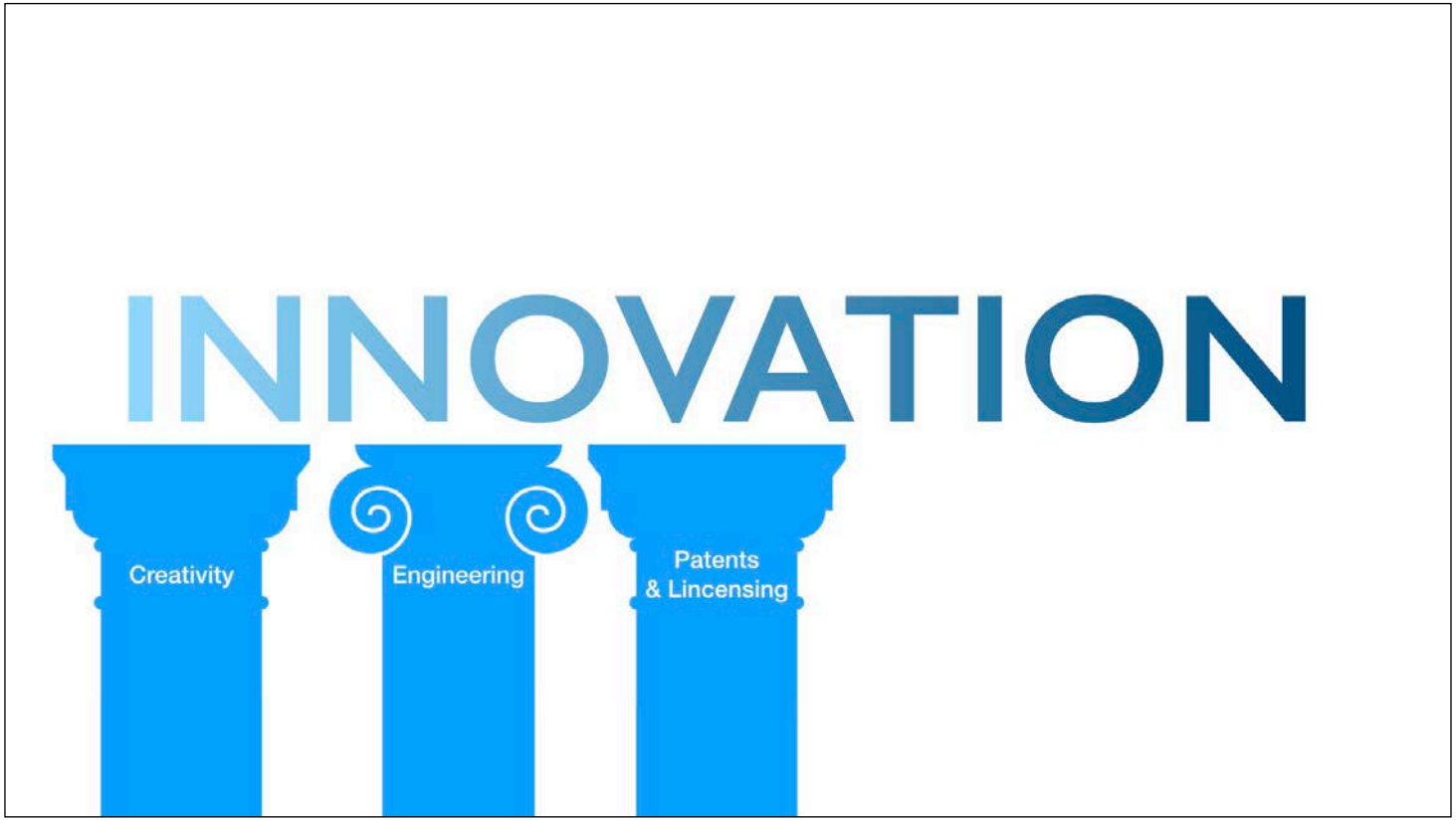
reduce
manufacturing costs





We had to perform extensive research to reduce the noise levels and then pressure and flow pulsations which were generated by the principle.

Finally we had to learn how to reduce the manufacturing costs, without compromising the other performance characteristics, such as noise levels or efficiency.



In parellel with all these activities we needed to work on patent applications, since our final goal was to license the technology.

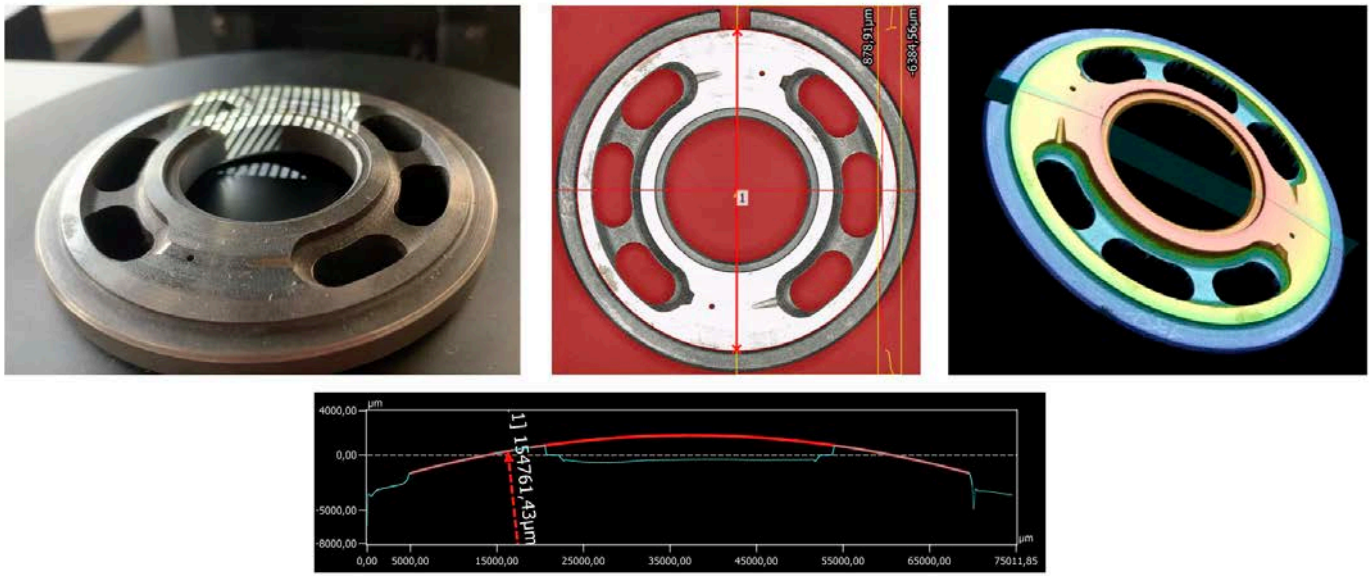
Intellectual Property (IP)

Welcome in the world of intellectual property or IP.

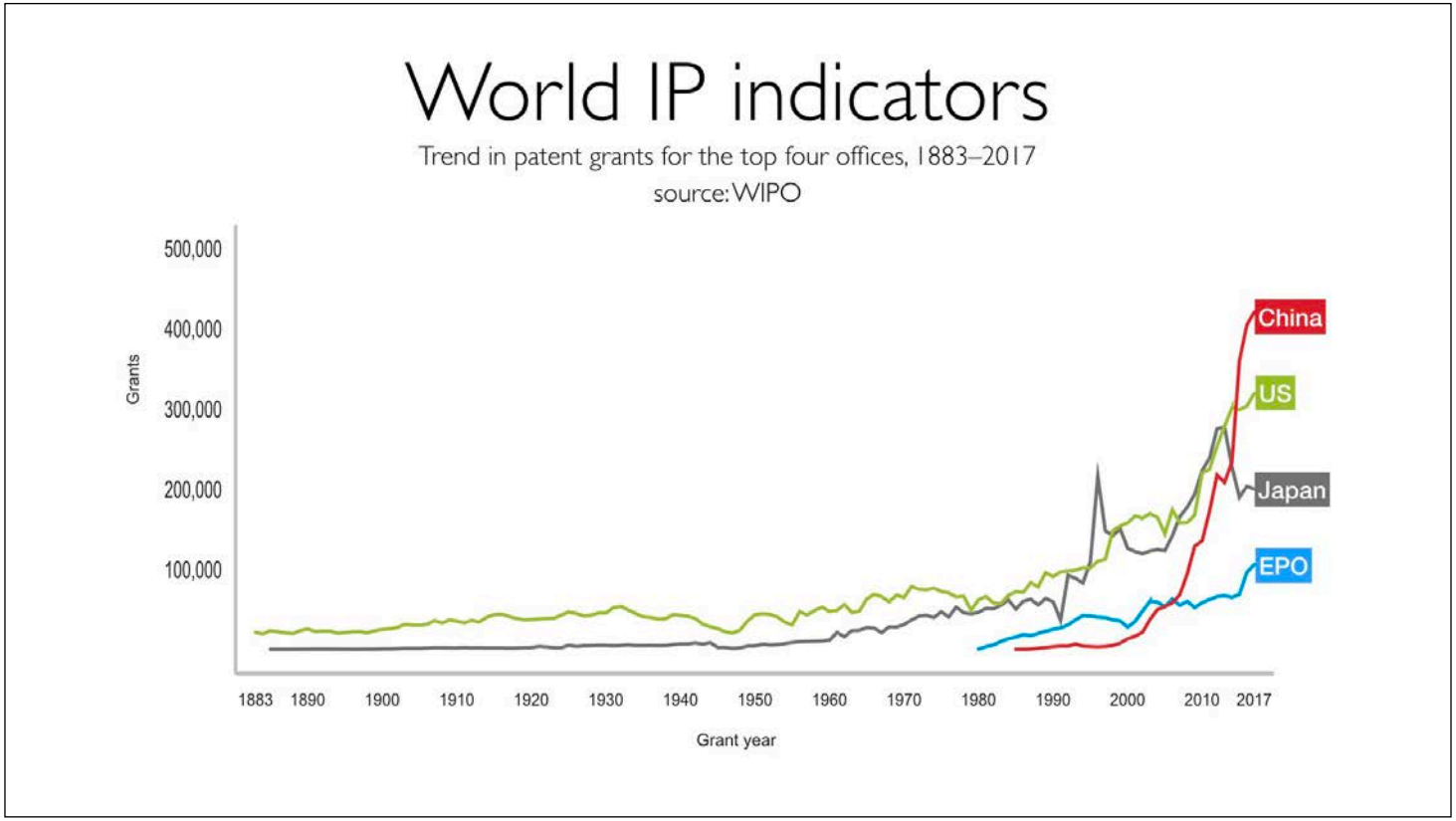
There are many ways to protect your IP. One way is to simply publish your results. This way you can't get any patents, but at least you avoid that others can file a patent on your hard work.

The second way, on the other side of the spectrum is to keep everything secret, hoping that these secrets won't leak to the outside world before you can commercialise your ideas.

the future of reverse engineering



However, this last strategy is no longer tenable. In the last decades the techniques for reverse engineering have progressed to a point that every design can be copied, and every design detail can be revealed, most certainly of mechanical constructions. 3D-microscopes can nowadays measure components in three dimensions with up to a micrometer precision. These photo are taken in our own facility. Reverse engineering of a complete pump is nowadays a matter of a few weeks, which is much more affordable than getting a license on knowhow. Without patents, anybody can copy your designs.

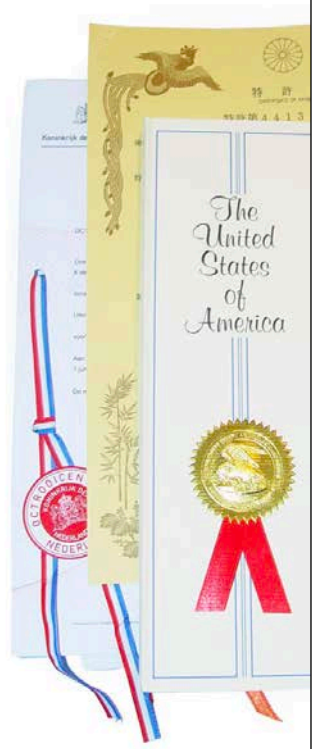


This is also reflected in the number of patents which is granted every year. This diagram shows the annual number of patent grants in the past 134 years. The numbers increase exponentially in the past decade, with China leading the market. In 2017, China filed more patent applications than all other countries in world together.

