Mapping Affinities

MAPPING AFFINITIES
Democratizing data visualization

Dario Rodighiero

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CONTENTS

*I disegni non sono decorazioni,
sono parole.*

— ENZO MARI, 2020

*We never look at just one thing;
we are always looking at the
relation between things and
ourselves.*

— JOHN BERGER, 1972

PREFACE

A case study lies at the heart of *Mapping Affinities* by Dario Rodighiero: that of a highly refined project that sought to map the research underway within EPFL, the Federal Institute of Technology in Lausanne, in Switzerland.

Yet the case study in question is much more than a mere case study. It raises profound questions regarding research, organizational structures, social dynamics, knowledge networks, the pathways followed by researcher careers, and university governance. In doing so, it opens up a broad set of perspectives pointed to in the book's subtitle: *Democratizing Data Visualization*. When it comes to data, Rodighiero demonstrates that the word "democracy" implies a multifaceted approach to mapping and visualization: an approach built upon scrutinizing data sets with a critical and creative eye; understanding visualization as a complex, interactive form of storytelling; and attending to the differing audiences and modes of engagement that a given data visualization strives to accommodate. The result is a compelling research account of community mapping less as a *product* than as a *process* whose successes and failures have to be examined as a function of their ability to engage the community in question and even audiences beyond the confines of that community.

The legacy scientometric and bibliometric systems that have come into common usage within universities over the course of the past few decades (in the company of Science Citation Indices, h-indices, and Impact Factor calculations) are reasonably good at describing a thin slice of the research pie: the published record, patterns of citation and authorship, the allocation of grants, and the composition of research teams. Like trusty bloodhounds, they follow the traces of that paper (and, later, pixel) trail that, in their 1979 seminal study, Latour and Woolgar identified as the fulcrum of laboratory life.

Mapping Affinities addresses the larger, more complex *rest of the pie*. Scientometrics and bibliometrics tell us little as regards the shape or texture of a research community, its network of connections to other intramural or extramural research groups, or the balance between the roles played by individual researchers and the units to which they belong. Moreover, because of their narrow concern with publications, they tend to be retrospective in nature and to neglect unpublished and informal modes of research interaction. How might research or collaborations be described not "after that fact" but as emergent or potential formations (i.e. with an eye towards predictive and/or recommended outcomes)? And how might one excavate beneath the surfaces of authorial order and citation networks into the stratified layers of knowledge forms and the communities that animate them? This is where Dario Rodighiero's focus on networks based upon affinity (rather than influence, impact, or formal collaboration) transports the book's reader towards a richer understanding of how a research community can be described, represented, and transformed into an object of experience that is performed by that very community.

The ultimate moral of the story that unfolds in *Mapping Affinities* involves the preponderant role performed by design, which is to say designers, in the successful mapping and visualization of complex communities like universities. Designers are challenged on multiple fronts. They need to further nourish and enhance conventional institutional data sets in order to render them sufficiently rich and complex. They then need to shape these data into experiences that are meaningful to multiple audiences: from a university's leadership to its researchers and students to the surrounding community. And in order to achieve these goals, they must deliver these experiences in multiple modalities, from the online to the on-site, spatialized, and embodied. Data democratization is ultimately achieved *by design*, not thanks only to the transparency with which data is devised, analyzed, and disseminated.

— JEFFREY SCHNAPP

Founder and faculty director of metaLAB(at)Harvard; Carl A. Pescosolido Professor of Romance Languages and Literatures and of Comparative Literature; Faculty co-director of Berkman Center for Internet and Society; Affiliate of the Department of Architecture at the GSD

INTRODUCTION

Today, organizations are more than ever complex systems. They are so large, ramified, and intertwined that their organic structure seems like a tangle of activities. Day by day organization members contribute to keeping these structures alive with their actions, behaviors, and thoughts. Organizations rely on these daily practices.

Sociology aims to untangle the network of daily practices through the analysis of the *digital traces* that members leave on the cloud by using desktop computers, smartphones, Wi-Fi networks, identity cards, and online services. The challenge is to recompose structures and behaviors using the data that its members left behind, in various forms and places.

Understanding from daily activities how an organization fluctuates deeply interests the management. The way in which employees work is fundamental to making decisions and planning the future. In particular, managers are interested in having a global perspective to optimize the *performance* of their employees as much as possible.

The concept of performance deals with the challenge of obtaining the very best from the organization, and management often uses indicators to measure their employees' performance. Today, however, two interesting things happen: one is that indicators are moving from tabular to graphical form, the other being that the same indicators are at the disposal of everybody as a form of transparency and self-examination.

Nowadays, performance not only interests corporations but also universities. In academia, scholars are often assessed through their publications using the *h-index* or the *impact factor*. Directors use such metrics to recruit scholars and, in turn, the same scholars try to improve these metrics to be positively evaluated. This bidirectional use clearly shows that academia adheres to performance-based logic.

Current academic policies do not usually take into account a dimension that plays a critical role in scholarly dynamics, the *affinity* between scholars.

This book focuses on the concept of affinity and the ways to visually represent it. Affinities are diversified and take many forms: from common interests to committee memberships, from teaching activities to publication co-authoring. Affinities are also multiple as scholars share different kinds of them at the same time, reinforcing their overall ties.

Affinities can be classified as *actual* and *potential*. A certain number of potential affinities indicates a predictable tie between scholars; these affinities might be representative for common interests, interdisciplinarity, intellectual culture, professional career, or scientific journals, conferences, and committees. Potential affinities become actual ones when a collaboration takes place; it may be the case of co-authoring a paper or supervising the same doctoral candidate. As a consequence, affinities offer two different dimensions: one is solid and composed of ongoing collaborations, the other is projected towards the possible opportunities to explore the academic environment.

The metric of affinities is crucial for academic organizations. Translating affinities into a visual representation draws a space where actual and potential dimensions can be combined. Contrary to the other metrics that reinforce the ranking between individuals, the logic of affinities is a tool to explore the present for future planning. The attempt is to represent the academic dynamics to foster new synergies. With respect to the logic of governance, planning these synergies is in the interest of both managers and employees to enable top-down as well as bottom-up initiatives. The metric of affinities has to be, therefore, at the disposal of the whole collective to visually lead individuals in personal choices.

This book is the result of five years working at the École Polytechnique Fédérale de Lausanne (EPFL), during which the problem of mapping affinities was addressed through a design approach. This problem was tackled by visual means, which represent the only solution to manage the enormous mass of data that humans are increasingly producing. The innovation of this work does not stay in the problem itself but rather in the reconciliation of humanities and technology through a new European Bauhaus.

METRIC SYSTEMS IN SCIENCE

A practice is defined as the application of a group of theories. A specific practice describes the way in which a group of professionals train their habits and the iterative activities that take place day by day, characterizing their working life. This repetitive training aims for personal improvement, which, without a doubt, scholars are not exempt from.

Pierre Bourdieu [1976] imagined society as a field populated by individuals. A magnetic force applied to this field moves them apart or out of the plane. It is the force of scientific recognition and the only way to reach a certain position or maintain it that consists of the *habitus*. Bourdieu defines it as an ensemble of behaviors that allows scholars to stay central in the field and remain durable. Each scholar has to put up a fight against that magnetic force by means of his *habitus*; that is his practice.

An apprentice thus enters the field through a process of *mimesis*. Through the observation of prominent scholars and the imitation of their practice, apprentices may converge towards a central position in a field. Obviously, that is not an easy task; it is not by chance that Bourdieu uses the word *resistance* to define it. Adopting established behaviors helps the apprentice to be recognized and accepted by scientific communities.

This section analyzes the practices of scholars by looking at the metrics used to quantify them. Successively, it will focus on a specific characteristic of the practice, scientific collaboration [SONNENWALD 2008]. The practice of collaboration will be investigated by measuring the actual and potential affinities that take place in academia.

VARIETY OF ACADEMIC PRACTICE

One of the most common activities in academia is writing, an action that is composed of a diversity of tasks [HARTLEY 2008]. Publications are the most common way for scientists to convey discoveries and assume a profound importance because of their immutable form in time. The common wisdom of a Latin saying reminds us of that: *Verba volant, scripta manent*, which means that the written words remain while the spoken words disappear. That importance is even greater when one considers that scientific literature is seriously examined for recruitment and promotion, along with the citations that authors collect during their academic career, which count

	Publishing	Teaching	Advising	Funding	Committees	Conferences
Writing	x	x		x	x	x
Organizing		x			x	x
Applying	x			x		x
Reading	x	x	x	x	x	x
Investigating	x	x	x	x		
Reviewing	x	x	x			x
Public Speaking		x			x	x
Attending		x			x	x
Travelling		x			x	x
Collaborating	x	x	x	x	x	x

as an index of recognition among colleagues. For this reason, scholars put a lot of effort into their writings, taking care of both their text structure [BAZERMAN 1988] and their aesthetic quality [BRINGHURST 2004].

Even though good writing is essential to being a good scholar, the academic practice cannot be reduced to that. The scholarly work is characterized also by didactic teaching, regular meetings, rational discussions, and so forth. And these activities can be different according to the discipline. Although some of them are transversal, some practices are more relevant in certain domains: for instance, monographs are valuable contributions in architecture [ROSSI 1981], exhibitions are part of the work of art historians [DIDI-HUBERMAN 2013], and visual analytics are crucial in computational sociology [BOECHAT & VENTURINI 2016]. Despite these differences, the tasks that compose academic practice may be arranged into six activities: publishing, teaching, advising, funding, committees, and conferences.

FROM PRACTICE TO DATA

Today, measurements are pervasive and entrenched in our society, which has instruments to measure time, light, temperature, altitude, distance, steps, and so on. Philosophers of history question the conditions that make something measurable [TAL 2020], but when these conditions are not available, human intervention is required to make certain events readable through abstract representations such as numbers, vectors, or classes.

Creating a metric is the result of a process of *translation* in which human and non-human actors meet, interact, and negotiate. It recalls Michel Callon's four-step translation: *problematization*, *involvement*, *enrollment*, and *mobilization* [CALLON 1986]. Tasks are transformed into data through the process of translation, so that activities can be measured through computational means. There is no doubt that data are full-fledged actors that take part in the social network the actor network-theory describes, in which both human and non-human intertwine and overlap [AKRICH, CALLON & LATOUR 2006].

Human intervention is required when something is not measurable. For instance, investigating a problem on a large scale, like the Amazon forest, implies a reduction [LATOUR 1999]; the forest has to be shrunken into a series of *samples* that can be accommodated in a laboratory to be examined. These specimens that represent the wooded environment are collected through the process of translation. Scientists start working with fieldwork projects, then work on samples that derive from a careful process of reduction. In a way, these researchers act as relativists, for their work is divided in two steps; in the laboratory, they do not interact with the object of study but rather with the *references* towards these. Samples have different forms: for instance, a fragment of cortex or an insect are specimens of the forest. Yet in the past few decades, a new form of sample has been introduced along with the rise of the information age: it is known as *data*. Data are digital fragments of information that are measured, collected, organized, and analyzed. The etymology of the term originates from the Latin *datum*, which means *something given*. Even though the term data is now part of the common language, its meaning is still debated: *capta*, *sublata*, traces, and vibrations are some of the terms that describe slightly different meanings of data [BEAUDE 2015; BOULLIER 2015; LATOUR 1999]. In particular, the significance of the term *capta* means that data are *something taken* and not given [DRUCKER 2011].

