## Chapter I: basic Considerations





# GETTING IN TOUCH

**like Huygens with
unknown Environments**

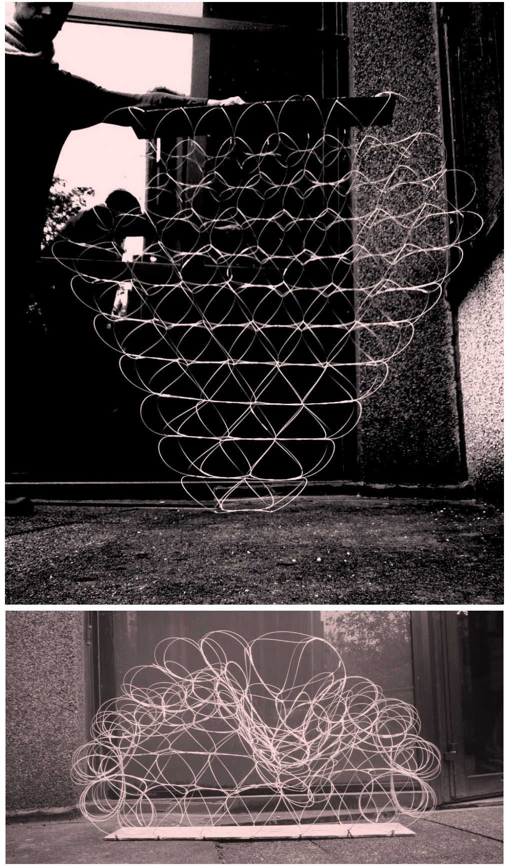
## Introduction

As Marcel Proust said, “Le véritable voyage ne consiste pas à chercher de nouveaux paysages, mais à avoir de nouveaux yeux.” Only – what if those new eyes were actually hands ?

The entry point leading to the conception of this project dates back to investigations on adaptive arrays of fiber-reinforced plastics, conducted 2020 at Cité internationale des arts. Instead of directly interacting with these structures by hand and seeking to imprint and process human behavioral information, one object was built with the sole consideration of simply letting it drop – heading for the device's interaction with a surface, and thus confronting it with an actual instead of a rather metaphorical landscape. This image immediately brought a significant event back to mind – so that the object was named after a probe sent to Saturn’s moon Titan in 2016 – “Huygens”.



GETTING IN TOUCH – like Huygens with Unknown Environments



Named after the Titan probe: „Huygens“

## BASIC CONSIDERATIONS

Notably, Huygens' instruments – in particular its Surface Science Package (SSP)* – were designed to determine the physical nature and conditions of Titan's surface, measure its properties, as well as deliver the gathered information about this yet unknown environment to the orbiting Cassini spacecraft and further to us on Earth – so to speak, an external observer. In other words, despite actually *getting in touch* with Titan, this far reaching exploration was indeed following a somewhat conventional approach to research – analyzing a subject matter from an outside position.

While this perspective – considering an inherent cut between observer and observed – is most prominently being challenged on a subatomic level, not only Bohr ("We are part of the world we seek to understand.") insisted that epistemic implications of these findings are not to be seen as limited to the very field of quantum mechanics. What if one does not consider the observer as external but as inherent to the very subject matter? What if we, instead of considering the probe as our extremity and thus part of our very apparatus of observation – what if we, instead of excluding Huygens from Titan's dynamic surface, consider the two as parts of one ensemble? What if we'd explore the potentials that arise from considering environmental and intrinsic dynamics within the same frame of reference?

Grasping something from up close is not just slightly different to observing it from afar – such closeness doesn't simply increase the resolution of our imaging. Also, touching does not just provide another sensorial influx than visual impressions. There are, instead, very different phenomena at play – we are dealing with a whole different character of engagement. In fact, tactility is not a one-way flow of information – touching is not a unidirectional thing. When touching, one is not just receiving information, one is not just passive. One does not remain external – haptics means simultaneously reading *and* writing.