Source: WIPO IP Statistics Data Center, https://www.wipo.int/ipstats/en/help/

floating cup IP

- 63 patents in 11 countries, including the US, Japan, and China
- 26 new patent applications
- agreements with license partners about IP sharing
- constant renewal of IP is needed



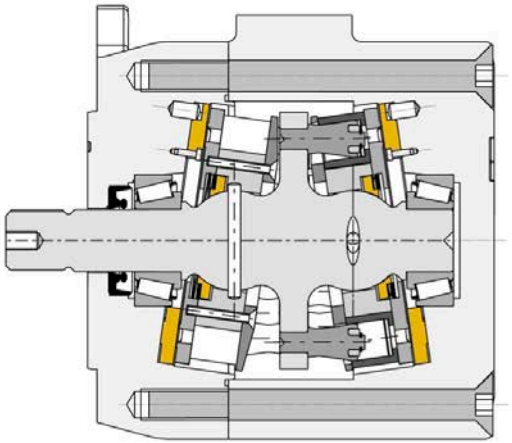
In the previous years we have obtained 63 patents in eleven countries, including the US, Japan and China. In addition we have another 26 patent applications running at the moment.

We also included paragraphs in the agreements with our license partners about patent sharing for new developments.

Patent portfolio management is a constant ongoing activity.

Patenting has therefore become an essential part of protecting our IP. But it is not the only way. We also keep knowhow secret. And we publish some of the knowhow which we believe is hard to patent, but at the same time want to avoid that others would be successful in getting a patent application in one or more countries.

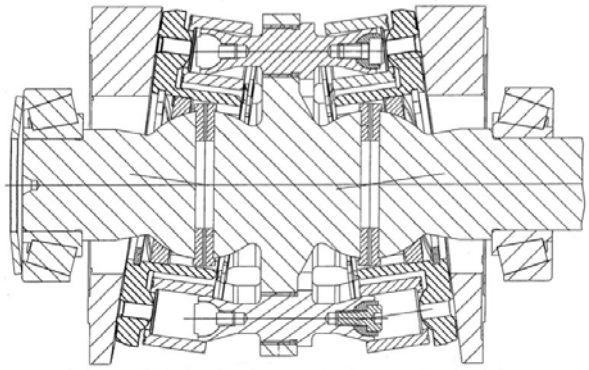
You'll get competition



Floating Cup Principle (2002)
INNAS

You should be aware that, as soon there is a chance that you might become successful, you will get competition from other companies. In 2002 we filed the first patent application for the floating cup principle.

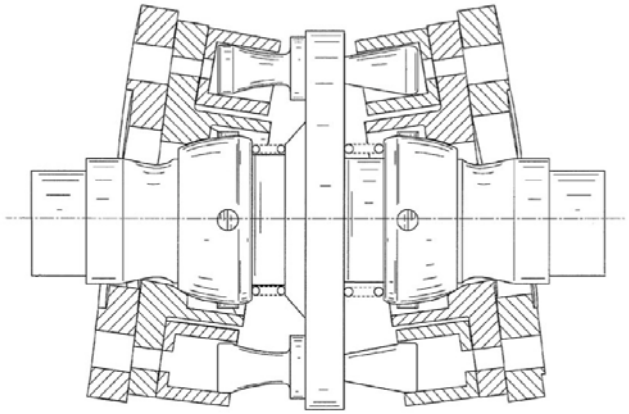
You'll get competition



Doppelkugeltriebwerk (2007)
Bosch Rexroth

Already in December 2003, Bosch Rexroth filed a competing patent application, very similar to the floating cup principle. This is a drawing from one of the many following patent applications from Bosch Rexroth. This patent application was published in 2007.

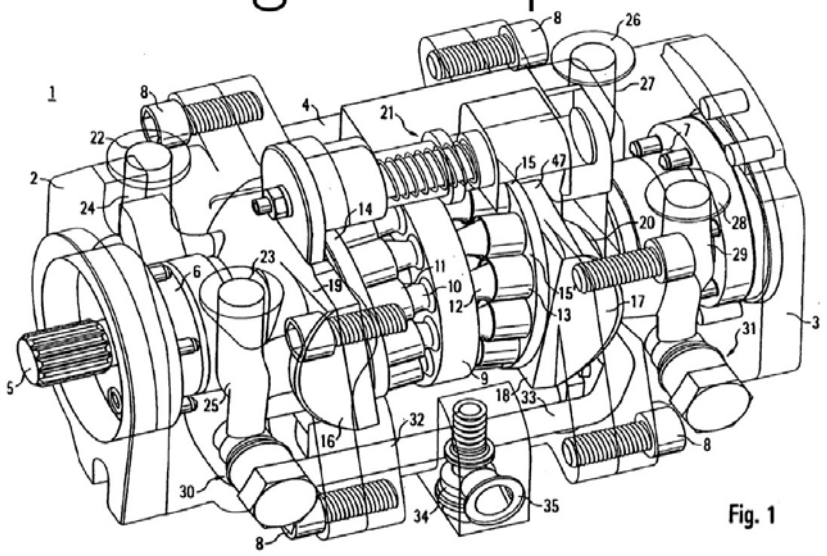
You'll get competition



Floating Cup (2008)
Caterpillar

One year later, Caterpillar followed with another nine patent applications.

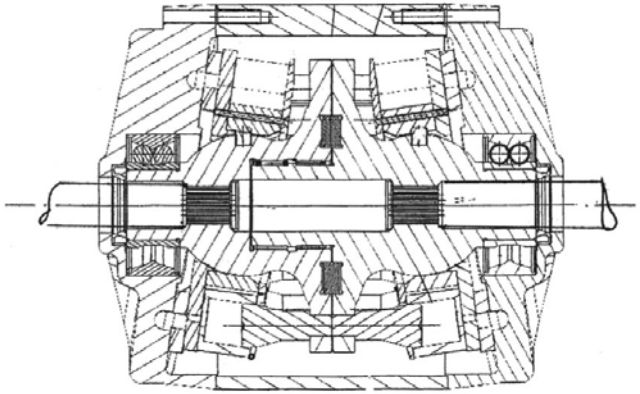
You'll get competition



Hydrostatic piston machine according to the Floating Cup concept (2009)
Brueninghaus Hydromatik (Bosch Rexroth)

Aside from Bosch Rexroth, the Brueninghaus Hydromatik division from Bosch Rexroth also filed patent applications on the floating cup principle.

You'll get competition



Module Hydraulique Compact (2013)
Technoboost/Peugeot Citroen

…as did Technoboost, a subsidiary from Peugeot Citroen.

If we wouldn't have taken the initiative in protecting our IP, we would not have been able to license our technology, which was the final goal of our investments.

License (if needed)

So there you are. You performed the creative task of finding an interesting and valuable first concept. You did all the engineering and patenting.

At this point, you have to make an important decision:

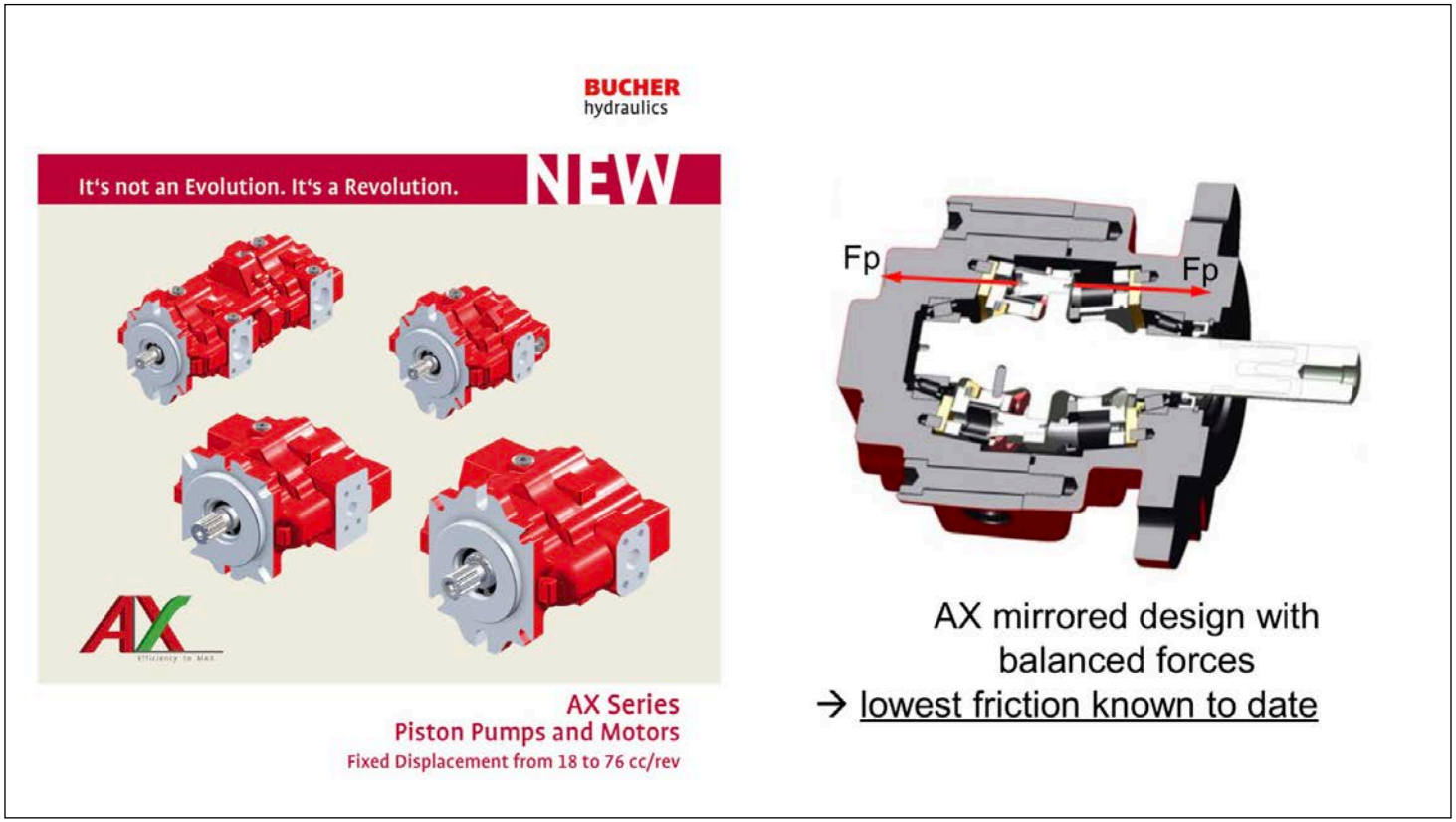
Start your own production line, or decide that others are much better in manufacturing, sales, service and after-sales than you are and decide to license the technology.

If this is also you decision,…

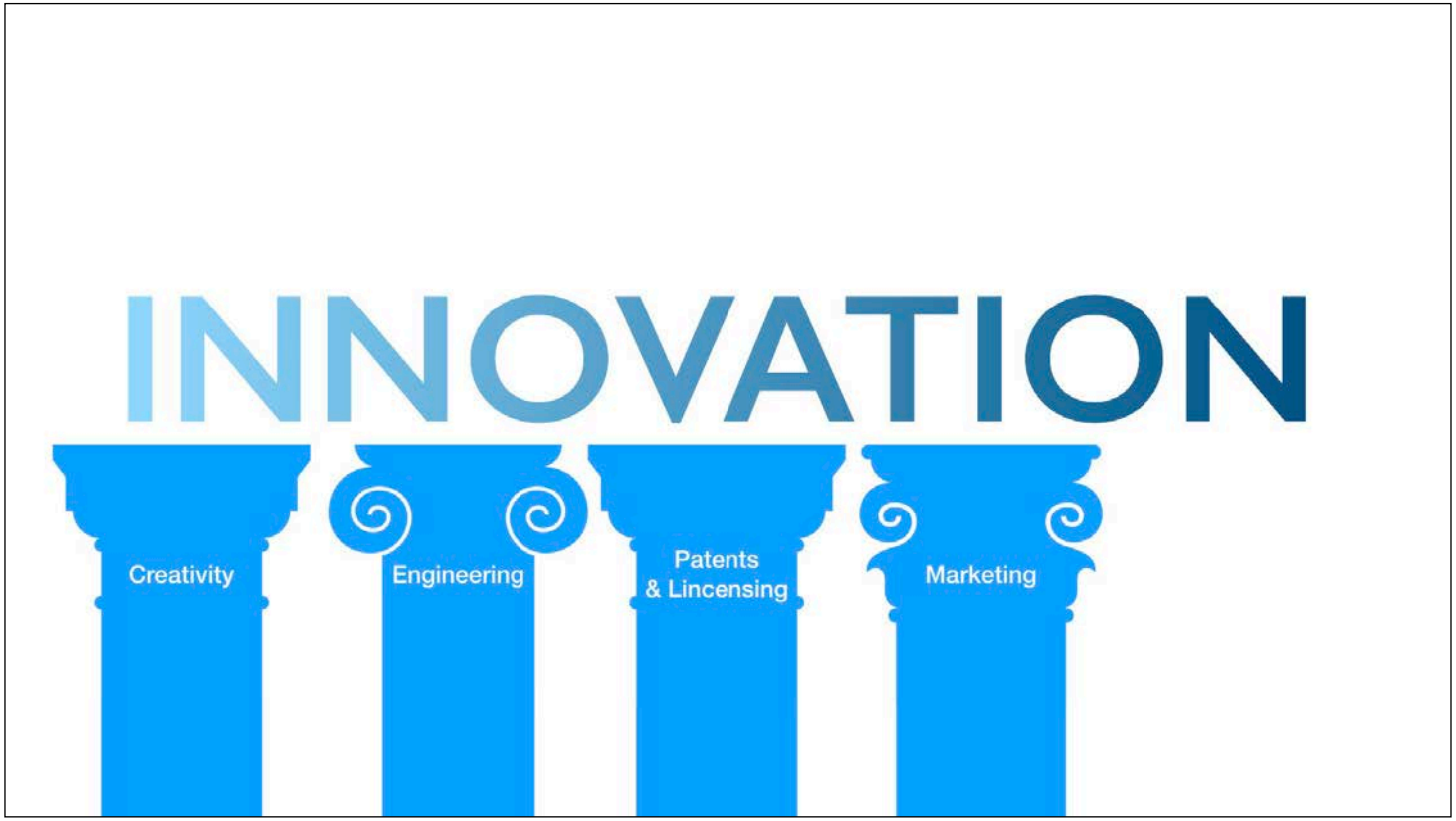
…then you'll end up at a table like this. You will have to learn to negotiate: the strategic game of giving and taking. And you will have to learn about law, especially international patent law.