At a time when large visibility is given to openness and transparency, the translation of data has to be carefully considered, as it may affect the results of digital projects [BOYD & CRAWFORD 2012]. Alain Desrosières [1995] proposes two key concepts for data production, *qualification* and *quantification*. The first corresponds to the categorization of data or the moment in which something is identified and elected to become data, while the second is the measurement of the qualified data in terms of numbers. Also, academic practices are not exempt from digital measurement. In the 1960s, the branch of *scientometrics* was founded with the specific interest of studying scientists through datafication. Today, scientometrics is a complex and still-growing field, which needs to be further reviewed before working on the concept of affinity.

SCIENTOMETRICS AND BIBLIOMETRICS

Scientometrics research focuses on the quantitative measurement of science. When introduced in 1969 by the Russian physicist Vassily Vasslievich Nalimov, scientometrics were interested in the quantitative measurement of experiments, scientists, scientific production, and the funding invested. In the same year, Alan Pritchard introduced the term *bibliometrics* with a slightly different meaning.

His neologism was intended to define a subset of scientometrics, specifically focused on scientific publications. Although these terms are used in an interchangeable way today, it is worth remembering how the former echoes science in general and the latter scientific publications [GINGRAS 2014]. Indeed, modern scientists are more concerned by citation analysis rather than other aspects of science that should receive greater attention. Modern bibliometrics has been introduced by Eugene Garfield who proposed the construction of the Science Citation Index (SCI), the first global repository of scientific papers. After the Second World War, the scientific community observed an exponential growth of articles, which in turn made important articles more difficult to find. To solve this issue, under the guidance of an advisory board made up of experts, in 1963 Garfield [1970] created an index to collect and retrieve all papers published by the most relevant journals. It has been the only existing collection of papers to be updated on a regular basis until 2004, when Elsevier introduced a similar system called Scopus, which was then followed by Google Scholar [GINGRAS 2014]. With the introduction of citation indexes, scholars were allowed to approach unexplored domains more easily and librarians could choose relevant journals to enrich collections pragmatically.

Yet even if the primary aims of citation indexes were to analyze the history of disciplines and help librarians, soon a serious issue arose: despite the warnings against possible abuses, these indexes began to be employed for another purpose that concerns scientists, academic assessment.

SCIENTIFIC ASSESSMENT

Scholars have always been evaluated for their academic publications. Peer reviews appeared for the first time in 1665, in the scientific journal *Philosophical Transactions of the Royal Society*. From that moment onwards, the peer review process became a diffuse practice, which scholars must deal with in the scientific circuit. It is amusing to think of Isaac Newton being rejected by *Philosophical Transactions*; the frustration made him promise not to submit another paper in his life and he did not. Even the Nobel Prize winner Albert Einstein was rejected by a journal; his work needed some corrections, according to the reviewer. Einstein was just as angry as Newton about the refusal, but he successfully submitted the same paper to another journal [GINGRAS 2014]. Although criticized for its subjectivity, its slowness, and its inequality, the peer review process is still one of the most popular methods of qualitative assessment for scientific research.

The use of more recent quantitative assessment increased with the introduction of the Science Citation Index. Two statistical measures made academic evaluation possible, publication and citation numbers.

Analyzing scientific literature facilitates the evaluation at different scales, not only for individuals but also for communities and countries. In addition, citations help to identify the most referenced authors of a specific discipline and thereby the most relevant ones. The SCI index was however not conceived for individual assessment, which turns out to be a dangerous practice compared to collective assessment.

Publication number is certainly not a measure of quality, but it might point out a subject of interest in a specific period, as it happens for the clash of civilizations [HUNTINGTON 1996]. Quantity is also useful for analyzing large scientific communities such as institutions, disciplines, or countries. Yet at the scale of individuals, quantitative analysis is misleading: a large number of publications and citations is an index of personal recognition but not a veritable evidence of a successful career. One good article among many low-quality ones indicates the quality of that article, not of the scholar. The need for a more precise metric gives birth to the *h-index* [HIRSCH 2005]. The h-index is an indicator that puts together the number of publications with the number of citations, corresponding to the maximum common number between the numbers of publications and citations. Contrary to the SCI, the h-index was expressly created to evaluate scholars, and successively also scientific communities. Although citation analysis is increasingly sophisticated and precise, a major criticism claims that such an index facilitates short-term scientific writing to perform better.

Another index that was not intended to be employed in scientific assessment is the *Impact Factor* (IF), which Sher and Garfield conceived to help librarians in their journal selection. The IF corresponds to a numerical value equal to the sum of the citations that a journal has collected during the two previous years, divided by the number of articles published in the same period. Despite its original purpose, today the IF is used by publishers to promote their journals [GARFIELD 2006]. Such a usage is speculative because it impairs good judgment, especially between different disciplines: the average temporality of humanities is indeed longer than the natural sciences' one [GINGRAS 2014]. Also, it damages academic practice because scholars are attracted—sometimes with financial aids—to publish in high-rated journals even if their subject matter does not fit. Such a behavior generates a higher rate of rejects and more work for reviewers.

The creation of indexes not only has an impact on individuals and journals; it also impacts institutions. The first academic rankings were introduced in order to evaluate world universities between 2004 and 2005. Their biases were so evident that further alternatives were immediately explored [HERTIG 2016]. Among them were the *Times Higher Education Ranking* and the *Academic Ranking of World Universities*, also known as *Shanghai Ranking*.

Metrics such as the h-index, the Impact Factor, and the world rankings clearly influence scientific practice. Their use during recruitment and assessment of employees already changed the way of doing research. Scientific and academic practices are more complex than the sole scientific literature. They are heterogeneous, multi-dimensional, and as rich as human nature. This book therefore explores the concept of affinities in opposition to the reduction of current scientific metrics, embracing the idea that scholarly practice cannot be measured by citation analysis only.

AFFINITIES AS A METRIC

Although scientific literature is central in bibliometrics, the etymology of scientometrics reminds us that science cannot be limited to publications only. The concept of affinity underpins the richness and the diversity of scientific and academic practices. Through affinities, we would like to step back to the wider meaning of these practices.

Affinities have a natural potential that relies on their relational dimension. This dimension corresponds to collaborations, which can be defined as the chemistry that associates scholars so as to make new discoveries [LEDFORD 2015]. Two types of affinity have been identified, *actual* and *potential*. Actual affinities correspond to real-life collaborations between scholars: a journal article signed by more authors stands for an actual affinity; the same goes for teaching when sharing courses implies a collaboration.

However, not all affinities are concrete collaborations. There exists a serendipity for which scholars come to work together through a latent possibility, which takes the name of *potential affinity*. Potential affinities refer to a potential of collaboration that can be created on the base of cultural intersections, similar profiles, or common interests.

The measurement of affinities, however, needs a further effort, as there is no dataset that has been created to fulfill it. The digital traces that outline affinities are scattered over information systems and the Internet: publications are available on digital repositories and classes on institutional websites. Some affinities, in addition, are not public and one needs permission to access them; frequently, this is the case with financial information. And some affinities do not exist because no organization decided to create a specific type of digital traces. As a result, data collection is a task that recalls an ethnographic field in which the ethnographer lives within a community to observe people's culture and habits. Data are not simply something given, they are something to discover and obtain.

VISUALIZING AFFINITIES

If affinities are initially translated from daily practice to data, there is a second transformation that is needed to make these data understandable, it is the visual translation. The visual projection of data allows the reader to look at information from a different perspective, which both reduces and amplifies data: reduction is needed when the amount of information is too large to be grasped, and amplification enriches further dimensionality to information that would be invisible otherwise.

When visualized, affinities appear as a hybrid that conciliates the community and all its members. These two levels of detail that characterize all types of communities can be related to two areas of data visualization: the organizational charts that are used to display the way in which corporations are structured, and the identity of the single individual, which is digitally represented through digital traces.

The visual investigation is herein presented in a sequence of chronological steps, showing how scientific and non-scientific communities have been represented over time. This section is not an exhaustive historical report, but rather aims to illustrate the changes of perspective using visual examples. The following figures exemplify the tension that exists between the individuals and the entire community, providing an understanding that will be useful to make the ethical choices at the center of the design process, described at a later stage, in the central part of this book.

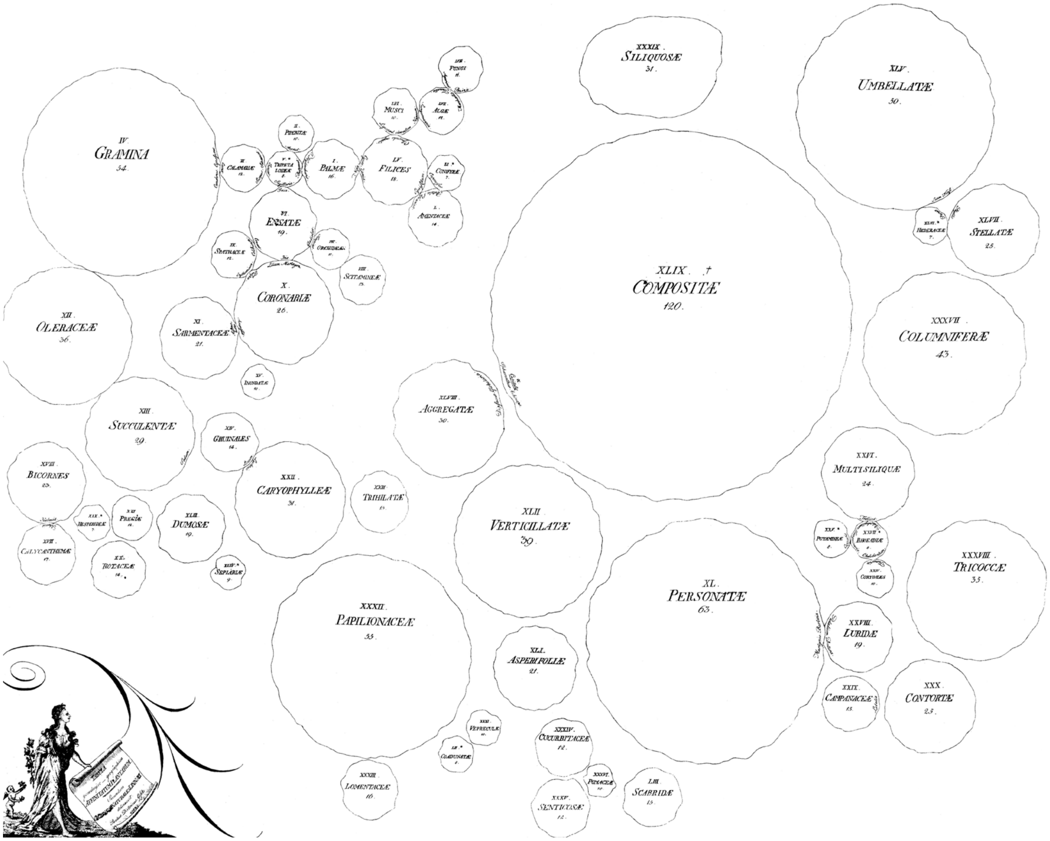
LAWS OF AFFINITY

When we discuss affinities, we first think of the book written by Wolfgang von Goethe, published in 1809 and titled *Elective Affinities* [GOETHE 1872]. The book is about a love experiment between Ottilie and the Captain, whom Eduard and Charlotte invited in their real estate not far from Weimar. Although the story is clearly inspired by the reactions that happen between chemical elements, the origins of the term "affinity" dates back to the eighteenth century when it was used to visually classify plants according to type.