In this regard, it is also worth taking a closer look at a much smaller scale. Also observation via electron microscopy, for example, is less to be compared with the visual sensation – but more with the sensing via a blind man's stick. Thus, the very same apparatus which is used for imaging atomic structures can, with the right adjustment, also be used to alter the position of single electrons – like with the nudge of a finger. Notably, it is precisely this potential that gave rise to nanotechnology. Similarly, quite some artificial projectiles sent to space have already left traces on other bodies in the solar system. However, by having a penetrometer mounted to its bottom, it is Huygens that was specifically designed to also allow the surface of Titan to Leave an imprint. In a way, Huygens has as much become part of Titan as Titan became part of Huygens. The two were influencing, were transforming – the two were informing each other.

Sperposition of reading and writing: „Double Pen" (2022 & 2024)

It is worth noticing that also in the arts – whether plastic arts or performance arts – subjective perspectives are indeed an explicit component and that – unlike in science – the search for supposed objectivity does not play a significant role. However, here too the basic distribution of roles usually follows the same old pattern – here the visitor, there the art work – here the audience, there the performer. Visual impressions are at the center, mutual engagement and participation remain an exception – moreover, signs saying "Do not touch!" and "Keep your Distance!" can be encountered all too frequently.

It is through this that art's potential impact on our society and beyond does indeed not meet its actual potential. We are living in times in which humanity is significantly contributing to the dynamics of our whole planet Earth – moreover, it has now become the main driver of environmental change. We can no longer afford to perceive "nature" from the outside. In such times, artistic practices could indeed act as a catalyst, reducing the distance, the growing alienation from our world. But as long as art works are being glorified as delicate fragilities, as long as conservationist perspectives continue unquestioned, and as long as idealized states are considered more valuable than proper understandings of navigating change, all this potential will remain silent.

We see ourselves at the helm, but do not yet know how to deal with this responsible role. However, if we understand ourselves as part of our environment, if we accept that in fact all our actions are a constitutive part of these complexities, if we no longer seek to dominate our surroundings but recognize that we are in a constant but highly open discourse with our environment – then we no longer have to remain in the prevailing paradigms of control. We are learning to accept inherent uncertainties, learning to even welcome them. We are learning to deal strategically with the unknown – and eventually learn how to navigate it. We are indeed steering towards uncertain times. Hence, not only probes like Huygens are meeting the unknown – but so are we.





In such a mutual exchange, such a continuous correspondence, it is clear that as much as we are influencing our surroundings, the same is true for the other direction as well. Whichever object in whichever field of concern is at stake, whether we look at the biological – keyword epigenetics – the psychological and sociological or also at the technological and the artistic level, the respective context is being imprinted, the environment becomes a factor within.


Similar contexts can favour a similar response: convergent evolution.

For example, if we seek to inhabit harsh environments, we cannot afford to be indifferent to the specificities our lifes are exposed to. A future lunar habitat, for instance, can only enable its required internal conditions if the structure, in a very specific way, correlates with the external conditions. The shown example also points out another remarkable phenomenon which can emerge from such context-driven developments – leading to cases, in which the decisive nature of this environmental agency is being exposed in a significant way: Thousands of years ago, human populations in europe's far north developed similar construction methods to survive in the harsh environment, as we are now developing in the context of future extra-planetary expeditions – transportable, partially lowered into the ground and covered with a thick layer of local substrate to shield the residents from the external conditions. It's a case of convergent evolution – different lines of development leading to similar outcomes – which is indeed a phenomenon that we also find in biological contexts – just think of the similarity of swimming organs of fish and marine mammals. Similar contexts can favor a similar response. Similar contexts can favor a similar response.

However, processual approaches which are not inconsiderate to external factors allow us to respond and adapt accordingly. Along the same line, the strategy of not just following one predefined goal enables us to be open to a multiplicity of possible pathways. In fact, also in space missions it is common practice that early findings are directly being reintegrated and thus influence the mission trajectory or even its objectives. For example, after encountering and sending back data from Saturn, course adjustments of Voyager 2 allowed a closer look at Uranus and Neptune. Or, when Rosetta first arrived at Comet Churyumov-Gerasimenko, early findings about the unexpectedly rough terrain of the comet's surface led to changes in the deployment strategy for the Philae lander. And, after being launched to explore Jupiter's magnetosphere and internal structure, also Juno's orbit was adjusted according to initial findings regarding the planet's intense radiation environment – to minimize exposure and extend Juno's operational life.