I started to like this part of the innovation when I realised how much creativity is needed to come to an agreement. These are some of the many questions that need to be answered. They are not isolated but are related: a world-wide license for a large field of use is for instance more valuable than a geographical limited license for a small field of use.

It’s a kind of maze in itself where both parties have to find their way.
The final result always needs to be a balanced win-win-result.



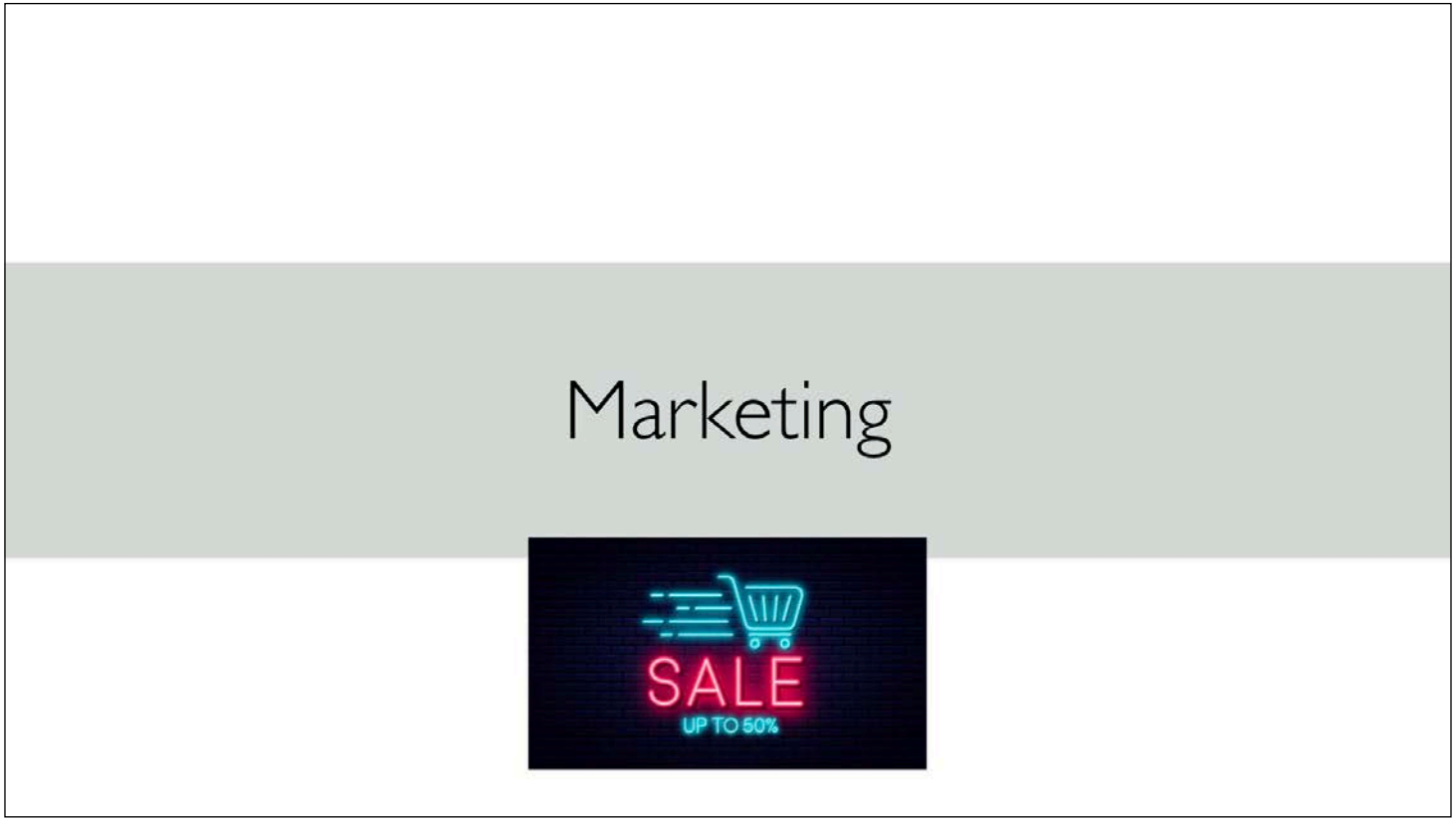
Although we are not allowed about the nature of our relationship with Bucher Hydraulics, we are very proud that we came to a solution which allowed Bucher Hydraulics to produce pumps and motors on the basis of the floating cup principle,



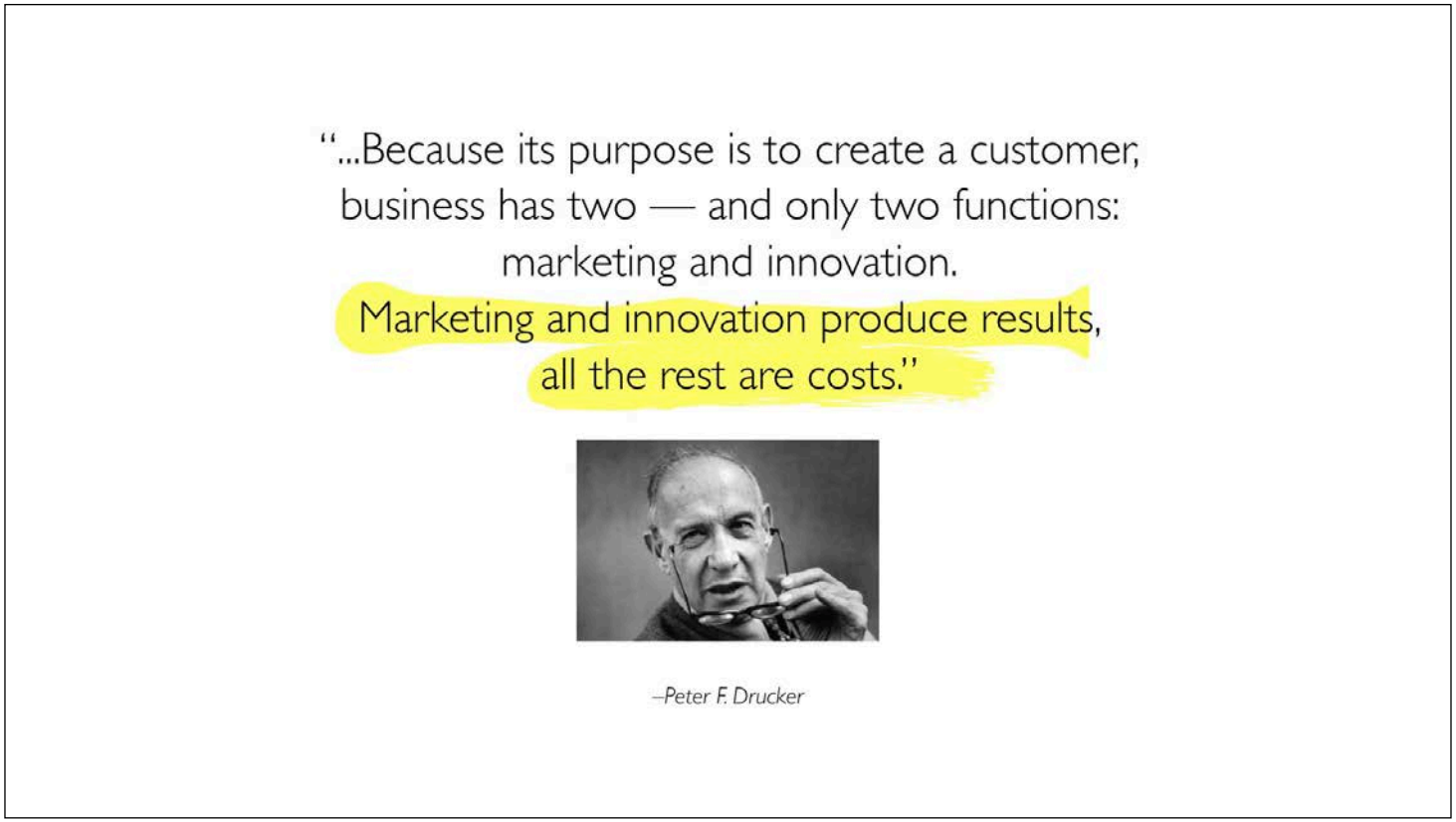
Most of you will accept the idea that you need creativity and engineering to come an innovation. Also the need for patenting and licensing is obvious for most, although most engineers believe that this is an activity for lawyers and management, and not for engineers.

It is our experience that also engineers need to consider IP as a core activity, right from the start of the project. Aside from learning about existing patents, it is important to examine whether your ideas have not been patented before somewhere else, since this would exclude the option of protecting your own IP.

The next pillar to support innovation is marketing.



Now I can hear you thinking: ‘Marketing is not an innovation activity, and most certainly not an engineering activity’. Maybe, this was the case in the old days, but modern innovation management can’t do without marketing.



My favourite quote is from Peter Drucker, the famous management consultant, educator and author:

"Because its purpose is to create a customer,
business has two — and only two functions:
marketing and innovation.
Marketing and innovation produce results,
all the rest are costs."

Marketing and innovation are equally important.