The German botanist Paul Dietrich Giseke published the circle diagram for the first time in 1792 [PIETSCH 2012], influenced by his teacher and friend Carl Linnaeus who once wrote, "plants show affinities on all sides, like the territories on a geographical map."

When he published his notes of Linnaeus' lectures, Paul Dietrich Giseke enriched them with a graphical representation of the families of plants, following Linnaeus' classification. The diagram below shows the families as circles whose size corresponds to the number of species and position is based on similarity, which is explicitated by small labels where the circles touch.

It is incredible to think how Giseke's visualization anticipated current network visualization. Its original way of organizing information leaves the form of trees



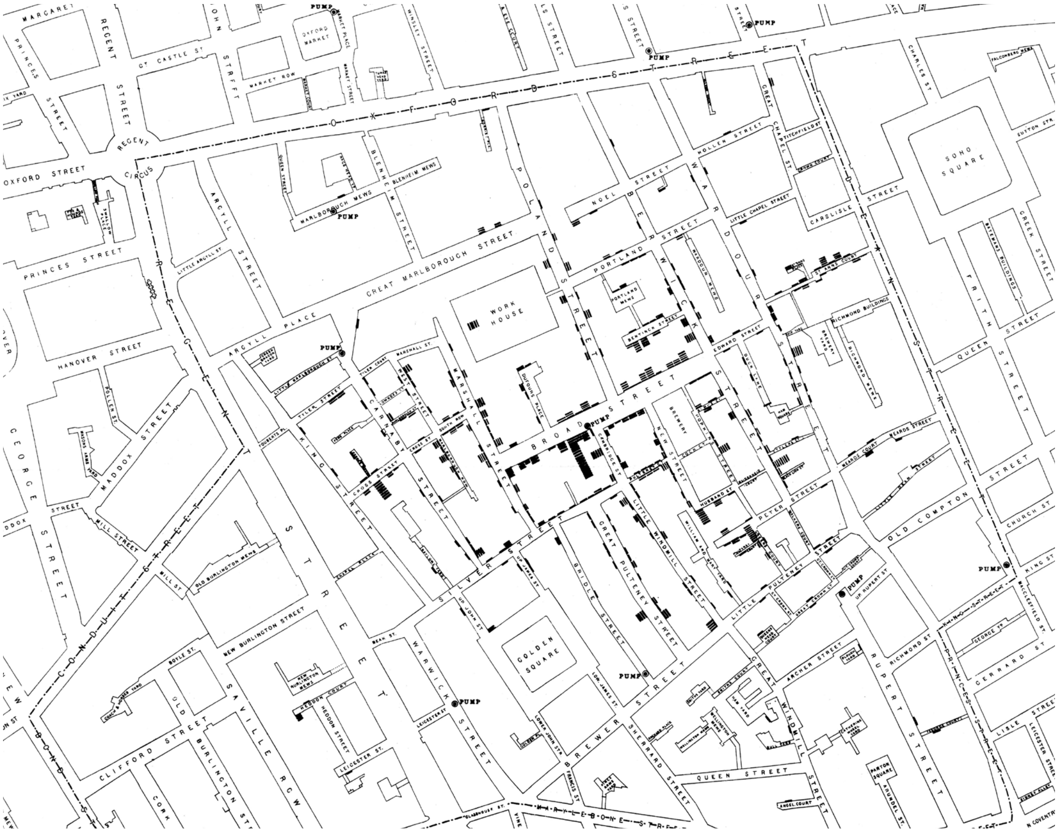
↓ This diagram created by Paul Dietrich Giseke shows families of plants according to the affinities identified by Carl Linnaeus. While the size is relative to the number of species, the whole arrangement is based on affinities that are accompanied by qualifying textual information.

and graphs used up to that day, to leave room to a two-dimensional arrangement that gets rid of the structural connection between elements for a more fluid and less constrained representation.

↓ This map represents Soho with the deaths from the cholera epidemic, which took place in London in 1854. John Snow made use of data visualization to identify the infected water pump by looking at the most infected areas.

MAPPING INDIVIDUALS IN EPIDEMICS

One of the fathers of data visualization is Dr. John Snow, whose reputation was amplified a short while ago by the scholar Edward Tufte. Tufte has the merit of having rallied the data-visualization community, which was scattered in different domains, through the publication of a series of books presented during public events all around the world



[TUFTE 1990; 2001; 2003; 2006]. Tufte [2003] tells John Snow's story in his third book, *Visual Explanation*. John Snow was a doctor who lived in the nineteenth century, when London was struck by the cholera epidemic. Like others in the city, Dr. Snow was facing the epidemic that severely affected the neighborhood of Soho. Even though he was sure that the problem was in drinking water, Snow was not able to demonstrate it in order to convince the representatives of the city to intervene.

So, he went from door to door to collect information about the dead, which was successively arranged on the city map by house number. He hesitated a while because pub workers were not affected by the infection—the fact that water was substituted by a daily ration of beer compromised a portion of data—but the spatial distribution of deaths clearly indicated one power pump as the cholera source. For him, the data visualization was proof to bring up to the municipality that he was right.

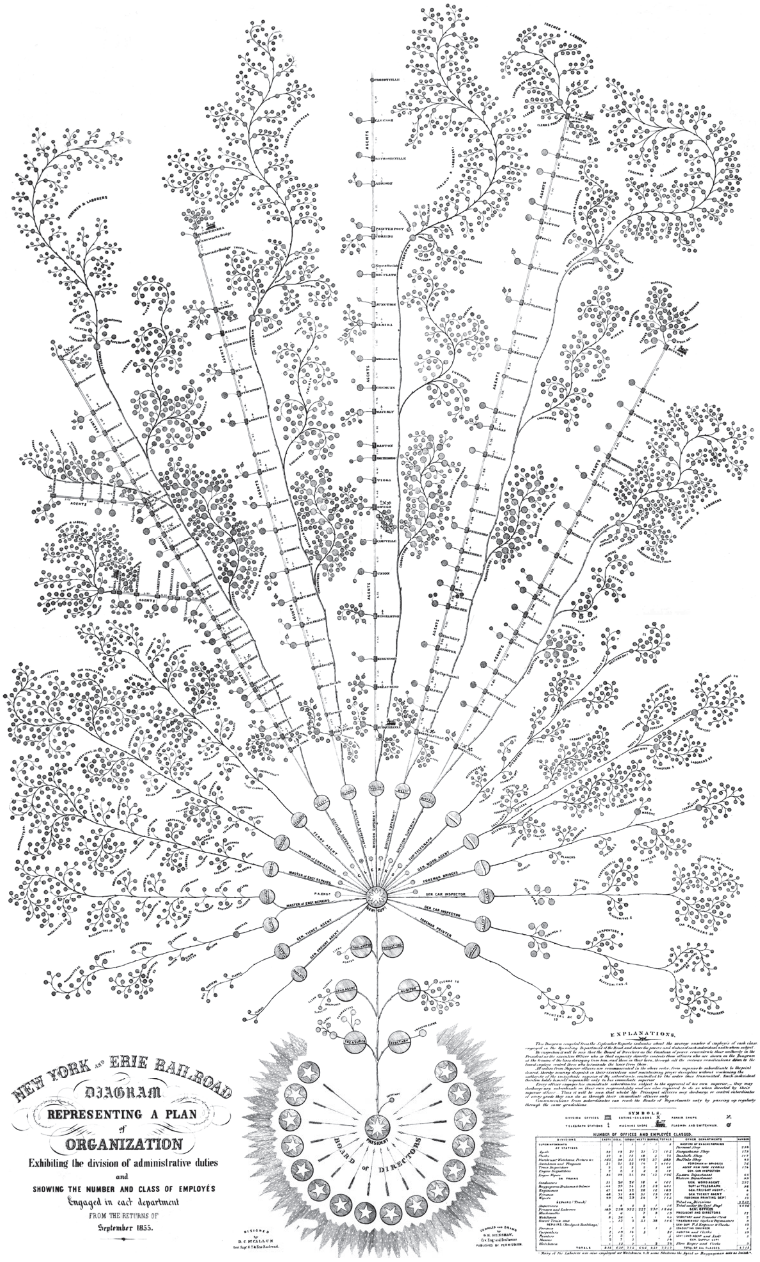
John Snow's visual exercise clearly brings up the tension that exists between the individuals and their collectivity. Taking the deaths one by one is not the same as considering them all together. And the visual mapping is the way in which insights can become observable.

Paraphrasing the Gestalt's maxim, "the whole is more than the sum of its parts" [KING & WERTHEIMER 2005], it can be said that the visual arrangement of individual elements makes the whole picture clearer, giving an understanding that would not be visible otherwise.

ORGANIZING INDIVIDUALS IN SPACE

Looking back at the history of visualizations, Daniel McCallum created the first organizational chart in the middle of the nineteenth century [ROSENTHAL 2013]. At that time, he was in charge of the complete reorganization of almost 500 miles of the New York and Erie Railroads. As the mission was risky because transports were organized on a single set of rails, McCallum led the reorganization by using a visual chart that was both a model and a map for planning. Even if McCallum's visualization seems static before our very eyes, it is a dynamic representation that adapts its shape according to daily prospects.

The visualization looks like a tree, a shape that was widely used during the Middle Ages to represent aristocratic families [LIMA 2014]. McCallum's chart inherited the trees' orientation, placing the president at the bottom like a strong root. Those lower in the hierarchy grow up towards the sky, until the lowliest workers take place at the top of the representation: conductors, brakemen, and laborers.



←When Daniel McCallum took charge of the operations of the New York and Erie Railroads, he underwent a visual reorganization. This visualization was used to maximize the efficiency of the company and is recognized as the first organizational chart.

The drawing was used as an instrument of decision-making, as it clearly represents the desired configuration of the company. The main branches, which start from a node decorated with a star, represent the rail lines with the train stops. Then, the units of workers are associated with the rails through the respective chiefs. What is impressive about this chart is not only its precision, but the fact that all individuals are represented one by one. Additionally, it is also interesting to notice how the final drawing is half topographical and half topological; even if the branches represent actual rail lines, the geographical positioning is unrealistic, implying that the abstraction of territory was a way to improve chart readability.