It is worth mentioning that a similar approach – strategic openness to unexpected insights and varying manifestations of pathways – is of great importance also in a field presumably very distant from ours – namely, in education, and here especially in the realm of academic art pedagogy. Imposing one's own way on students – indeed young artists and grown up persons – treating every student the same way, indifferent of their own character and course of development – will hardly help them find or further develop their own practice – their very own approach to artistic exploration. Instead, when being open to their very own way of being, detecting and responding to their own form of engagement, it soon gets clear that it does indeed need as many ways of "teaching" as there are students. Especially through individual discussions and material engagements, with each and every one, a different form of communication, a different language, and a very specific shared space of understanding can be originated. Shared conceptual spaces are arising, and amazing





new worlds are unfolding – which could indeed have never been foreseen.

Notably, it is exactly such a shared space of understanding which has the potential to serve as a kind of template for the examination at hand – a space of engagement that can be navigated from either side. Another example hereof we can find in the co-evolution of species. Species do not only adapt to the environment they're in, but in certain cases, various species co-adapt in relation to each other – so that their developments are in fact interdependent, they evolve together. However, as indicated, the kind of interaction which this project is concerned about is hardly the collaborational dynamics between two comparable actors – but between an operational device and its environment. With reference to Huygens' encounter as well as its mutual engagement with the atmosphere and the surface of Titan, one may indeed find more suitable comparisons.

There are, for example, valid perspectives emphasizing that also here on earth organisms are shaping their environment as much as the environment is shaping them – that organisms and environments interact reciprocally. And we can observe this phenomenon on various scales. If we consider the global picture, biological, geological, and atmospheric processes are deeply intertwined – Earth's geological and atmospheric dynamics can simply not be fully understood without also considering its biosphere. Note, for example, that it was photosynthetic organisms like cyanobacteria, who 2.4 billion years ago drastically changed the composition of the Earth's atmosphere – which in turn influenced geological processes such as the oxidation (and red coloring) of iron deposits. The biosphere and geological processes co-influence each other. Moreover, through various biogeochemical processes – organism's biochemical engagements – life itself plays a crucial role in regulating Earth's climate and maintaining its habitability. But this is also true on a very local level – organisms show behaviors that alter their surroundings for their own benefit. Beavers construct dams, generating ponds where they can build their lodges. Corals build

calcium carbonate structures that increase the alkalinity of the water – which is crucial for the survival of the corals themselves. Also, earthworms raise the soil's pH, createing a more hospitable environment not only for plant roots but, again, also for themselves.
What if we'd transpose this integrative perspective to our field of space exploration – that not only organisms can increase the habitability of their environment, but also technical devices can render their environment navigable? That the device – no longer isolated – forms an ensemble with its environment? How far might such an interaction potentially reach?

A promising access point for these questions is indeed related to the very notion of habitability – namely the aforementioned concept of operational life. For survival in whatever environment, it is obvious that not only internal but also external factors are of relevance – how the surroundings affect the probe has a direct influence on its lifespan. If the environment is too inappropriate – it's soon over. However, conversely, this also implies that as long as there is survival, there is also a kind of conformity – in other words, a correspondence between probe and environment. In order to have a positive impact on the operational life to delay the point of death, it is therefore reasonable to orient towards rendering the device's internal dynamics more considerate of external circumstances and implementing the ability of responding to them adequately. In other words, we strive for a direct integration of the collected sensory impressions into a device's behavior, thus, to strengthen the discourse with its environment.