Marketing:

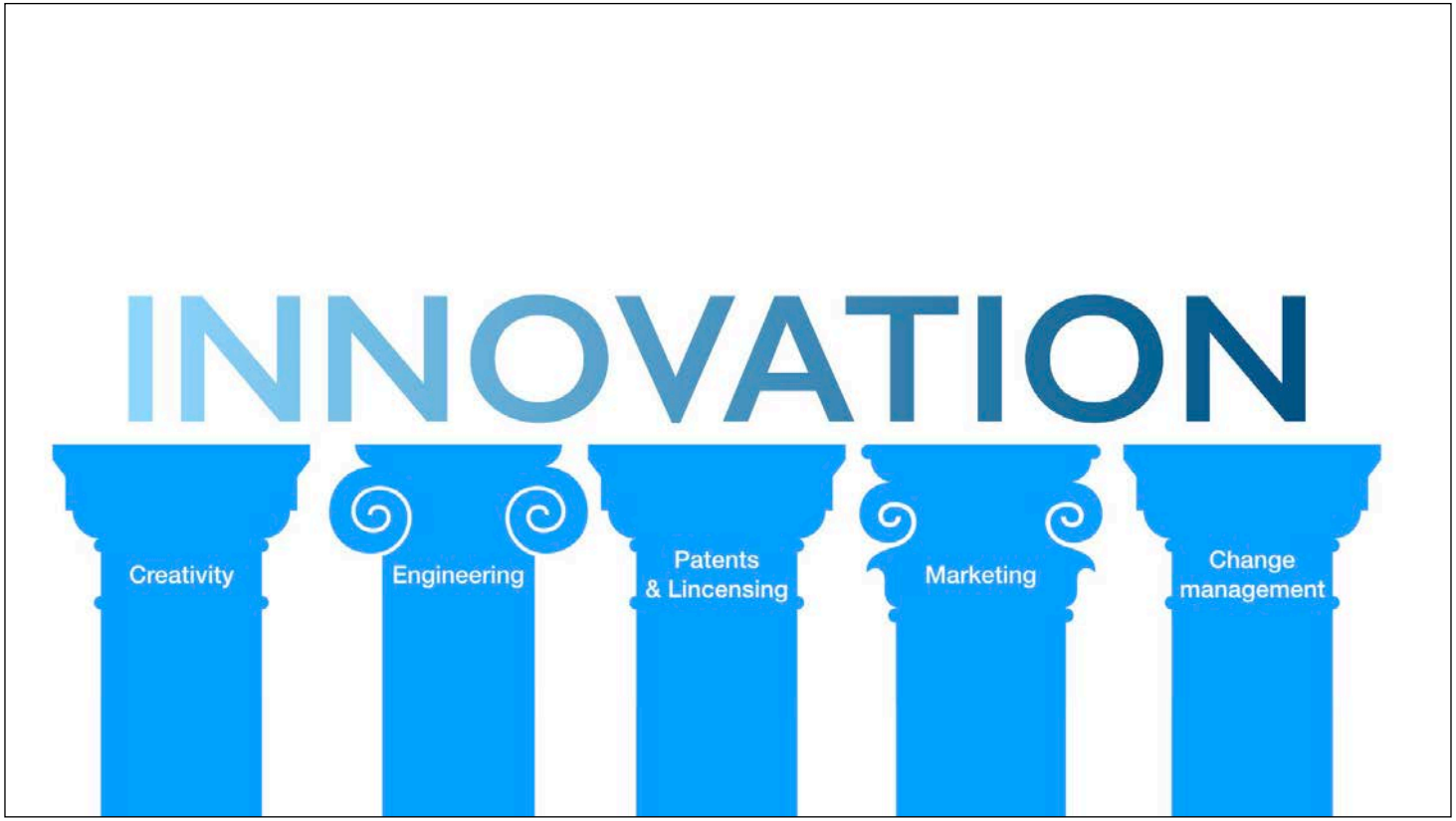
- technology push is not enough
- you also need market pull
- go to fairs and conferences
- write papers and brochures
- build a website
- allow others to test your inventions

In order to get continuous support for your work as a developer, you need to realise that technology push alone is not enough. Yes, you might be very proud about your work as an engineer, about how clever your new inventions is, but you will become frustrated when you discover that others don't share your opinion and enthusiasm.

Aside from technology push, you need to create market pull. So, go to exhibitions and conferences. Write papers and brochures. Build a website, and allow others to test your inventions.

You will have to accept that your financing problem is a marketing problem.

And maybe it also helps you to accept marketing as a necessary element, when you learn that the essence of marketing is teaching.

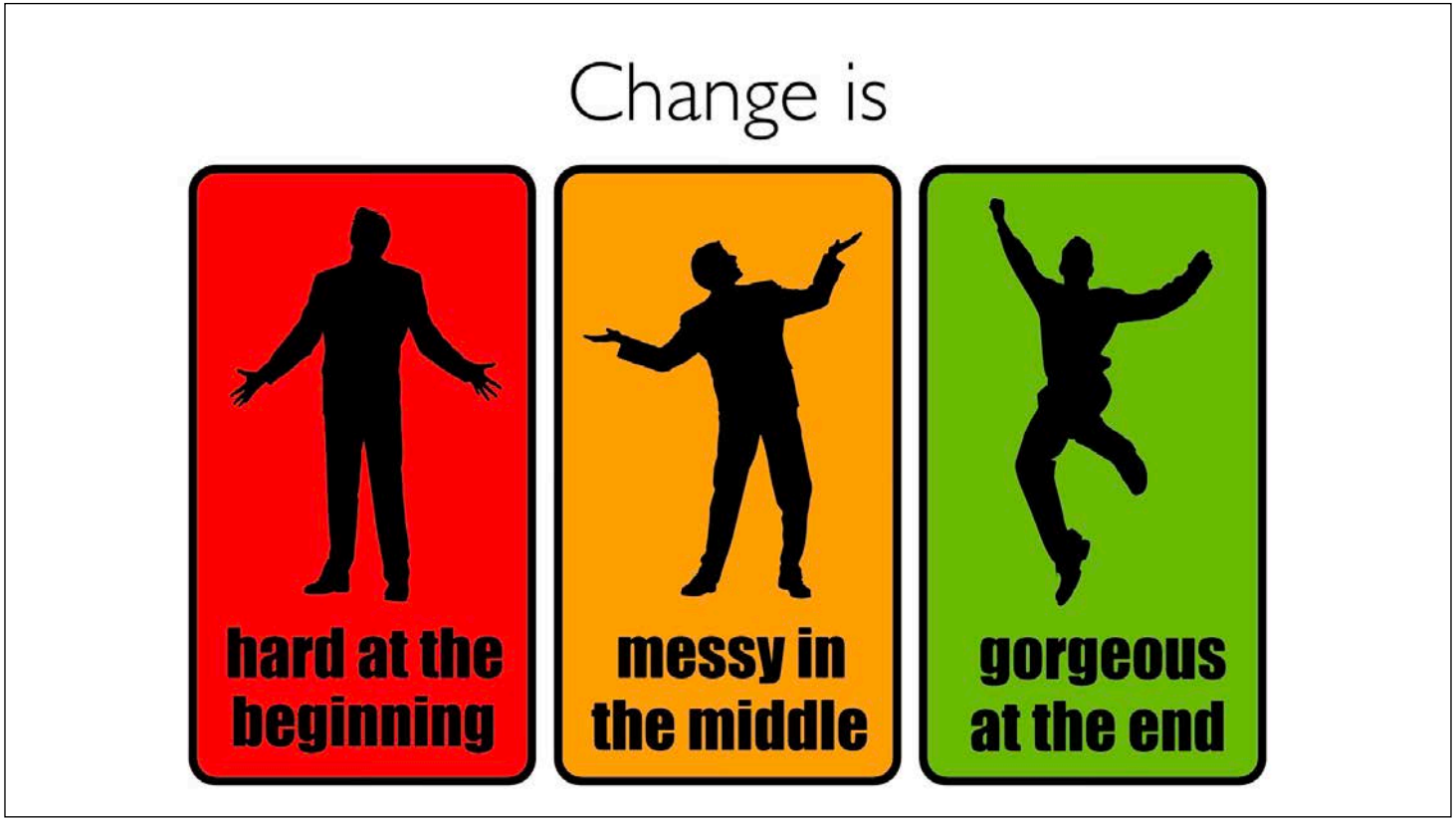


Which brings me to the last pillar of innovation. I told you that others will not share your enthusiasm about your brilliant invention. Don’t be frustrated, but learn about the theory of change management.

Change management

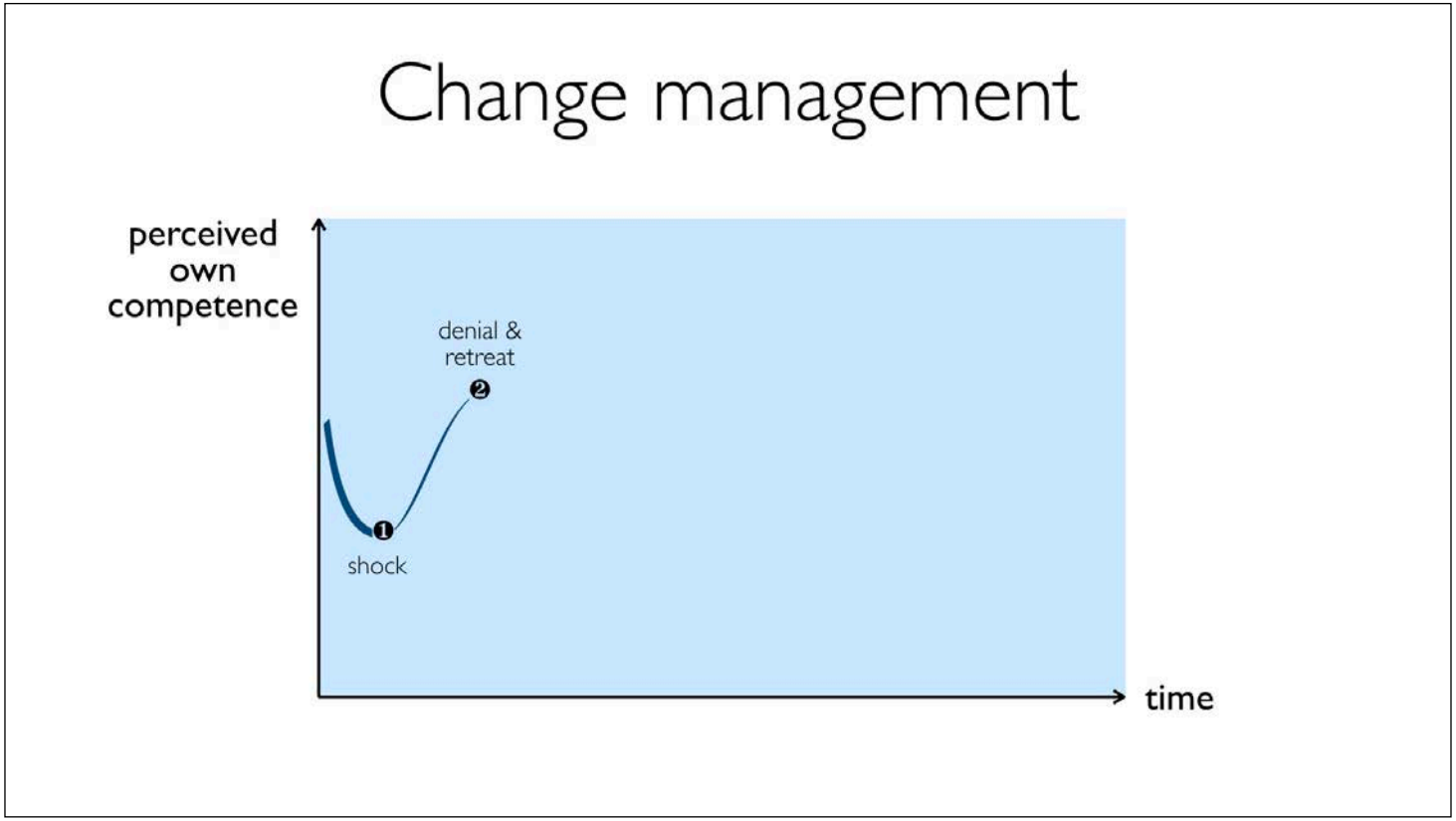
As I've said at the beginning, innovation is about change. We all like change, don't we? And we hate dealing with people who resist change. The kind of people that holds on to traditions and tries to keep things as they are.

Well, guess what? We are those people. We all try to avoid change.



The effects of change might be gorgeous, at the end.

But the change process is messy in the middle, and hard at the beginning.