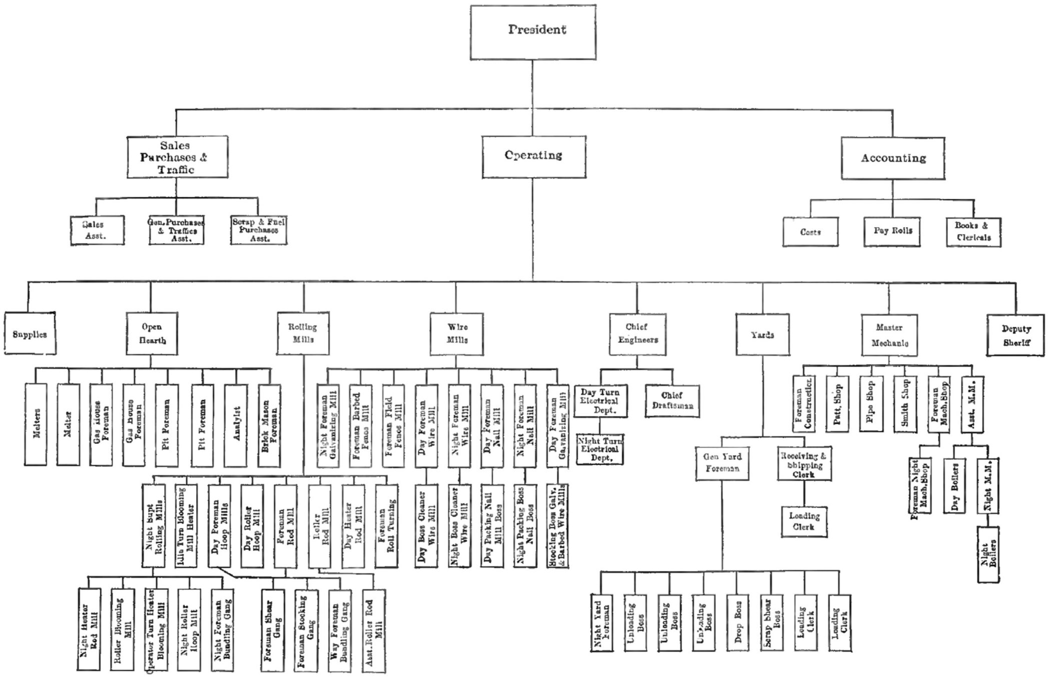
IMPOVERISHMENT OF VISUAL LANGUAGE

Organizational charts were further developed, stressing the gap between management and employees through graphical abstraction. At the end of the 1930s, the engineer Willard C. Brinton [1939] published a book that included many visual examples. These examples clearly show how individuals have been increasingly anonymized by a representation recalling an engine composed of gears, which can be easily replaced when broken or malfunctioning.

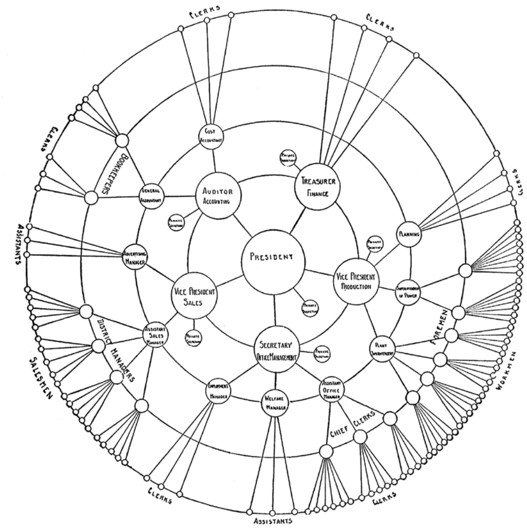
Even though the arborescence is preserved, the tree shape is inverted like a pyramid. The president dominates at the top as the person elected to govern or, more mythologically, as the pharaoh blessed and inspired by God. Visually speaking, it represents a great loss. If in family trees the ancestors were recognized as the progenitor of present relatives, the inversion shows a president controlling from the top. The diagram loses that sense of heritage given by the roots, placing the management in a panoptic position.

Organizational charts appear extremely simplified. Any ornament is removed because it is considered useless, and the care and accuracy of the image itself cannot be compared to crafted maps like Daniel McCallum's. The chart appears as an ephemeral object that will be replaced soon; it is no longer a document intended to last over time. Nevertheless, it happens that organizational charts introduce interesting variations, as in the circular diagram. The manager is situated at the center, giving the feeling of being part of a community and not at the head of it. The workers are seen as extensions of the manager, conveying a sense of collectivity characterized by no specific orientation.

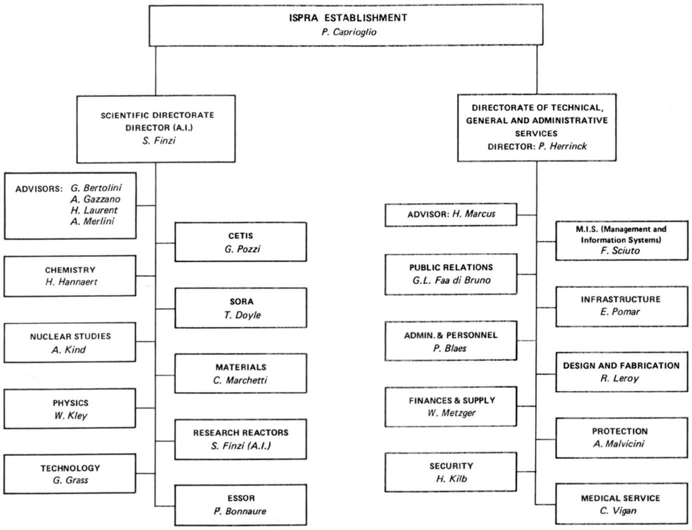
However, a few efforts had an impact on current organizational charts. The European Commission, for example, has never changed their organizational chart in

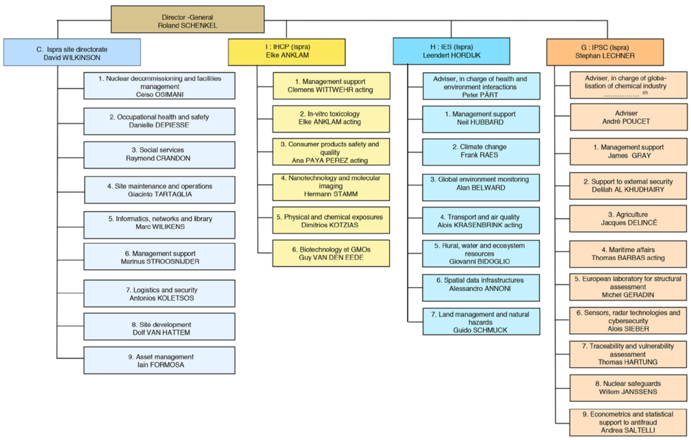


↑ This image shows a classical example of an organizational chart, which simplifies the company. This diagram was very common at the beginning of the twentieth century. ©[BRINTON 1919]



→ Organizational charts might contain variations when compared to the classical tree model. This visualization features a centric view where the president is placed at the center of the diagram. ©[SMITH 1924]





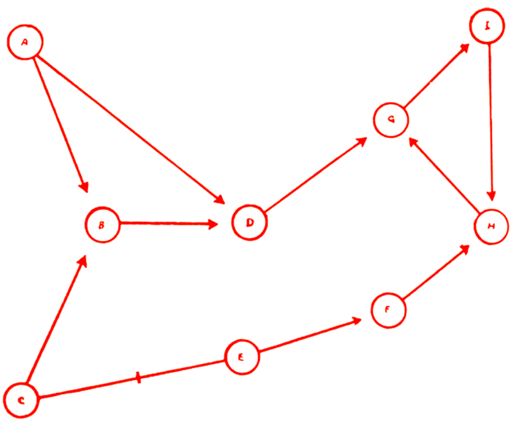
↑ The organization of the Joint Research Centre of the European Commission in Ispra is represented in two different years, in 1972 [PERSONAL ARCHIVE] and in 2008 [FERIGATO *et al.* 2009]. Within the time span of thirty-six years, the visualization layout remained the same, except for the introduction of colors. ©1972-2008 European Commission thirty-six years. Furthermore, it represents only the top managers, excluding the large part of officers and harming community resilience by fostering a sense of separation between employees and management.

DIAGRAMS OF FRIENDSHIP

While the private sector has favored a representation that gives little attention to individual identities by embracing simplification, a group of social scientists ran in the opposite direction.

The psychiatrist Jacob Levy Moreno [1934] was the first to systematize social relations in diagrammatic shapes, the so-called *sociograms*. During the 1930s, many scientists migrated to the United States because of the events that were unfolding in Nazi Germany. At that time, Kurt Lewin, Fritz Heider, and Jacob Moreno became the most prominent practitioners influenced by Gestalt psychology [SCOTT 2000]. This influence contributed to the creation of sociograms, which rely on the principle that the whole and its elements are two equally fundamental perspectives of the part-whole tension [VARZI 2019]. Sociograms, indeed, offer a general view that guarantees the independence of the single elements. This happens today in network visualizations.

↓ This sociogram represents individuals by nodes connected by directional relations. The arrow illustrates a univocal connection, the segment at the center shows a reciprocal link. ©[MORENO 1934]



Moreno's sociograms show friendship in terms of attraction. After a series of interviews, qualitative data are transformed into tabular information that describe the friendship degree between individuals of the same community. These data are successively translated into a network where individuals are represented as circles, labeled using the letters of the alphabet to maintain privacy. The visual grammar is then completed by lines indicating the relation: arrows are used to display directional relations and crossing segments to display reciprocal relations.

Jacob Levy Moreno introduced a visual method to display data that was unrelated to the topography of a place. On the one hand, he gave a visual form to tabular data that were usually arranged in rows and columns, on the other hand, he transformed social reality into an abstract representation.

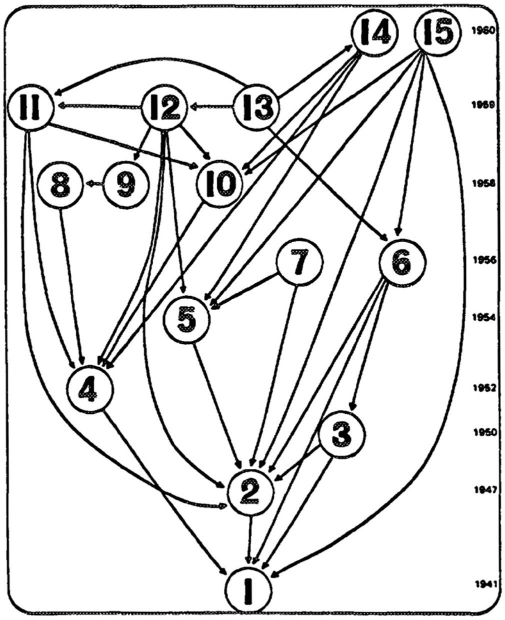
Differently from previous visualizations, Moreno valorized the social ties that naturally take form. These relations differ from hierarchical charts because they are unplanned and highly unpredictable. Such a visualization represents an overlap with two structures: one assuring an overall view of the organization, and one representing the single social ties that exist between individuals. This happens because individual elements maintain their independence even though they are topologically organized. Sociograms have proved to be valid instruments to visualize the self-organization of individuals through their relations, or affinities.