And basically, we can already see a kind of such mutual engagement in each and every material encounter – even if it is simply a matter of heat exchange, air resistance, friction or the mutual impact of colliding objects. With this in mind, it is worth noting that, for example, the successful glide of a parachute does indeed also include the actual air conditions. As such, probes are specifically designed to cope with the expected circumstances. Ifa probe for the moon is sent to Venus, it would hardly withstand





the pressure of its dense atmosphere when approaching the surface. However, as the focus of the present investigation lies specifically on unforeseeable environmental conditions, we're interested in the interaction with external components that cannot be planned in advance.

It has been outlined above how early insights of a mission can lead to adjustments of the a spacecraft's trajectory – not least to extend the operational life. However, this still involves people on earth as a decisive factor, but there are indeed examples in which a device is able to also autonomously adjust – systems that reduce the need for external control. This often involves automatic corrections of occurring deviations in the orientation of a spacecraft. Thereby, self-stabilizing components autonomously act in a way that counteracts the unwanted motion – e.g. for bringing a rocket back to a stable, vertical path. Also the Hubble Telescope has such an intrinsic adaptation mechanism – reaction wheels maintain its precise orientation in space, to prevent it from drifting away from a specified target.

Notably, most of the time such intrinsic adaptation mechanisms are based on real-time data gathered from continuously monitoring the device's performance. However, it can indeed get more intrinsic than this: There are examples – also in space technology – in which auto-adjustments are not relying on electronic data processing, but instead take advantage of specific physical principles. Thus, the device's response to external impacts is based on specific mechanical designs or intrinsic material properties. For example, having long, slender structures that extended away from their main body, made early satellites automatically align with Earth's gravitational field. Also, some early spacecraft used bimetallic strips – like those in common room thermostats – consisting of two different metals that expand differently when heated, causing the strip to bend in response to temperature changes and, through that, to perform mechanical tasks without the need for electronic sensors.

Now, these methods may seem simpler than systems based on electronic sensors and real-time data processing. And indeed, digital technologies have been dominant for decades – at least in the public perception. However, we are currently experiencing the switch to a somewhat “post-digital” era – in which electronic and software-based solutions are no longer seen as the pinnacle of technological development, but as simply one dimension among several. As such, solutions that embody an advanced understanding of physical principles and integrate deeper understanding of natural phenomena are far from being “low tech”. The mentioned examples should therefore be seen in one line with the ongoing research and development of smart and metamaterials. It is no longer just electronics and software that drive functionality and innovation, but also the inherent capabilities of materials themselves. In fact, while traditional views conceive materials as something that is merely shaped or used – as something passive – there is now a growing recognition of the active roles that materials play. Instead of seeing them as static components, materials are considered dynamic elements that can shape the behavior and performance of a system. They can be seen as possessing their own form of agency. Thus, as artificially engineered materials, designed to have intrinsic properties – or rather behaviors – that can not be found in naturally occurring substances, metamaterials can make the material itself a key player in the functionality of a device – as well as in its interaction with the surroundings. For example, based on the internal structure of such materialities, external influences can cause specific transformations which in turn affect the material’s behavior towards its environment. For instance, metamaterials can be designed to block, absorb, or redirect sound waves and vibrations. Thermochromic materials change their color in response to temperature changes – which could, for example, influence the heat management of a device. Very promising are also self-healing polymers – which can autonomously repair themselves when damaged, without any need for external intervention.

Note that in a way, the respective environment is being imprinted in these materials – but not as in a simple mold, nor in the sense





of a marker used to extract data. Instead, their responsive architecture is capable of embodying external stimuli in ways that alter the material’s mechanistic performance. Hence, they are not only carriers of meaning, instead, they are themselves processing it. In this context, it is also worth taking a closer look at the relatively new but promising fields of memristive and neuromorphic systems. Memristors are physical components in electronic circuits which are most easily described as resistors with memory – they change their resistance depending on the history of the current that has passed through them. As a result, the precise performance of these systems does not follow a defined preset, but instead is interdependent with the very context it is operating in. In other words, it is being programmed by the very environment it is exposed to. In the aforementioned trend towards an increased integration of physical principles on the material level, these systems play a prominent role – marking a deeper convergence of hardware and software, domains which had been treated strictly separately for a long time. Moreover, such memristive systems are indeed not unsimilar to biological neurons and synapses – opening the possibility to a shift from algorithmic to material-based machine learning.