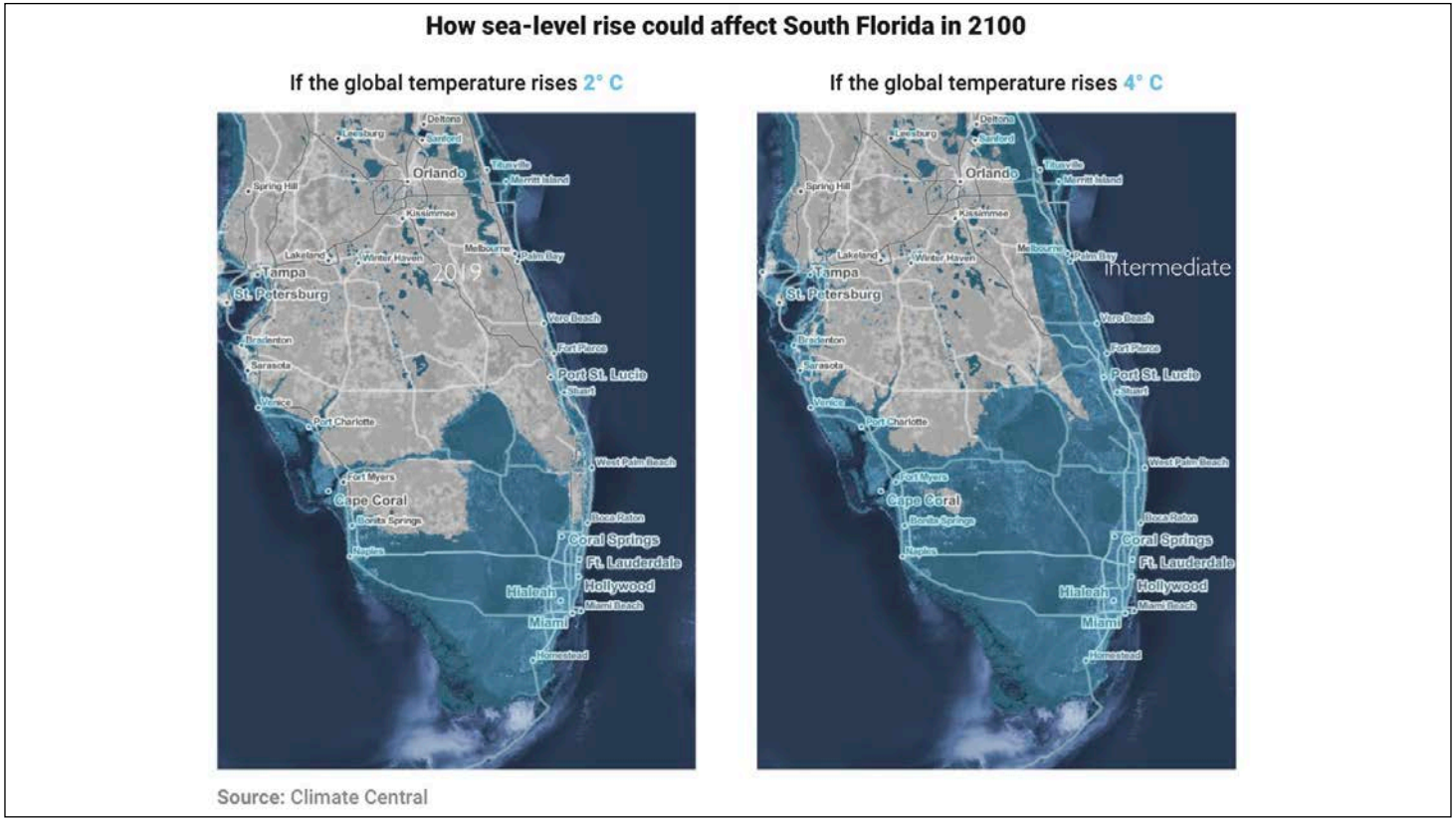


This is illustrated in the so called change curve. It shows the perceived own competence on the vertical axis, and the time on the horizontal axis.

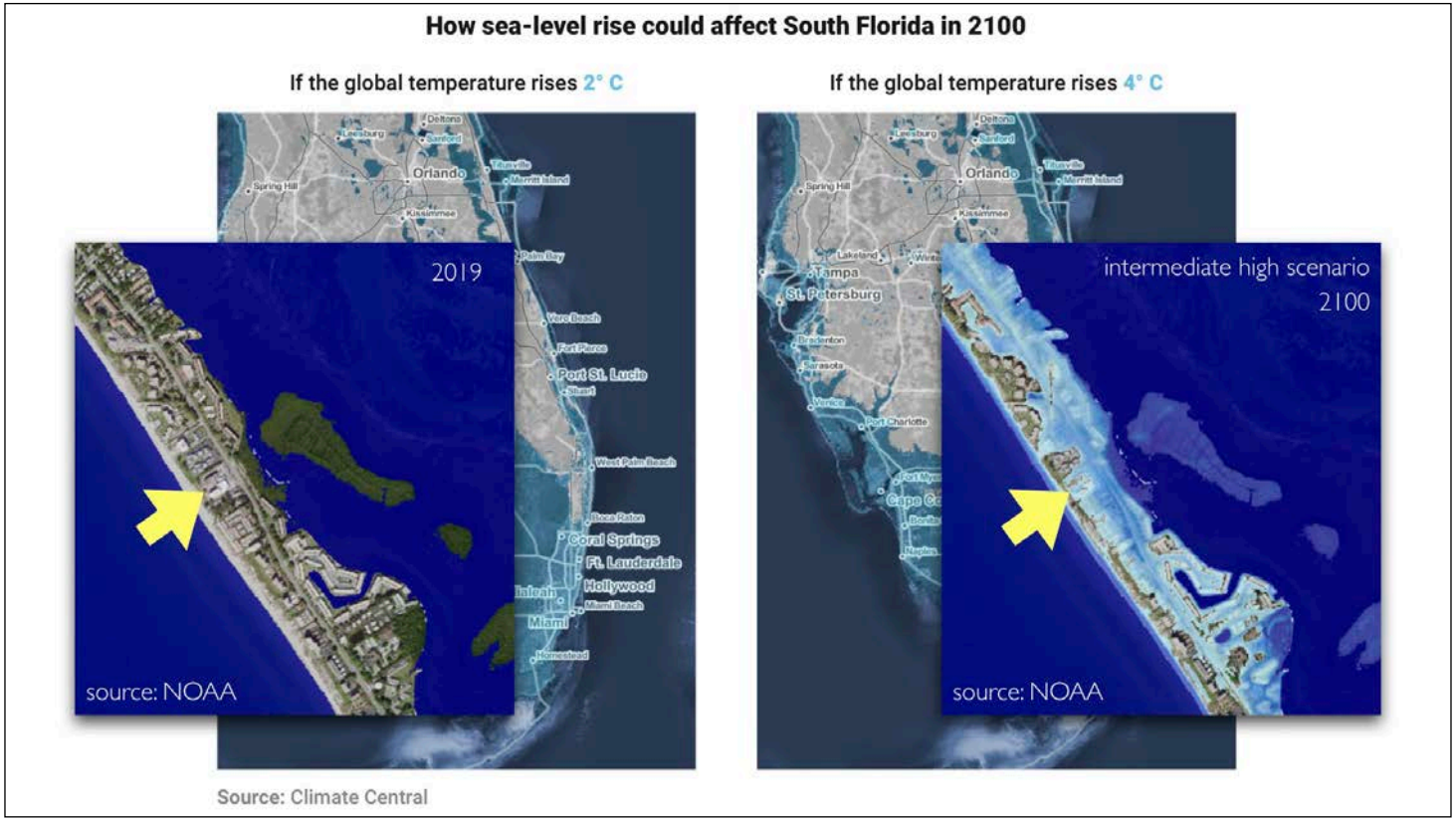
Where the shock of a forecast or diagnosis will reduce you self esteem, denial will increase your perceived own competence. The theory of change management tells us that it can be comfortable to stay in a state of denial or retreat.

Let me show how denial looks like:

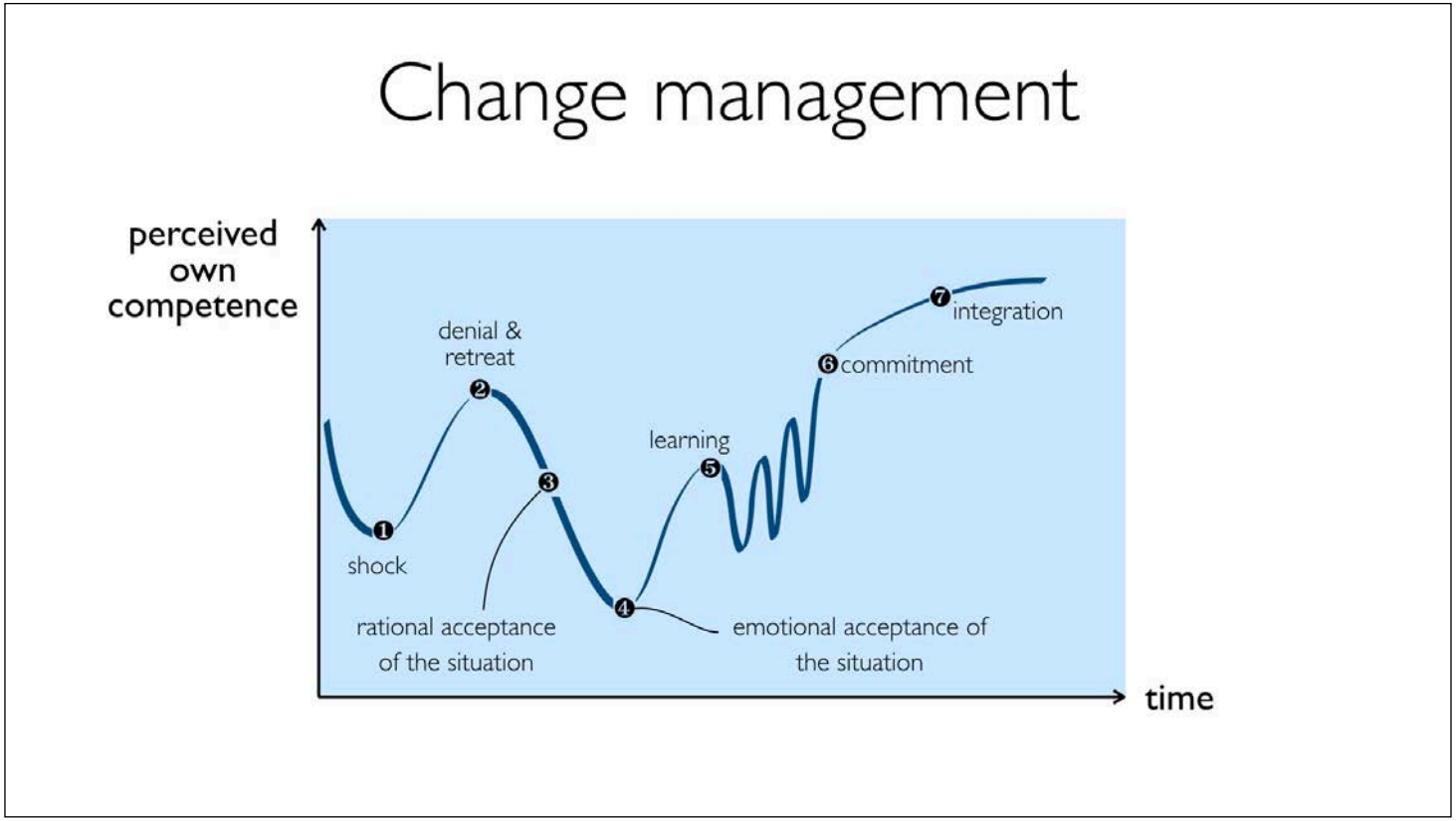
Please enjoy the following episode of the movie ‘Erik the Viking’ https://www.youtube.com/watch?v=ee6-sl9rdtA



These are predictions on how sea-level rise could affect Florida in 2100.



More, in detail, these are the predictions for the location of this conference. But, of course, this will not happen. At least if you find your comfort in denial.