AFFINITIES IN ACADEMIC LITERATURE

Social relations are part of human nature and exist everywhere. The academic environment represents a valuable example of such relations. In research, one of the most common relations is represented by authoring.

Academic practice is intimately related to the act of writing, which contains a universe of social ties. In particular, two aspects of writing are relevant to the relational sphere: citations and collaborations. A/ *Citations* are an example of recognition among scholars, which allows for comparison, advancement, criticisms, and praise of scientific literature. Citing creates a link from the past to the present because an author can cite the works that have been published or are in the publishing process. B/ *Collaborations* are relations that scholars have with their closest peers. If writing is an intimate practice, it is common for authors to collaborate with someone else they respect or admire.

Allen Gordon authored the first citation visualization [GARFIELD 1970]. The network in the figure below shows articles as num-



↑ First citation visualization, created by Allen Gordon, which shows a group of scientific articles connected by referencing and arranged temporally from the top down [GARFIELD 1970]. ©1970 Thomson Reuters bered nodes connected by their internal references. The graph has a vertical direction like a pyramid, placing the older articles at the top. The numbering follows the same rule, the oldest article at the top, and the most recent articles at the bottom. Citation networks are often time-based, as their relationships rely on references to works previously published. Additionally, taking a more general look on this visual method, it is interesting to notice that citation analysis focuses on articles rather than individuals. However, although these visualizations do not display individuals, the nodes indirectly represent one or more authors.

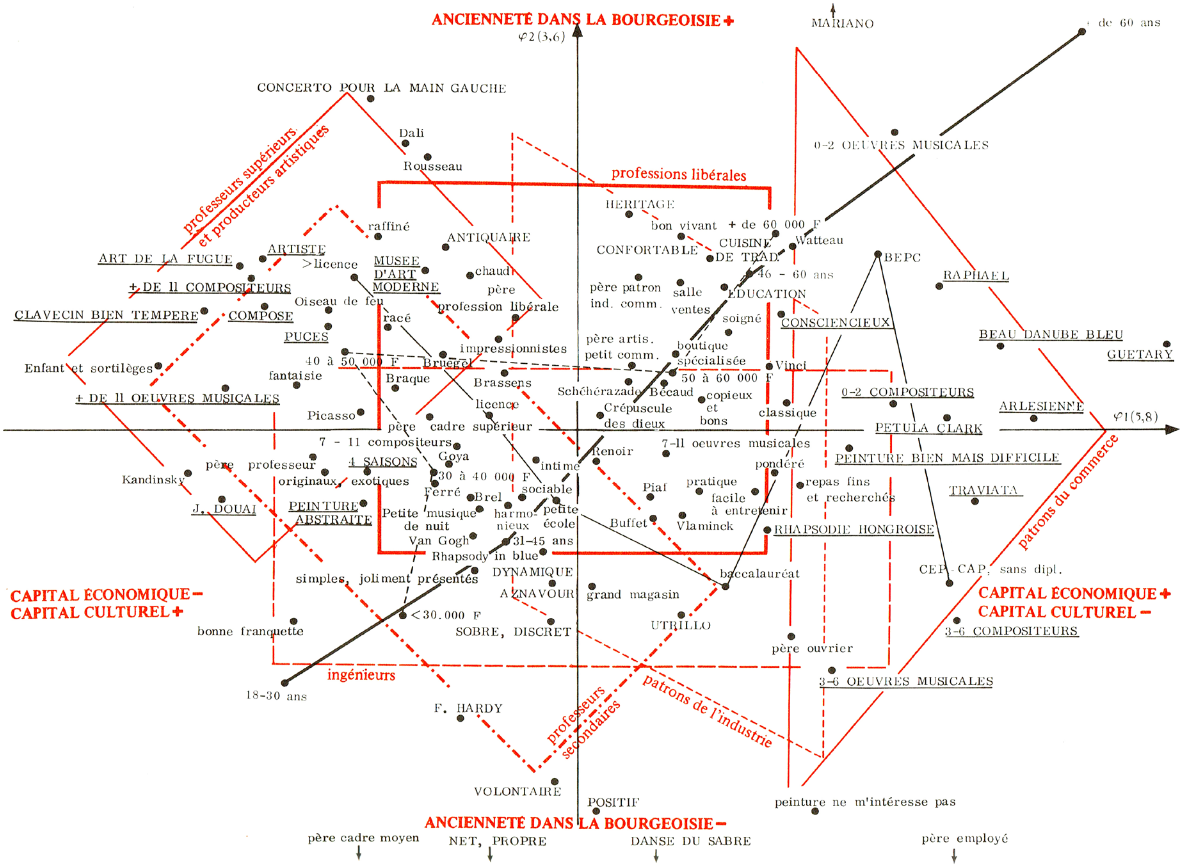
This differs from authorship visualizations where individuals are represented by nodes. The scholar Caty Börner, for example, has an extensive specialization in co-author networks. One of her papers, therefore, illustrates a time-lapse animation of a department co-authoring network of the University of Indiana [BÖRNER *et al.* 2005]. In a highly quantified form of network visualization, the size of nodes corresponds to the number of papers an author published, and the thickness of links corresponds to the number of co-authored papers.

Contrary to citation visualizations, co-authorship visualizations reveal the collaboration patterns. These relations are expressions of actual affinities that show how individuals work together. Collaborations suggest that authors know each other, spend time in meetings, make drafts, contribute to all of the small activities that converge towards a publication. Although in some cases citations also include peers, references bear a likeness to potential affinities indicating, for example, the closeness of a standpoint or the proximity in a specific domain.

ARRANGING INDIVIDUALS BY SIMILARITY

A typographical rule says that margins elevate the visual elements contained in the page. That rule also applies to visual languages in general, from photography to film. When data visualizations are printed, these margins make way for annotations that the reader may add as an additional overlay of information.

The sociologist Pierre Bourdieu loved to rework visualizations. When his publications went with computed diagrams, these were enriched by his annotations. Bourdieu demonstrated an interest in statistical data analysis since the 1960s, using a method called the Multiple Correspondence Analysis (MCA). This method was used for underlying spatial structures of specific datasets [LE ROUX & ROUANET 2010]. An initial qualitative survey was translated into data, which in turn were computed and projected on the Cartesian space. Bourdieu [1979] was interested in the annotation that followed the



↑ ©Pierre Bourdieu [1979] identifies social groups, drawing geometrical shapes on the visualization, which situates intellectual interests.

projection: this figure shows how he identified social classes by framing intellectual interests. The process of identification, which is rooted in human beings, is the typical mental effort that a visualization asks from its readers (it will be the argument of the last section of the present book).

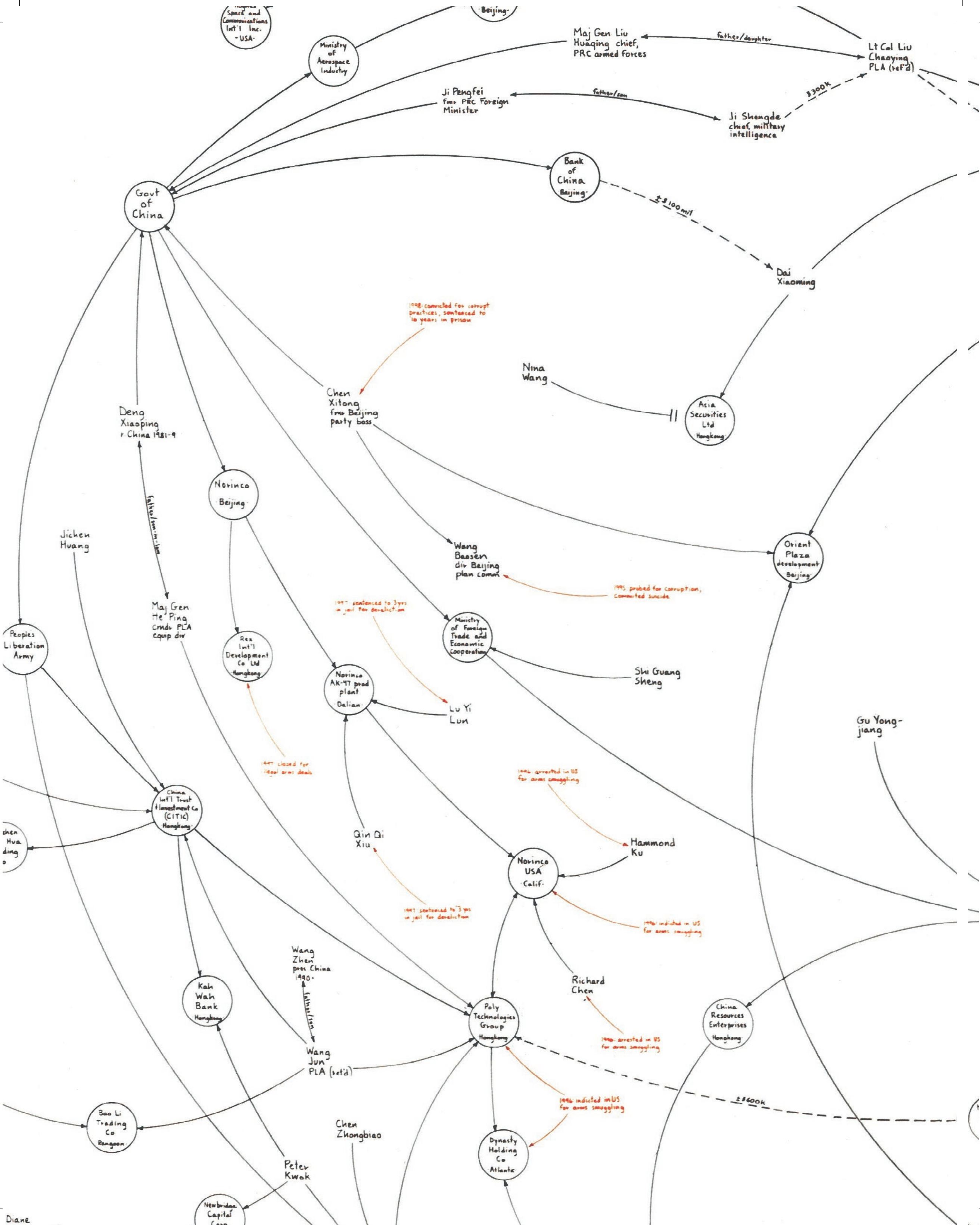
The projection resulting from MCA evolves according to the specific type of entity. In his text *Le Patronat*, Bourdieu represents individuals as entities [BOURDIEU & DE SAINT MARTIN 1978]. According to demographic, familial, educational, and professional characteristics, his visualization arranges individuals on two axes: one axis opposes private to public, and one opposes newcomers to those established in the field. Such visual mapping clashes with the relational logic of networks: if Moreno's approach is appropriate to show relations, Bourdieu's is better to spot similarities. That opposition recalls the contrast between the actual and the potential affinities previously discussed: the former embraces a relational logic, while the latter privileges a method which is based on similarity.