It is exactly those capabilities of adaptive material systems and their contingent mechanisms that point to a core investigation of the sculptural practice within this project: Dealing with complex bending-active arrangements – as shown also in the “Huygens”-Object in the very beginning – these structural examinations are openly exploring multistable formations, including their topologies, their navigability, their programmability, and importantly, also the vast range of conceptual implications which all these structural insights may provide. Also here, the possibility for different outcomes is embodied in the structure. Through the specific arrangement of pre-stressed elements, these objects articulate complex stability landscapes that not only allow the structure to move across energy barriers to transition from one stable state into another, moreover, prevailing states often represent crossing points from which the transformation can follow a number of different paths.

It is worth mentioning here that when these systems are applied as an artistic medium, then the actual object of concern – the actual artwork – is not a sculpture's prevailing shape, nor its static visual appearance, but indeed its changeability and (haptic) navigability. Note, that while the transformable natore of such an object is based on its architecture, the actual transformations are being initiated and guided by external influences – and that we ourselves are indeed part of the environment which these objects are exposed to. By haptically interacting, the artist himself, collaborators or also visitors take part in the internal force relations of the object. Thus, these participants do not remain external to the object – but are becoming a constitutive part of the artwork itself.

However, it is worth noticing that navigating through the buckling procedures and the bifurcational landscape of those bending active arrangements not only affects their immediate formation – it does also have long-term consequences. A central factor in this regard is the fact that the fiber-reinforced polymers they are built with have the property of slowly creeping – dependent on the specific duration and strength of the load to which they are submitted. What this means is that over time, a more or less tiny part of their elastic transformation becomes plastic – but even this small change can become a determining factor. It is important to mention that – after being transferred to a different state – objects can usually be returned to their previous form. However, these transitions may be reversible – but not without preventing previous conditions from leaving decisive traces. Note that at precisely those points of bifurcation – delicate points of decision – the difference in whether a structure takes one direction or the other is so small that the smallest changes can have a significant influence. But the stability landscape of these objects is slightly changing over time – leading to the development of specific tendencies. Hence, the traces of earlier formations also have an impact on later decisions – also these structures have a kind of memory.



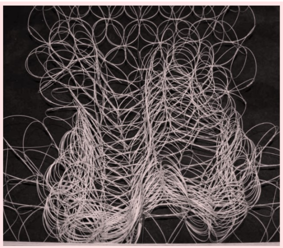


The shown system gives a good example for illustrate this. It constitutes a field of decisions – an arrangement of a large number of structurally identical, but not entirely independent bifurcative subsystems. These are all stabilized 4-point arrays, each of which can collapse in two directions – upwards or downwards – but also remain at midpoint. Such balanced ternary subsystems are lined up serially one behind the other, in rows which are staggered on top of each other – forming a spatial arrangement extending in two dimensions. If one of these points of decision – for whatever reason – happens to move upwards and stays there for a certain period of time, then it will also the next time – now due to its own intrinsic motivation – again strive to go upwards. In this way, over time, each of these subsystems develops and articulates its own history.

Also the combined functionality of these subsystems is of great importance. For example, if one point is flipped upwards, then this prevents the point directly above it to flip downwards – the two parts would simply be in each other's way. Thus, due to the specific architecture, the individual collapses are to a certain extent linked to each other – whereas some arrangements are "permitted" and others are not. As a result, complex folding patterns emerge, of which the exact form – at least in the early transformation procedures – cannot be predicted. Initially, even the slightest deviations in handling lead to a different shaping of the overall system – if only one point decides differently, the entire process takes a different path from this point onwards. However, over time, this is no longer the case. Due to the growing tendencies of the individual points, also their collective formations become increasingly established – and emergent folding patterns start repeating themselves. An initially undifferentiated system develops a well-differentiated transformation behavior – by bringing internal and external factors into alignment, it is programming itself.