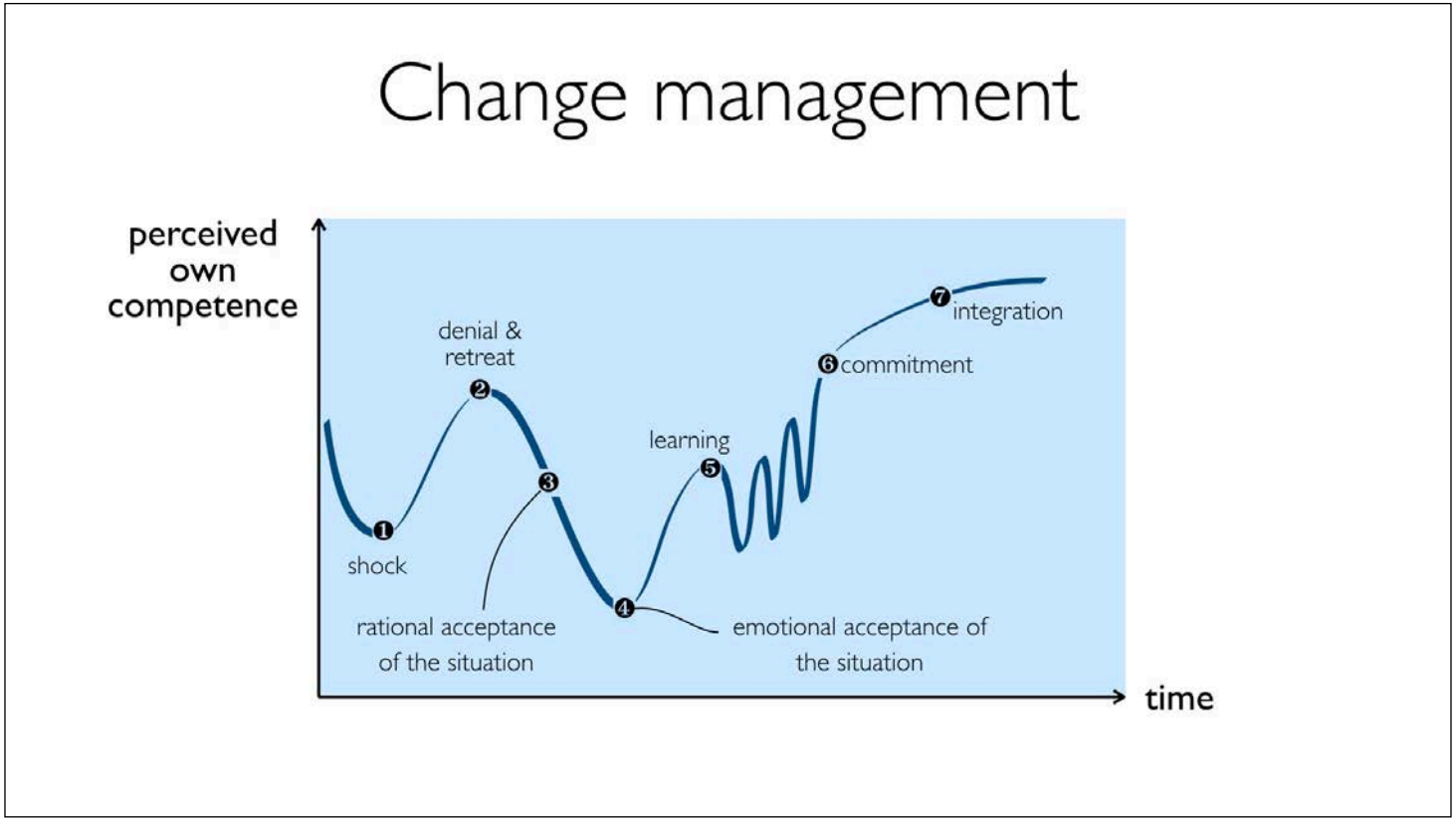
If we want to go beyond the point of denial, and we go trough the process of accepting the situation, then we go through a crisis: our perceived own competence will be reduced to a minimum and we will feel insecure and bewildered.

You need management support, a coxswain, to go through this crisis and get to next point, which is learning. Learning sends you into the maze. It is a wonderful, exciting but also messy process, because you will make mistakes. In the end you'll find a new way to which you can commit.

It is only then that your perceived own competence will be higher than at the start of the change process.

Finally, the new situation needs to be integrated or hardwired.

But, and this is important, you don't need to go through all these phases. You can get stuck in denial, or even at the lowest point, in a depression.



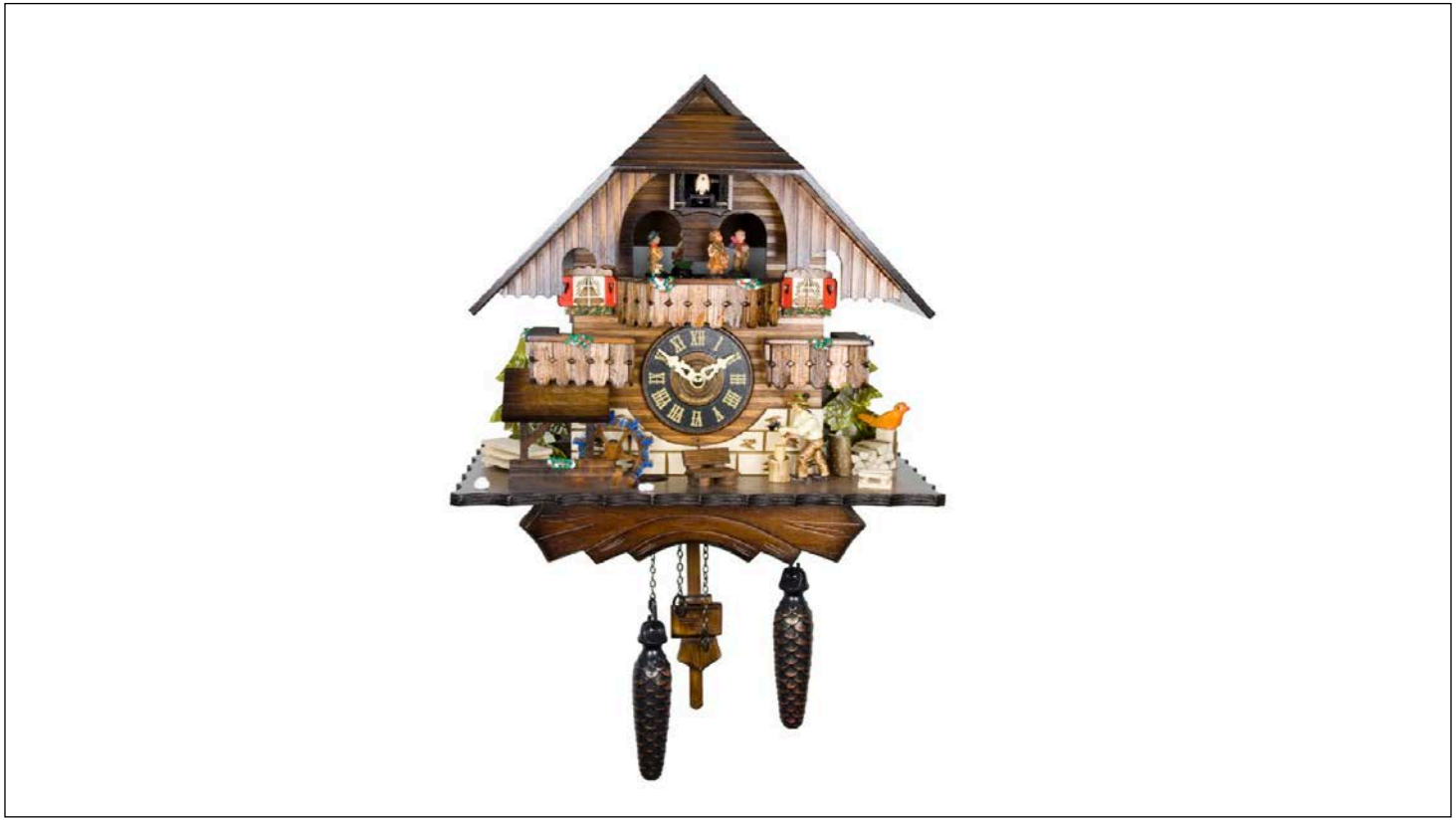
So where are we, generally speaking? Where is fluid power?

There is no doubt about it that we suffer from denial. We are stuck in it.

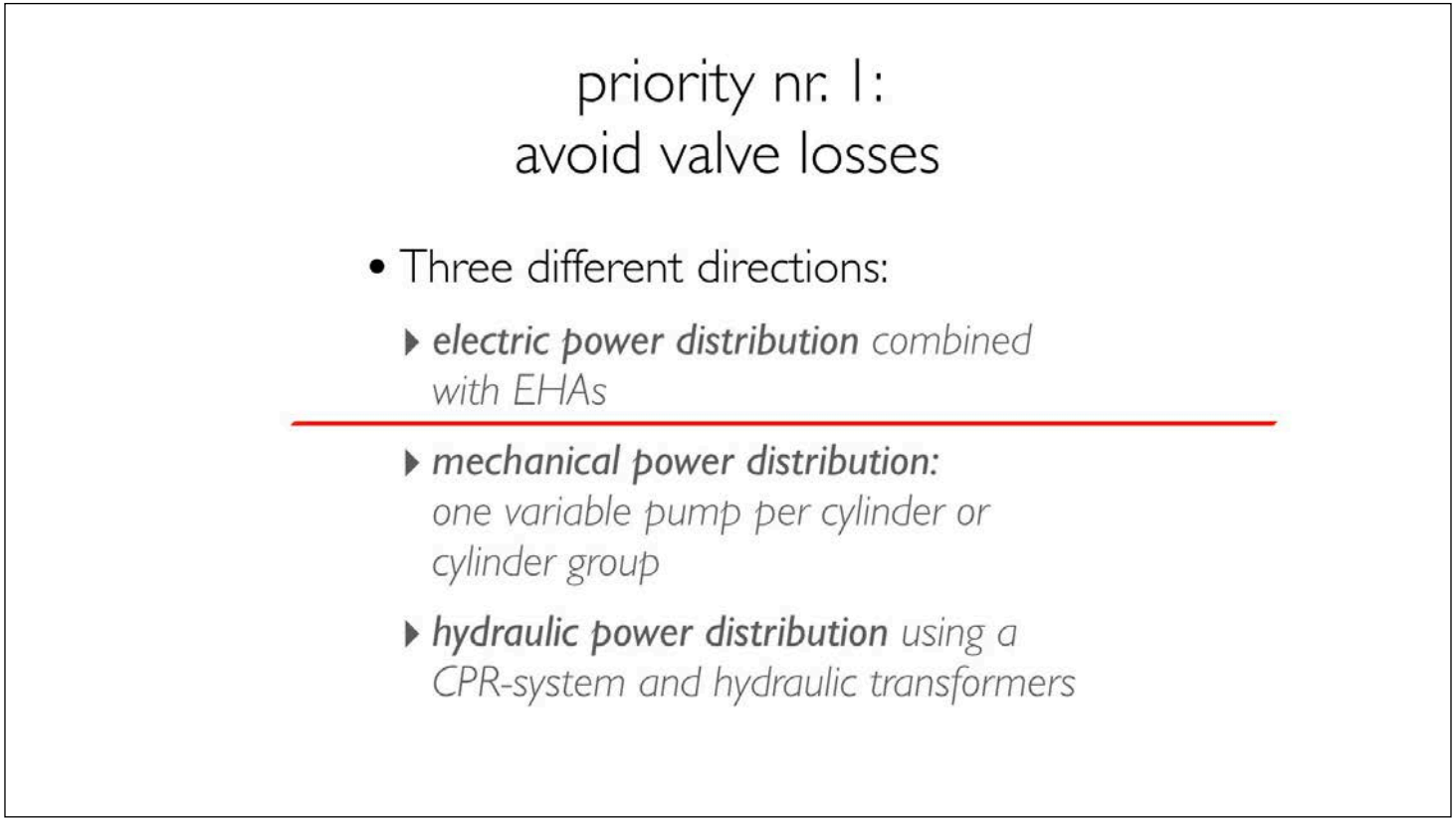
As I have shown to you at the beginning, experts have warned us for more than 25 years that we need to improve the efficiency of our systems and components.

Yes, we keep on repeating the diagnosis, But, alas, we refuse to take the cure.

We don't do anything about the main problems.



Adding electronics to our components, doesn’t help making fluid power more efficient and less expensive! We should ask ourselves if adding electronics is not a form of denial. After all, we can comfort ourselves with the idea that we work very on innovation, whereas we avoid working on the most crucial problems.