Although in *Le Patronat* Bourdieu [1979] does not enrich the visualizations with annotations, in his book *La Distinction* this process is visible, as exemplified in the figure shown here. The visualization points out the social groups as geometrical shapes, as in the case of engineers who are framed within a dotted rectangle. In doing so, Bourdieu creates categories suggested by his own view, providing a supplementary level of information that perfectly integrates the computed one.

AESTHETIC OF ORGANIZATIONS

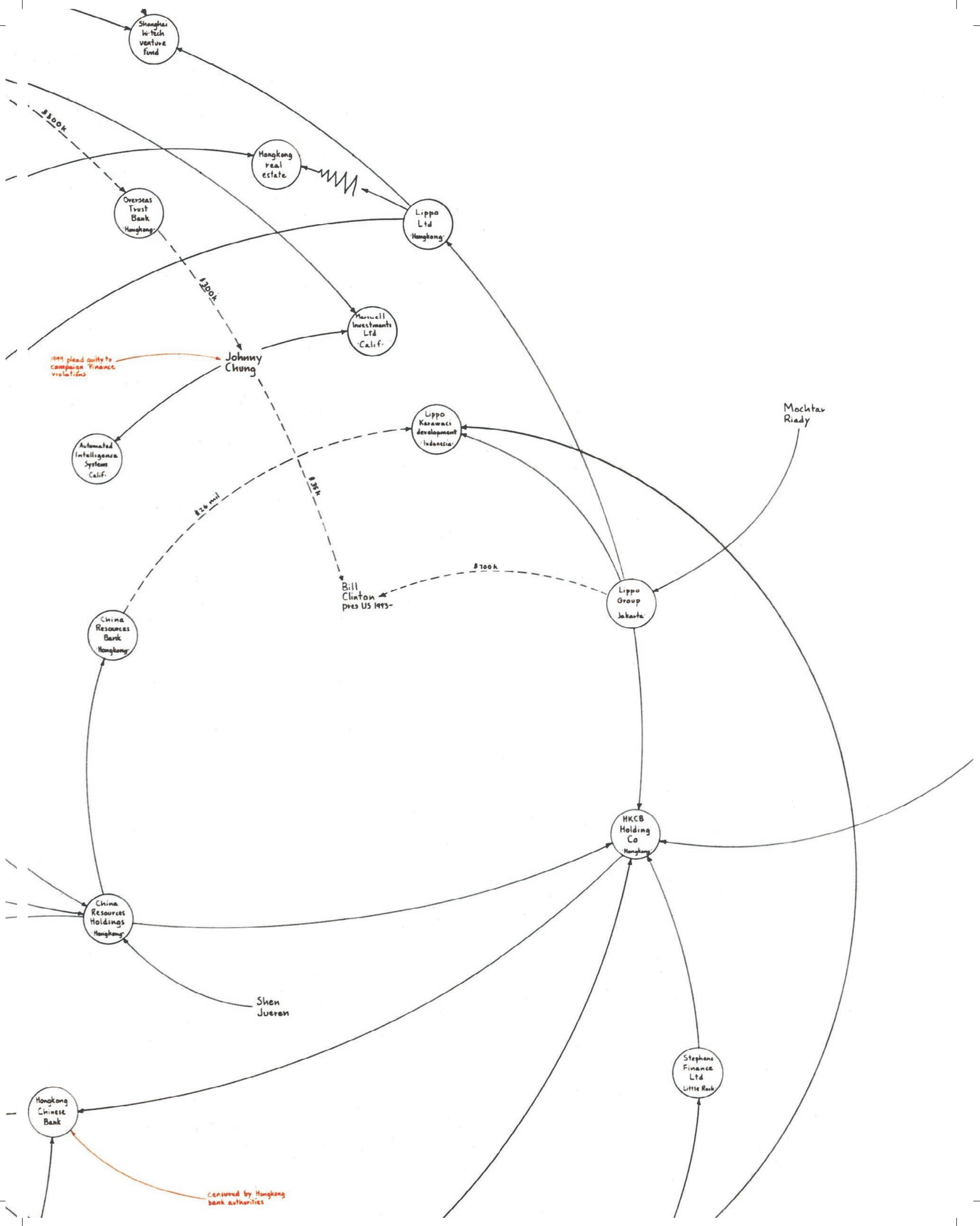
Mark Lombardi was an American artist who saw network diagrams as a way of making art [HOBBS 2004]. He was interested in revealing conspiracies of financial and political frauds by opening up the black box of their mechanisms, and he found an excellent tool for displaying them in networks. The following figure shows a typical Lombardian visual investigation in which he draws the unclear relation between the United States' former president, Bill Clinton, and the Lippo Group, a real estate development company in Indonesia. Artwork was just a passion for Lombardi, but at a certain point such a passion became a job, only six years before his death. It is interesting to notice how Lombardi was influenced by the visualization expert Edward R. Tufte [HOBBS 2004], in particular by his second publication *Envisioning Information* [TUFTE 1990].

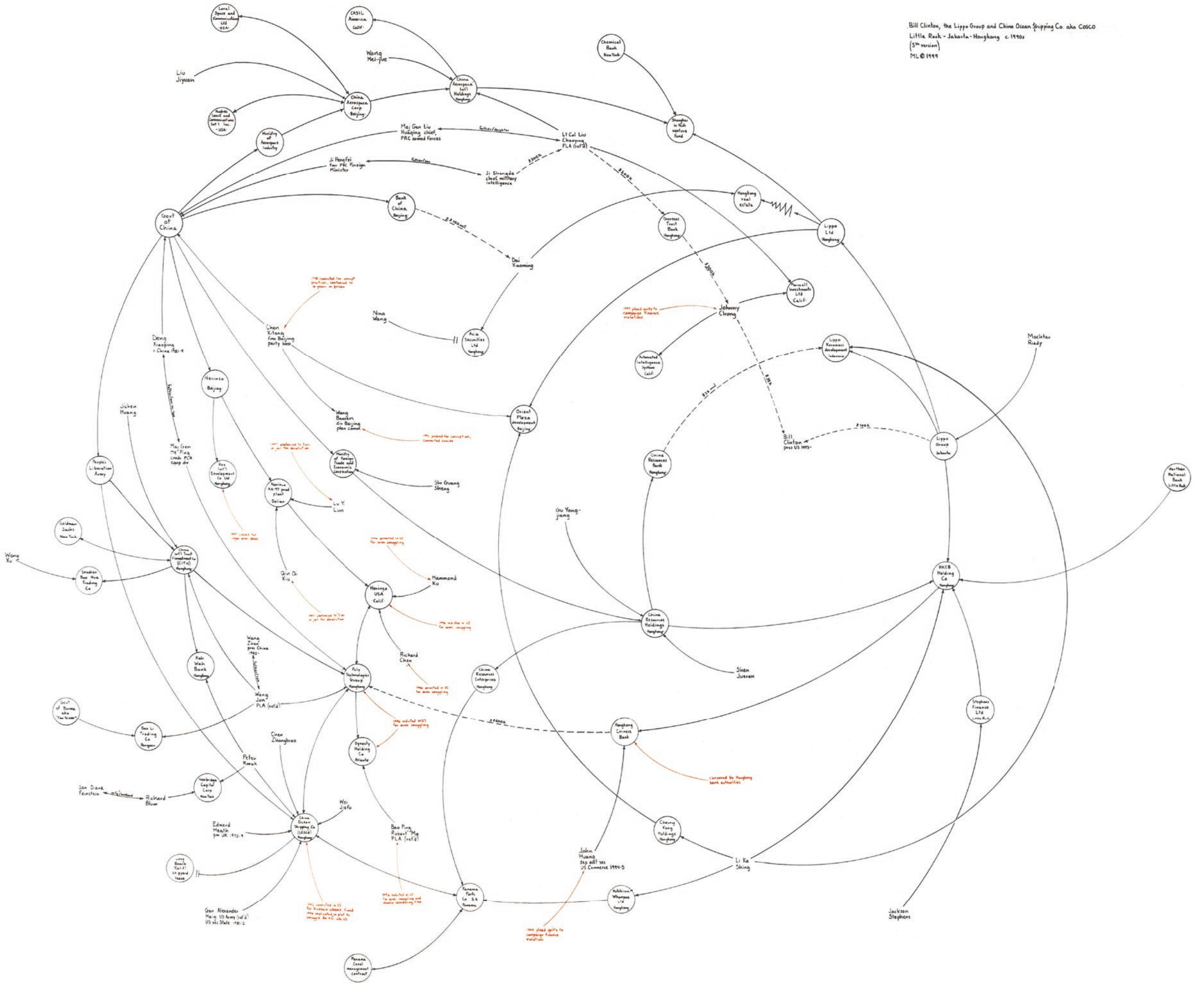
The lesson Lombardi left is rich in inspiration. First, he demonstrated how networks can be a powerful tool to organize information. Then, he picked out the aesthetic value of diagrams, elevating the pleasure of reading



Space and Communications Int'l Inc. ·USA·
·Beijing·
Ministry of Aerospace Industry
Maj Gen Liu Huaqing chief, PRC armed forces
father/daughter
Lt Col Liu Chaoying PLA (ret'd)
Ji Pengfei fmr PRC Foreign Minister
father/son
Ji Shengde chief, military intelligence
$300K
Bank of China ·Beijing·
±$100 mil
Govt of China
Dai Xiaoming
1998: convicted for corrupt practices, sentenced to 16 years in prison
Nina Wang
Asia Securities Ltd ·Hongkong·
Chen Xitong fmr Beijing party boss
Deng Xiaoping r. China 1981-9
father/son-in-law
Norinco ·Beijing·
Jichen Huang
Wang Baosen dir Beijing plan comm
1995 probed for corruption, committed suicide
Orient Plaza development ·Beijing·
Maj Gen He Ping cmdr PLA equip div
1997 sentenced to 3yrs in jail for dereliction
Peoples Liberation Army
Rex Int'l Development Co Ltd ·Hongkong·
Norinco AK-47 prod plant ·Dalian·
Ministry of Foreign Trade and Economic Cooperation
Shi Guang Sheng
Lu Yi Lun
Gu Yong-jiang
1997 closed for illegal arms deals
1996 arrested in US for arms smuggling
China Int'l Trust &Investment Co (CITIC) ·Hongkong·
Qin Qi Xiu
Hammond Ku
Novinco USA ·Calif·
1997 sentenced to 3 yrs in jail for dereliction
1996 indicted in US for arms smuggling
Wang Zhen pres China 1990·
father/son
Richard Chen
Kah Wah Bank ·Hongkong·
Poly Technologies Group ·Hongkong·
China Resources Enterprises ·Hongkong·
1996 arrested in US for arms smuggling
Wang Jun PLA (ret'd)
1996 indicted in US for arms smuggling
±$600K
Bao Li Trading Co ·Rangoon·
Chen Zhongbiao
Dynasty Holding Co ·Atlanta·
Peter Kwok
Newbridge Capital Corp

Diane


Shanghai hi-tech venture fund
$300k
Hongkong real estate
Overseas Trust Bank ·Hongkong·
Lippo Ltd ·Hongkong·
$300k
Maxwell Investments Ltd ·Calif·
1999 plead guilty to campaign finance violations
Johnny Chung
Automated Intelligence Systems ·Calif·
Lippo Karawaci development ·Indonesia·
Mochtar Riady
$35k
$26 mil
$700k
Bill Clinton pres US 1993-
Lippo Group ·Jakarta·
China Resources Bank ·Hongkong·
HKCB Holding Co ·Hongkong·
China Resources Holdings ·Hongkong·
Shen Jueren
Stephens Finance Ltd ·Little Rock·
Hongkong Chinese Bank
censured by Hongkong bank authorities



↑ ©Mark Lombardi [1999] reports the involvement of the former president Bill Clinton with the Lippo Group through this artistic network [HOBBS 2004].

to the ease of comprehension. His compositions appear minimalistic because they contain a lot of empty space, yet this helps strengthen their content and improve reading.