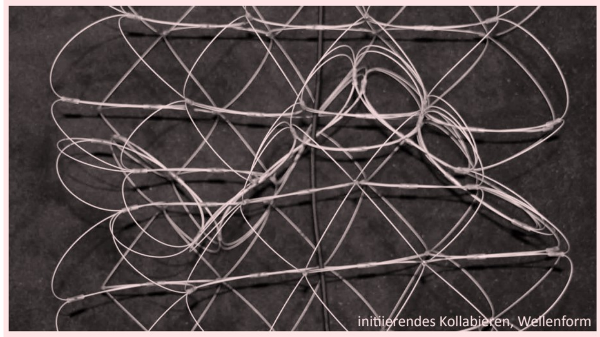
It is worth highlighting that, through specific setups of this adaptive material system, its arising structural tendencies can indeed also be rendered functional – by traditional means. The outlined spatial extension, for example, provides channels in transverse and diagonal directions throughout the entire structure – channels which can indeed be used for the transportation of fluids. Now, it is indeed plausible that the resulting device could well serve as an autonomous switching control unit in whatever distribution system for liquids or gasses – for instance, a water or air management system. In such a setup, the formation of the adaptive structure and the flow going through it are directly dependent on each other. Collapsed points of decision alter the flow in the respective channel. However, not only does the formation determine which channels are open and which are closed, not only do collapsed decision points change the flow in the respective channel. Also changes in the flow - especially if they are impulsive - can cause certain gates to open and/or others to close.

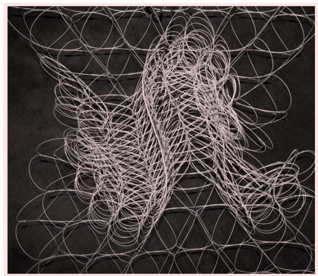
To give a bit more clarity about this kind of functionalization, is is worth noticing that external participation takes now no longer takes place through direct haptic interaction. Instead, participants elsewhere could interact with that flow and thus now communicate indirectly with the adaptive assembly. And this very usage is also influencing the flow in the future – thus, not only do early formations impact later formations – also their functional performance depends on its own history.

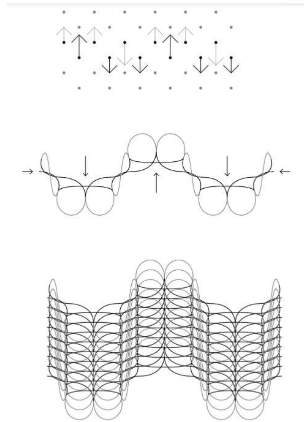










**Collapsing poits of decision and their collective behavior**

Now, let's slowly reconnect these considerations to the general thread of investigation – sending a more or less hypothetical probe / projectile into space for mutually engaging with an unknown environment. And indeed, by changing their behavior according to the specific context they are exposed to, contingent mechanisms like the outlined examples do have the intrinsic capability to openly encounter and respond adequately in such a setting. However, this kind of perspective – looking at this very encounter from within the very material system – does not just render us capable of more deeply engaging in technological potentialities. It does indeed also have crucial theoretical implications – which do bring us further in approaching the very initial question regarding how far this encounter may actually go. Note that we have changed our perspective substantially in one particular aspect: Whereas before, it was us who appeared as decision makers and as final recipients of gathered information, the present considerations now no longer revolve around ourselves. It may seem strange at times, and some threads may remain hanging loose, however, slowly but surely, we can now seek to remove ourselves from the equation.

Let's first take a closer look at the role of measuring. The example of the haptic sense which we referred to earlier demonstrated that measuring and acting do not have to be considered as fundamentally separate. But here too, measurement and action coincide – in fact, in a similar way[1]. This becomes increasingly important the more immediate a response has to take place – or, from our perspective, the more distant from us this encounter is located. Note that if a probe on Titan sends a signal to earth, it needs to wait for more than two

1 The more immediate, the more embodied and less data-based the ability to respond is – in other words, the more it is a constitutive factor of the very material system – the harder it gets to distinguish between acting and sensing at all. Whether we look at simple bimetal strips or more complex memristive systems – or if we consider wind flaps that open automatically in strong gusts and thereby reduce air resistance: sensing and reacting cannot be differentiated – it is the very traces an environment leaves behind, which is already the proper response to it. Again, material (mutual) engagement is not a one way thing.