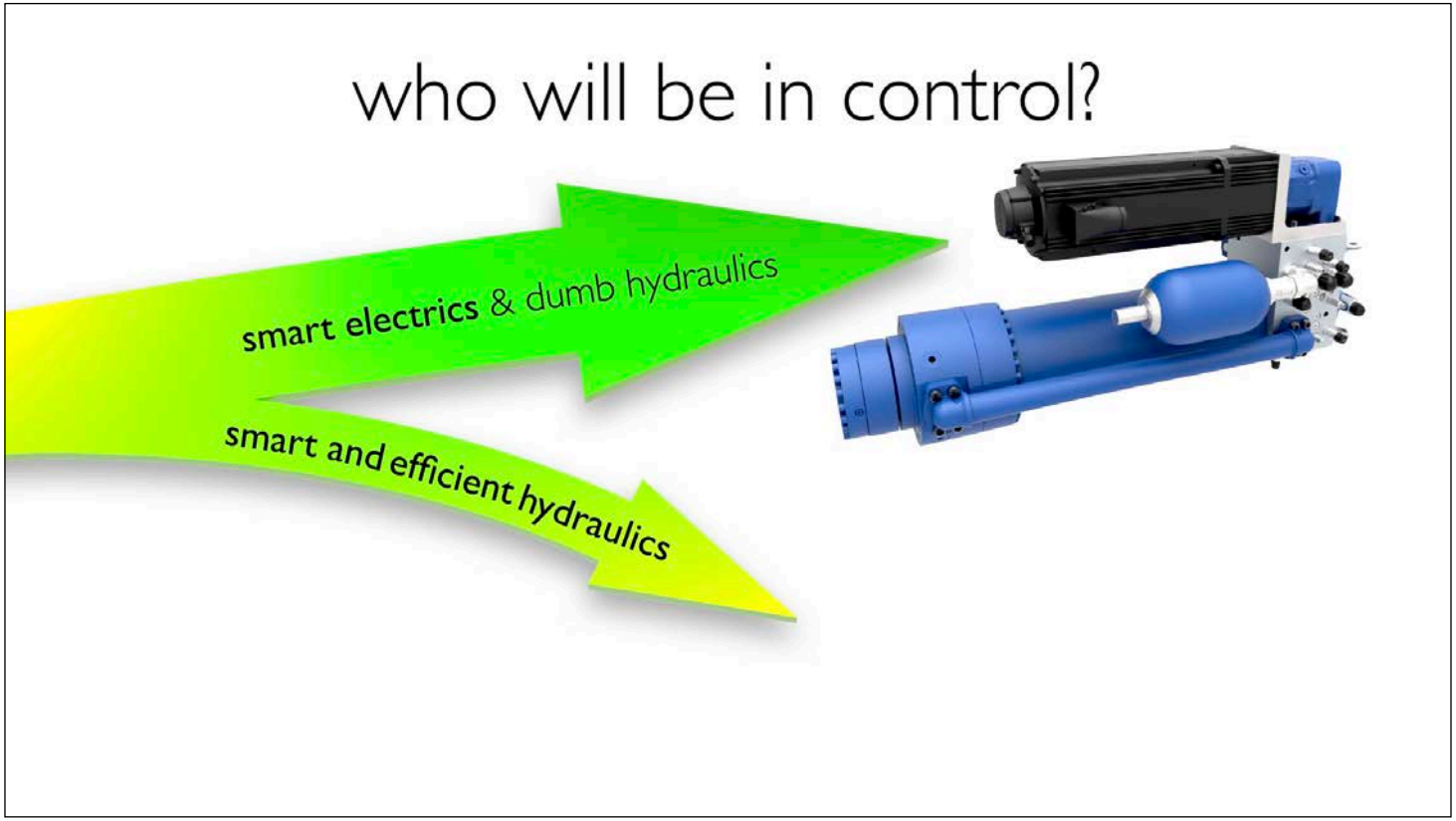


We know, or should know, that our first priority should be to eliminate valve losses. And, as I have showed to you before, these are the three possible directions:

- electric power distribution
- mechanical power distribution
- and hydraulic power distribution

It is still open which direction will be prevailed. It's up to us: in which of these technologies are we going to invest?

But, before choosing, you need to be aware that the first solution is not a hydraulic solution: it's an electric solution.

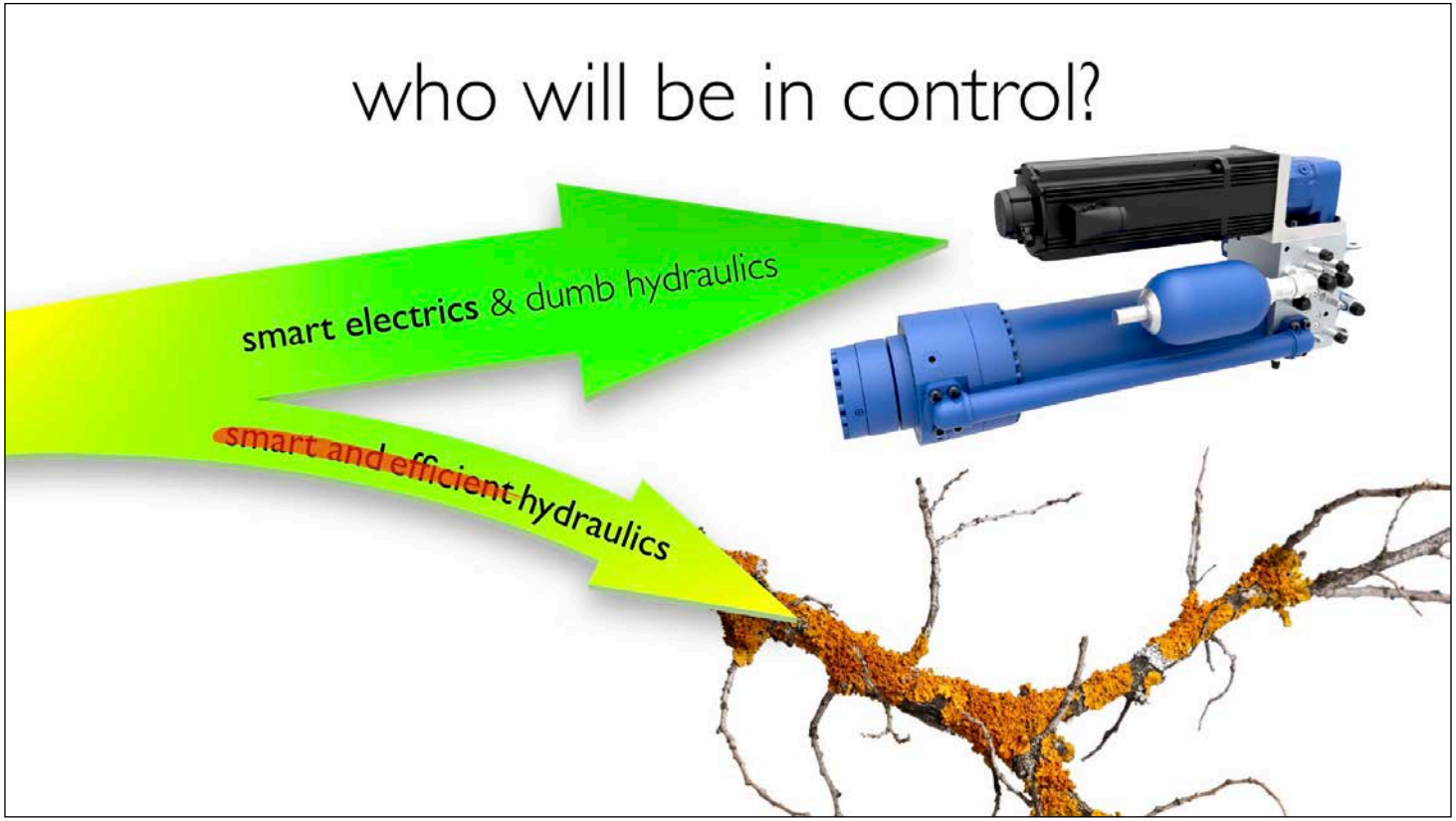


The next decade will be interesting. We are at a junction right now.

Yes, we could and should develop smart and efficient hydraulics.

But the current trend is towards electro-hydraulic actuators. That is not the same as smart hydraulics. It is smart electrics combined with dumb hydraulics.

This is a warning to all of you, if we don't chose a clear direction,…



…if we don't develop smart and efficient hydraulics, then the world will change us or force us to change.

Electro-hydraulic actuators will shift the control task from hydraulic systems to electric systems. If this happens we will only be left with some simple hydraulic cylinders, constant displacement machines and simple valves.

If this will be our future, then we can stop having the fluid power and motion control conference, but just call it motion control, or electric motion control.

We will become a dead branch. We will loose control.

So, what have you been listening to?

what you've been listening to…

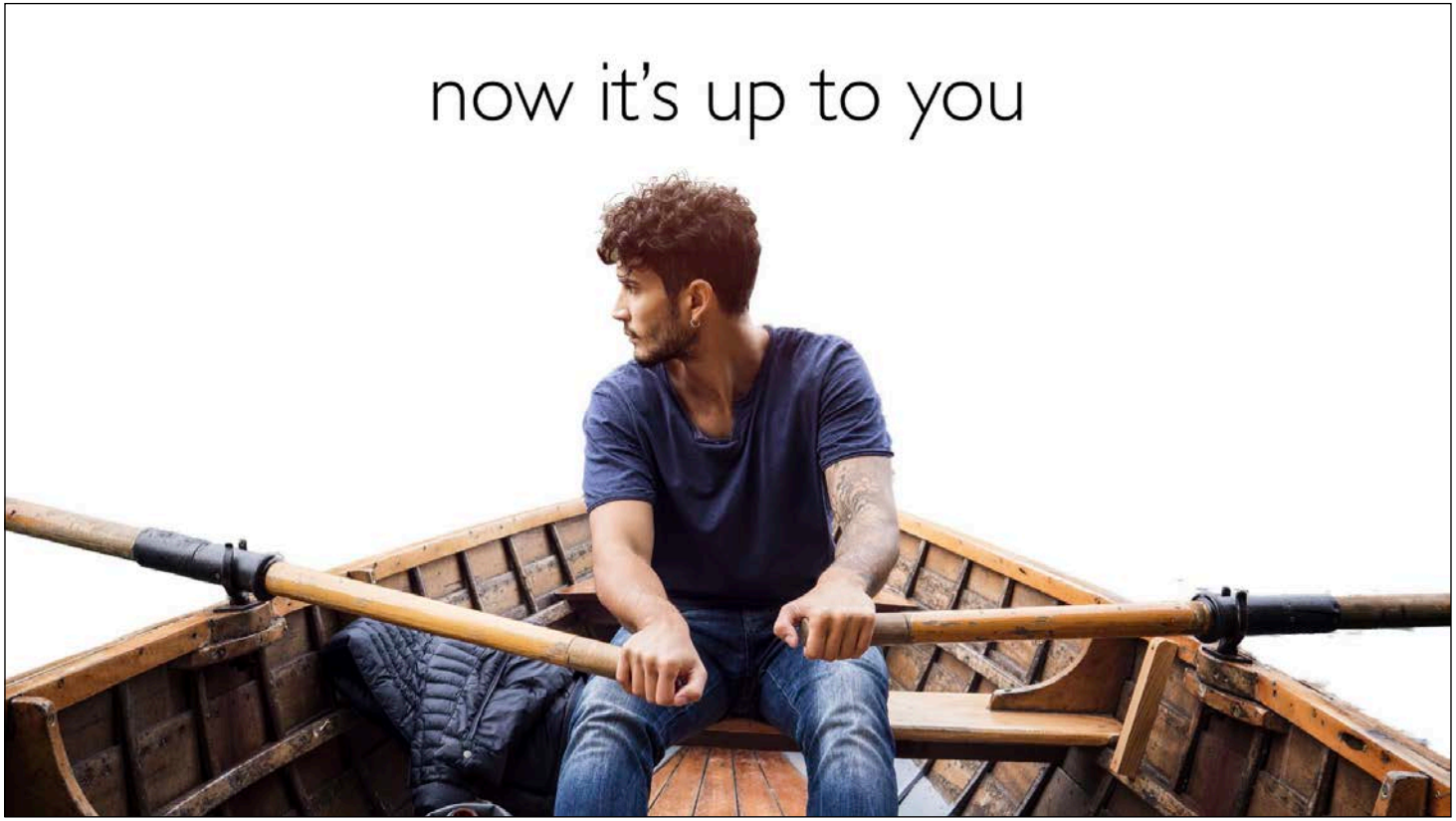
- What predictions were made in the past 50 years?
  - *New predictions*
- We talk the talk but don't walk the walk:
  - *we don't innovate (enough)*
- What is needed for innovation?
  - *Floating cup development as an example*
  - *Main ingredients*
- Change management

I showed to you how, through the decades, our leaders have warned us that we needed to change the industry, especially regarding energy efficiency.