Following an ideal of transparency aimed at showing the abuses of power and their actors, Lombardi draws individuals with their proper names. And representing them using their real names makes the visualization more attractive.

The impoverishment of the visual language that took place at the beginning of the twentieth century in organizational charts contrasts with Lombardi's richness and diversity given to individuals. He simply states that the social ties, regardless of their context, are always composed of real people that cannot be substituted by placeholders.

DATAFICATION OF ACADEMIC PRACTICE

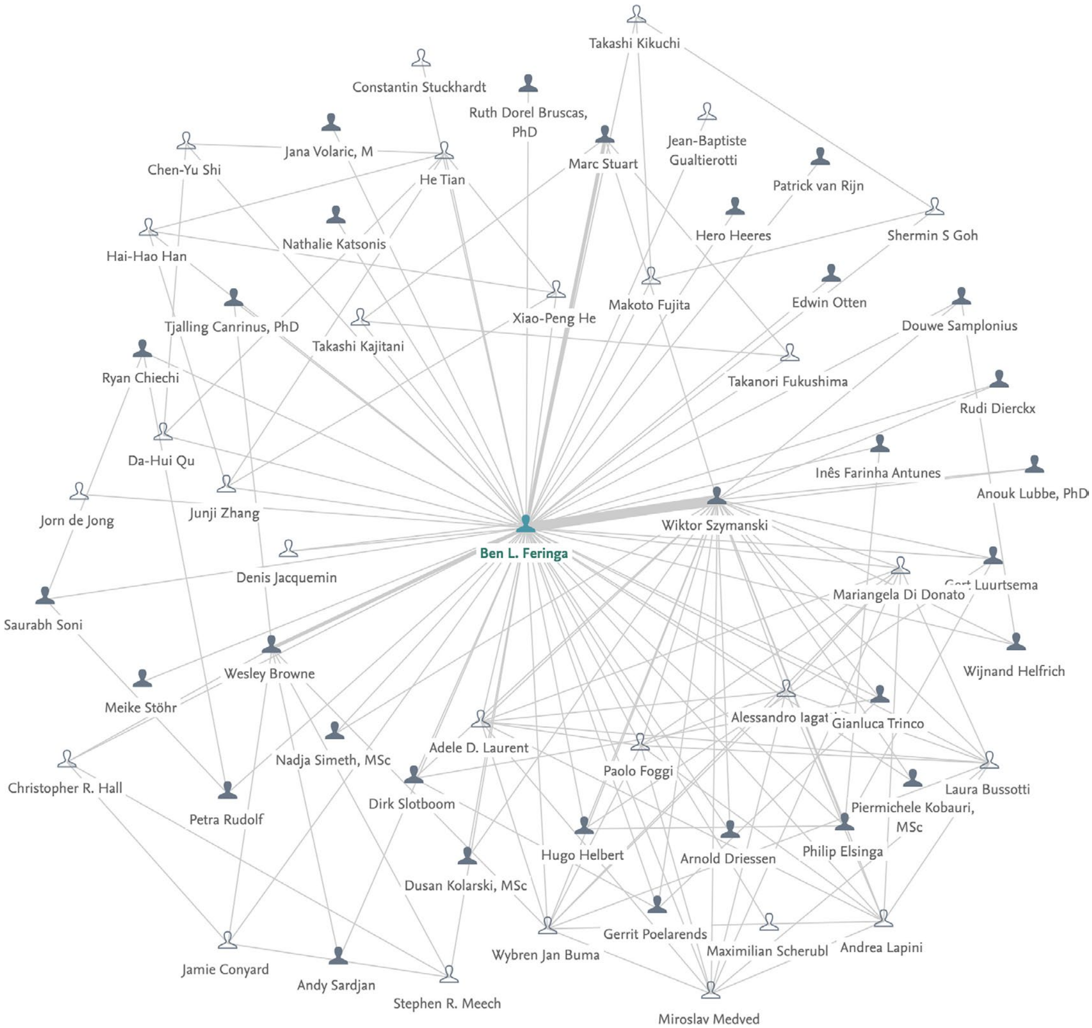
Once inquiry goes further, the scientific practice depends on a complex network of actual and potential affinities. Although co-authorship and citations cover a relevant part of digital traces, the variety of activities a scholar performs daily is still incomplete.

The software Pure by Elsevier is a rather good example to understand the academic irreducibility. Such a comprehensive information management system is created for institutions that collect diversified information related to scholars and their practice.

↑ The University of Groningen provides a visualization of each associate's personal network. The diagram enriches academic profiles with a collaboration network. ©2021 University of Groningen

Classes, journals, and research interests are collected and connected in a gigantic institutional network, ready to be extracted at the moment of need. Among the specific queries that can be handled by the system, there is a panoramic view of collaborators. The figure above shows the collaboration network of the Nobel Prize winner Ben Feringa [UNIVERSITY OF GRONINGEN 2021].

This visualization reveals all the authors who published at least two papers with Ben Feringa. Internal peers are colored in black, and external ones are white. Although this visual queries relies on authorship only, the



↑ The figure shows the collaboration network of the Nobel Prize winner Ben Feringa. ©2021 University of Groningen information system leaves room to multiply and more complex networks to explore the diversity of academic practice.

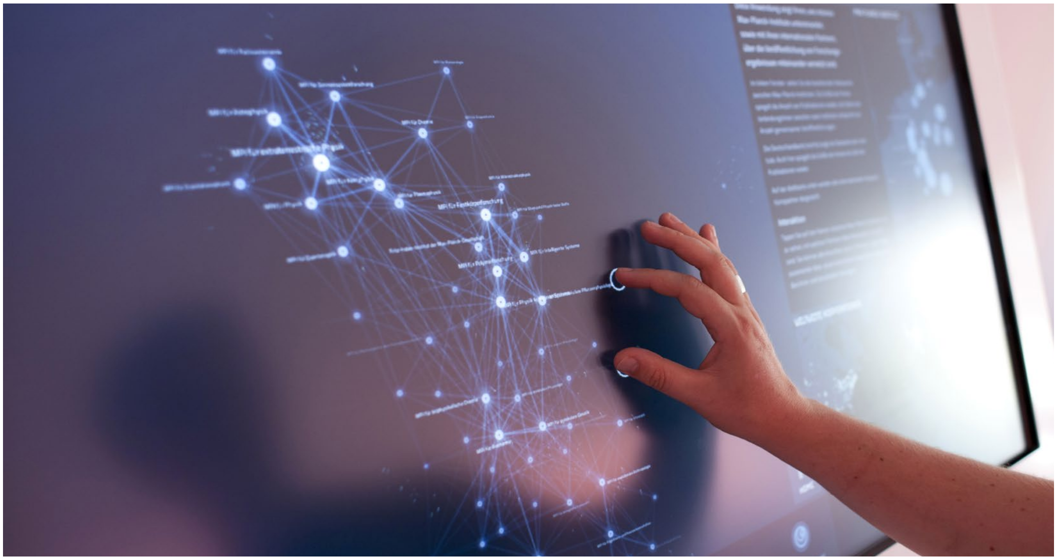
MAKING SCIENCE PUBLIC

Today, making research open access is increasingly important for two main reasons. One is that visibility guarantees greater autonomy in funding [EPFL 2020], the other is that making science public provides transparency in the use of public financing. Transparency is already a political leitmotif in architecture: The City Hall in London and the New German Parliament by Norman Foster (2011), are great examples of architectural transparency.

The example of the University of Groningen shows us how the diversity of academic practice is a matter of transparency. Although publicizing personal work might be controversial because of its sensitiveness, and although the questions of privacy emerge in making science public, the datafication of scholars has been amplified to reach public space such as museum exhibitions, for instance.

Moritz Stefaner, a renowned designer used to addressing data to the public, created two museum installations that focus on scientific practice. These data visualizations were showcased at the Max Planck Science Gallery in

↓ Max Planck Research Network shows collaboration at the level of the collectives of research. ©[STEFANER & WARNOW 2012]



↑ EPFL Data Monolith is part of the Datasquare exhibition at ArtLab. One configuration of the monolith shows professors arranged according to their expertise. ©[STEFANER & BAUR 2016]

Berlin [STEFANER & WARNOW 2012] and at the EPFL Pavilions in Lausanne [STEFANER & BAUR 2016]. While Max Planck's focuses on the collaboration between institutes and external partners, EPFL's reaches out to the scholars' identities whom the visualization makes recognizable to the visitors, and this is worthy of note.

At the EPFL Pavilions, the exhibition *Datasquare* hosted a section dedicated to big data. Among the installations in the section, there was the Data Monolith, a massive data visualization, whose goal was to give an overview of the EPFL through the expertise of its employees. Yet, a very small part of these employees is visible because only professors have been displayed as the most prominent figures of the polytechnical institute.

This digital installation addresses some issues that are central to our research. First, there exists a threshold of privacy that varies according to the academic position and the delicacy of information. Second, scientific communities can be represented as a visualization, a website, or a museum installation depending on the audience. Third, there is a growing need to map large organizations in public spaces.

THE CASE STUDY OF ENAC SCHOOL

The concept of governance reappears at the beginning of the twentieth century [GARNER 2016]. Its meaning dates back to the Greeks, for whom it corresponds to the skill of steering a ship, but its current significance goes along with a process of decision-making that does not belong to the leader only, rather to the network of actors that supports decisions [PIERRE & PETERS 2020].