hours to receive our response. Due to this delay, adjustments need to be made independently, all short-term decisions must be made locally, hence, autonomously. This shows that we have indeed already moved away from the idea that every measurement data is captured primarily to be forwarded to us outsiders. Instead, the device's sensorial capacities allows it to re-integrate the experienced aspects directly back into the system itself. Hence, internal communication becomes our key factor – not a transmission to the outside world.

And, along with these considerations of increasing independence, we can now also tackle another obstacle that must be faced in this endeavor of leaving us out of the equation: the still prevailing paradigms of control. However, here too we have already come more far than one might think. As we see, early and more simple examples of the aforementioned mechanisms of selfregulation, like the common bimetallic thermostat, are actually methods of self*stabilization.* Hence, they are operating in ways that even if the context changes, the internal conditions seek to remain the same. Despite external fluctuations, no matter the environment, a predetermined equilibrium shall remain stable. However, as outlined above, this is no longer the case with the rise of implementing contingent mechanisms. Instead of a predefined narrowing and confining the overall development, these devices are opening spaces of possibility – rendering viable a multiplicity of different pathways. Now, instead of having an internal drive to stay the same – indifferent of the actual context – we are seeing an ability to bifurcate, to differentiate – according to the respective environment. Instead of having the same outcome in disregard of the context, now different environments also entail different outcomes.

With their inherent potential for a multiplicity of pathways, unpredictable environmental conditions no longer represent threats from which internal factors need to be protected and isolated from. On the contrary, these external factors are now allowed to enter – as well as to intervene constructively with the internal processes. We no longer seek to tame uncertainties but start welcoming them. We moved on from defining them as dangers to strategically integrating their potentials. We are no longer imposing how to react, imposing the specific character it it needs to develops, how to behave, how to evolve. We no longer see ourselves as a god-like / patriarchal figure in the background. We are no longer presupposing an internal equilibrium – it only emerges through an open correspondence with the specific context which the device happens to be indulged in. In other words, we have begun to not only hand over control to the device itself – but also to its environment.

This significant turnaround – that external influences are no longer treated as problematic, disturbing factors, as sources of trouble or failure that need to be contained and counteracted – also brings us further with another deep-seated peculiarity in our conceptions, which is in fact very strongly linked to our control thinking: our general thinking in terms of errors and mistakes. If we take the quest for mutual engagement and independence seriously – and then something unexpected happens – who are we to label it inappropriate? We need to let go. Things may remain unsuitable from our individual point of view – but this perspective is no longer valid. We need to put ourselves in a different perspective, one in which there is no fear of losing control – in which mistakes are no longer mistakes, but important insights – in which material failures are not errors, but a formative part in the process of becoming – and in which, again, influences from the environment are not unnecessary interferences, but legitimate environmental contributions.

Indeed, this correlates strongly with the very character of exploratory practice itself – whether we look at the scientific, the artistic or whatever other realm. Moreover, it is precisely this encounter with unexpected discrepancies to our very preconceptions, as well as the willingness to accept them, which actually constitutes the basis for new discoveries. It is the unknown which brings us further, the very serendipitous nature





of our practice itself. In this regard, we can for example take a look at the development of new medicines. Often it is not the sickness which the respective research was trying to tackle – and which it got financed for – that the new substance ends up treating. Instead, it is one of its unexpected side effects which renders the discovery profitable. And this is no different in the field of material science: The eventual area of use, as well as the actual range of applications for a newly developed material, often has little in common with the original point of investigation.

So obviously – if we look at our paradigms of control as well as our thinking in terms of errors – we did already leave them behind, at least in regard to our strategic approaches. Which leaves one more step – to „simply“ transfer this implicit openness from the very methodological level to the actual content of our endeavors. Also regarding the project at hand, it is precisely here that content and method coincide – and the foundation for this endeavor has now been laid.