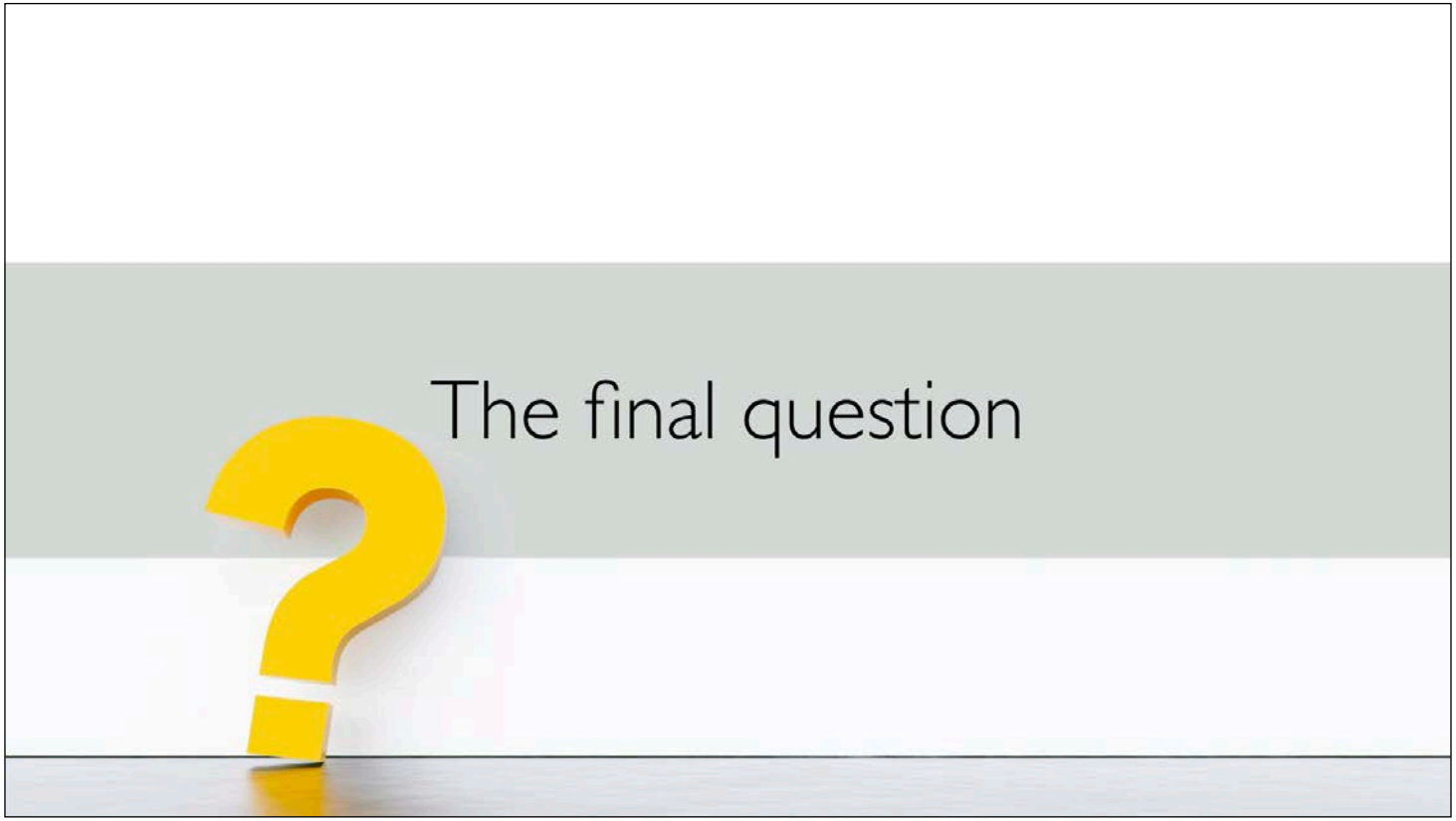
But we talk the talk, but don't walk the walk. We don't innovate, at least, by far not enough.

I showed to you, by means of the example of our own floating cup development, what is needed for innovation. What are the main ingredients for the innovation recipe?

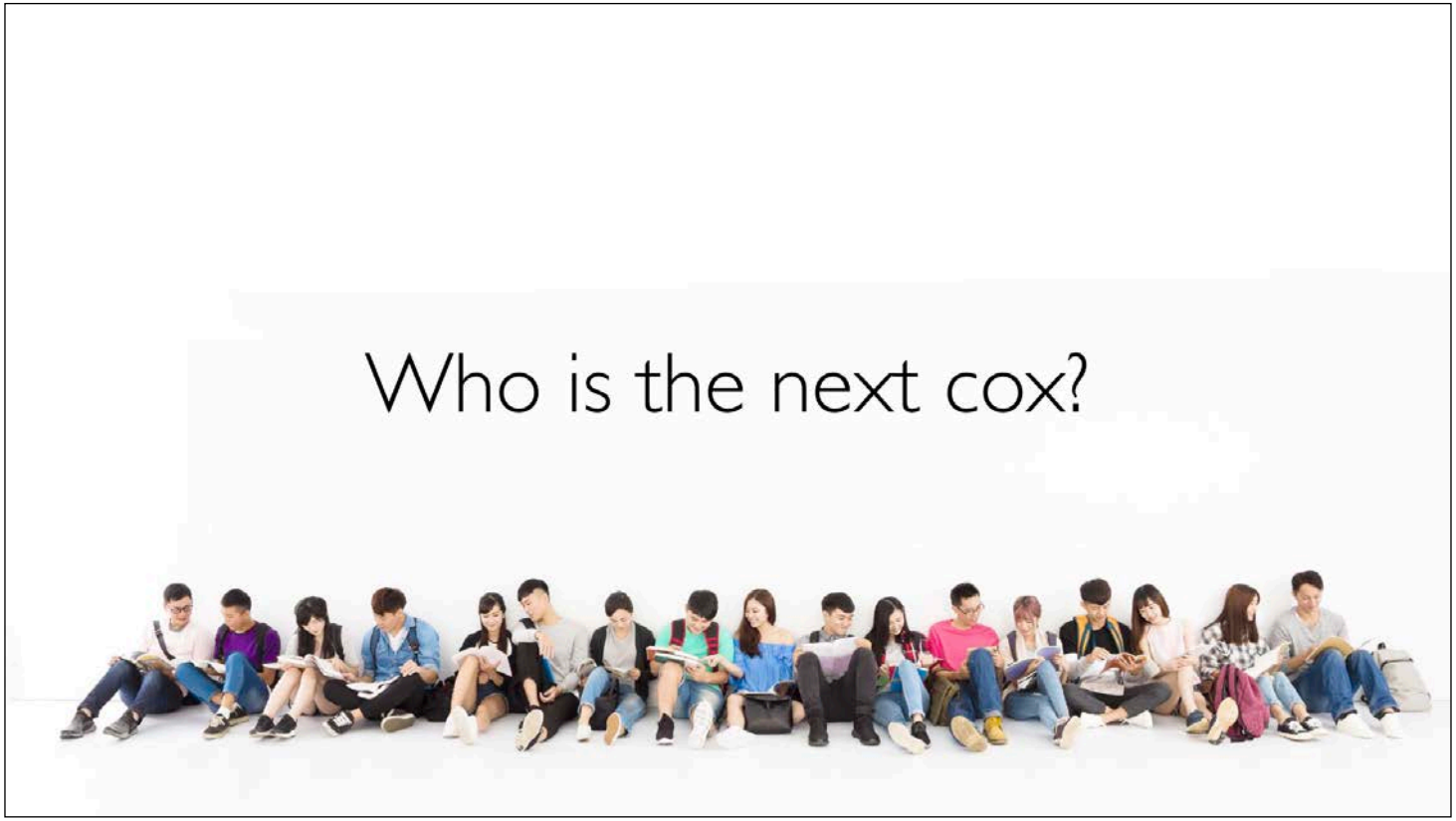
And finally, I told you that innovation is change, and the change isn't easy, but that we all resist to it.



And now, it's up to you



Let me end my presentation with one final question to the younger people in this audience:

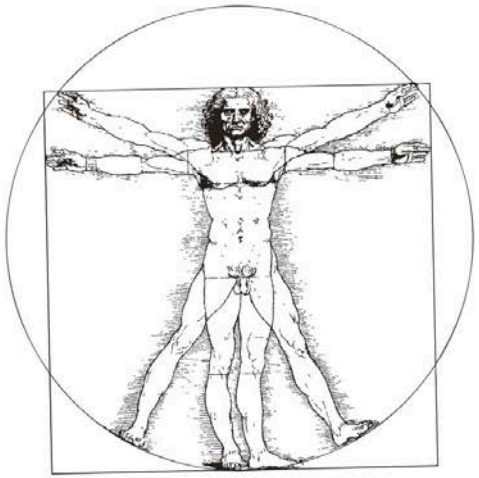


Who of you is the next cox? Who wants to lead the fluid power industry towards a future in which new opportunities and new markets are really created? Because you made it happen!

This is not a question that you can answer now. But the answer will come when you open up your mind for the world that is changing around you.

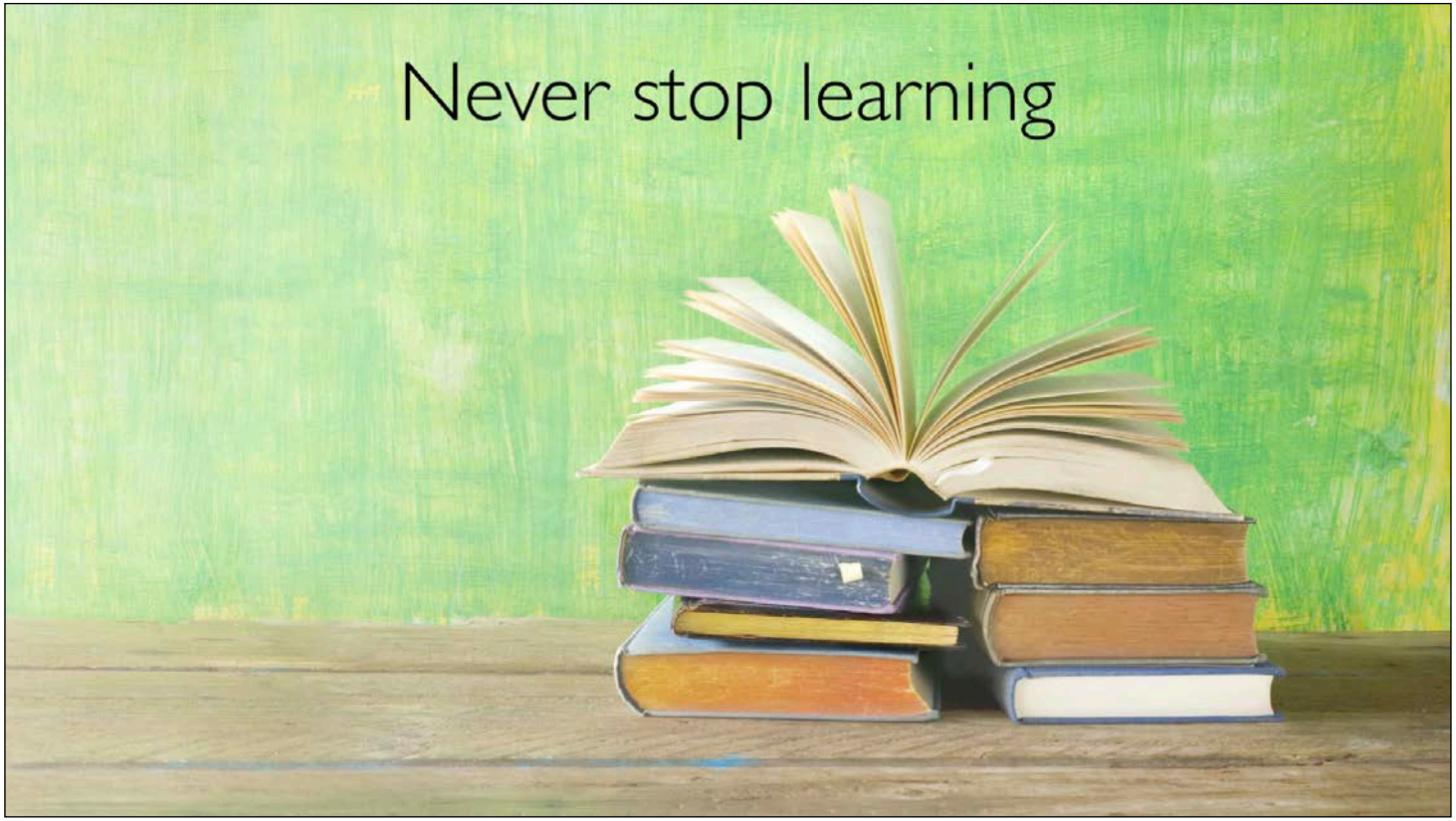
Be smart, in several ways

you'll spread
your wings



and you'll take
to the sky

Be smart, not only as an academic or technician, but also start reading literature, go to musea, listen to what musicians have to tell us, learn to debate. Spread your wings, and you'll take to the sky.



Never stop learning. Don’t think that learning stops as soon as you leave university.

Be an entrepreneur

don't complain…

…but act

Become an entrepreneur. Stop complaining about things you are not happy with, stop blaming others. Act! Do something. Find solutions.

Dare to ask ‘Why’? When we tried to find a new pump principle, the general rule was that the swash plate angle needed to be as large as possible in order to get to a high power density and to achieve a high efficiency. We asked ‘why’?

Furthermore, we were told that 24 pistons per pump is ridiculous. Much too expensive, and very high leakage losses. We asked ourselves ‘why’?

And now it’s up to you to ask the same question: Why?

"As for the future,
your task is not to foresee it,
but to enable it."

–*Antoine de Saint-Exupéry*

"As for the future, your task is not to foresee it, but to enable it."