Maps are instruments for governance: with the expansion and the growing complexity of academic organizations, new instruments are needed to navigate the structure of universities, faculties, and schools. These instruments can be referred to as maps or, more technically, data visualizations, as they summarize information that would be difficult to read otherwise. Their use is not limited to explore complex systems, but also to develop a greater understanding of a specific topic in order to support negotiations and decisions [HOYNINGEN-HUENE 1987].

In the logic of governance, a map for academia has to be designed for both the managers and the deans as well as the scholars and the employees, as the institution is usually steered in two ways: a top-down decision-making from the management is balanced by a bottom-up self-organization that takes place among employees.

The Affinity Map is an instrument conceived to support governance. This section sets the context in the academic environment by introducing the actors and the needs that have driven its design process.

SWISS FEDERAL INSTITUTE OF TECHNOLOGY

The case study takes place in Switzerland at EPFL, the Swiss Federal Institute of Technology. EPFL is an engineering college focused on research, education, and technology transfer, founded in 1969 in addition to the existing federal polytechnic of ETH Zurich. The campus hosts a cross-cultural community of around 15 000 people among students and staff, with more than one hundred different nationalities represented.

The EPFL is composed of five schools and three colleges, which are organized in sections and institutes; the sections are for education while the institutes are for research. Institutes are then organized in laboratories, each headed by one professor. Unlike most academic universities, which, generally, guarantee the continuity of laboratories over different headships, EPFL's are created for one professor and close when that very professor leaves.

The five EPFL schools cover the following programs: Basic Sciences, Engineering, Computer and Communication Science, Life Sciences, and Construction, Architecture and the Environment. This last program is under the responsibility of the School of Architecture, Civil and Environmental Engineering, usually called by its acronym ENAC. The ENAC is organized in three institutes, which in turn are organized into laboratories hosting professors, senior scientists, postdocs, doctoral students, secretaries, teaching assistants, and interns. Although the composition of the school seems very rigid, the laboratories share axes of research that cross the institutional hierarchy, offering ample opportunities of collaboration [ENAC 2016].

SCHOOL OF ARCHITECTURE, CIVIL AND ENVIRONMENTAL ENGINEERING

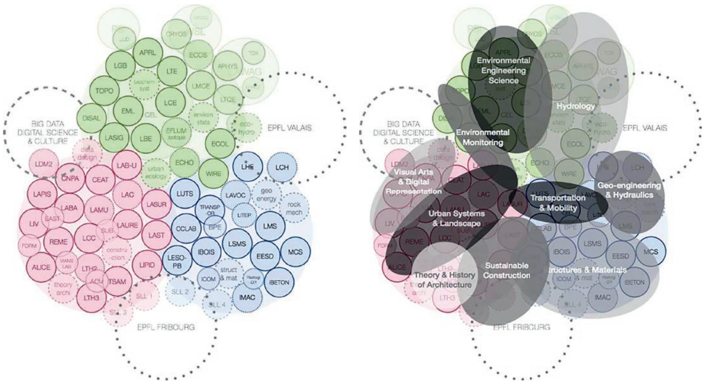
The ENAC is run by a dean, supported by a team and a direction board. Deanship strategic proposals are approved by a council, which is composed of the dean along with the representatives of the teaching body, the intermediary body, the students' body, and the administrative and technical body. The deanship and its political structure are responsible not only for its members but also and especially for modeling the school in its development.

The ENAC is organized in institutes and sections, but also develops new synergies with external centers such as the Smart Living Lab, a research unit based in Fribourg. The ENAC employs new professors who establish new laboratories. This is what happened with professors Nicola Braghieri and Paolo Tombesi who joined the institute of Architecture a few years ago establishing two laboratories, LAPIS and FAR.

The school evaluates professors on a yearly basis. For instance, tenure-track professors are confirmed after a period that spans between four and eight years assessing their academic activity mainly on publications and grants. Although this evaluation today makes use of tabular data, it cannot be excluded that professors will be confirmed with instruments of decision-making based on data visualization in the future [HOPKINS *et al.* 2011].

MAPPING THE SCHOOL

Marilyne Andersen became the dean of ENAC in 2013. Before taking charge of the position, Andersen investigated all the laboratories to understand how the school was working and which subjects of research were studied there. She drew an organizational chart to



←The dean's drawing spaces out the ENAC laboratories according to their affinities, while its colors indicate the institutes: red for Architecture, blue for Civil engineering, green for Environmental engineering. The same drawing overlaps with manual selections indicating the axes of research within the school, which represent potential collaborations between the units. ©2013 Marilyne Andersen

better get the general picture, much like Mike Lombardi with his inquiries [HOBBS 2004].

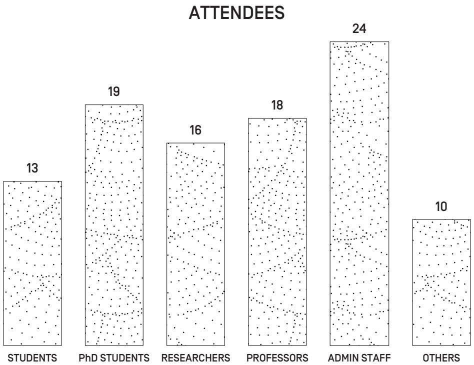
Charting provided her with a drawing of the laboratories, organized by color and interest. Utmost care was given to the new laboratories and to the external poles that describe the synergies out of the school in a process that already belongs to the sphere of decision-making. A second version focused on the research axes. The management shows great interest in these axes because they summarize the organization in major groups. For instance, *sustainable construction* is a transversal axis placed on the border between architecture and civil engineering.

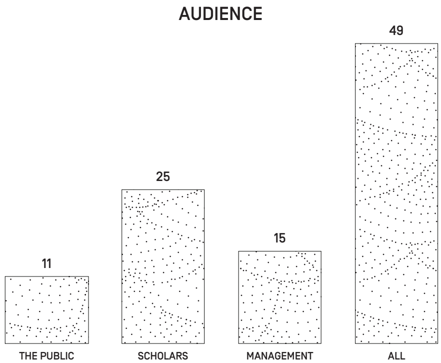
THE SCHOOL FROM THE INSIDE

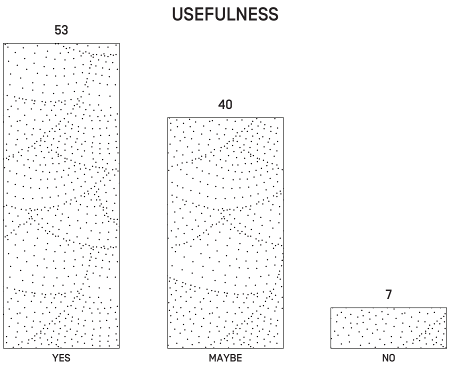
The dean employed a visual method to arrange the academic community by drawings. It was the demonstration that something was missing: a visual tool for exploration and decision-making. When the dean realized the potential of visual mapping and the difficulties of drawing organizational charts by hand, she established a research project. The Affinity Map, therefore, took shape as a project to map the ENAC School.

Although such a project was initially intended to support the management, some positive feedback suggested opening the project up to all ENAC members. During the ENAC General Assembly in 2015, attendees were asked for their opinion about sharing the visual instrument to all the scholars. All the attendees, who covered a large variety of roles in the campus, were asked to answer two questions about the project by using remote controls. The first question about the strength of the project received good confirmation: a large percentage of the audience was convinced of the project. The second question focused on the audience; attendees were invited to choose the most appropriate audience for the map among three possible choices: the public external to the school, the community members, and the management. The results were surprising: not only the attendees were favorable to open up the map to all three audiences, but the preference for the community members was stronger than for management.

It was quite emotional to see that more than 93% considered the map a useful instrument for the entire school; this represented a form of official approval for opening up the Affinity Map to a larger audience. From that very moment, the map has been conceived as an instrument of governance for all the members of ENAC. If the management was rather interested in decision-making, the scholars were curious to see their own positions on the map. In a bottom-up logic, the scholars wanted to reflect on themselves to modify their practice, in a process of self-evaluation.







←Charts show respectively the distribution of general assembly attendees, the attendees' consideration about the final users and the attendees' answers about the value of the map. ©2015 ENAC

PARTICIPATORY DESIGN

Design is the iterative exercise used to solve or improve a situation through a sequence of thoughtful decisions, undertaken by an individual or a team. Although the best solution does not exist, the design process aims to create the best result according to a given set of constraints and compromises, including the designer. When the process involves figures with different skills, the outcome shows a distinct personality, which reflects the whole group. Also, the map is the result of a host of factors including both human and non-human contributors. The former is represented by the specialists contributing to the project, such as the managers or the developers, while the latter includes inanimate objects such as data, programming languages, and the academic environment. This section discusses the actors that were crucial to the design of the map.

Data, in particular, have a key role in the design process. The visualization quality depends on the data, which designers have to translate into visual elements. These, in turn, compose the visual grammar that defines the appearance. Data design actively intervenes in the process, affecting the output.

The map we developed was shaped at a monthly or bimonthly rate during regular meetings. These involved the deanship, the thesis directors, and me. The meetings took place in Marilyne Andersen's office, which was equipped with a large conference table and a spacious library but did not have enough space to also accommodate a projector.

Meetings gave us the opportunity to share and discuss visualizations. These visualizations were usually printed as A0 posters and placed on the conference table or hung over the library using magnets. Each meeting was organized in three parts: the presentation, the discussion when everyone was asked to provide input, and the closing roundtable for planning the next steps.

The whole planning was interspersed with periods of development, involving software developers, project managers, computer scientists, designers, sociologists, data keepers, and so on. All of them contributed to the project in many different ways. Software creation requires the involvement of professionals with different skills, as was the case with maps in the Middle Ages [HARLEY 2001], whose creation would include editors, draftsmen, engravers, printers, and colorists, publishers, sellers…

PRELIMINARY INTERVIEWS

The first meeting ended with the agreement to arrange some preliminary interviews with professors covering management positions, with the goal of identifying their interests in the Affinity Map. At that time, the map had already been presented by the dean as one objective of her mandate and ENAC members were aware of it.

As the interviews took place in early 2014, four professors were chosen as respondents: Luca Ortelli, director of the Construction and Conservation Laboratory (LCC) and of the Institute of Architecture (IA); Philippe Thalmann, director of the Laboratory of Environmental and Urban Economics (LEURE) and of the institute of Urbanism and Land Development (INTER); Eugen Brühwiler, director of the Structural Maintenance and Safety Laboratory (MCS) and former director of the Institute of Civil Engineering (IIC); and Christof Holliger, director of the Laboratory for Environmental Biotechnology (LBE) and also former director of the Institute of Environmental Engineering (IIE).

The interviews were structured to last forty minutes in which professors were asked to describe their laboratories in terms of both research interests and scholarly collaborations within the school. Then, the conversation shifted towards the annual report and the indicators of academic evaluation. Interviews concluded with a general reflection about the map. The following text summarizes the most relevant arguments of discussion that arose during these interviews.

Professor Ortelli, for example, argued that evaluation metrics scarcely consider teaching activities, although they are crucial for universities. He challenged us to deal carefully with metrics and turn the heterogeneity of scientific practice into the major feature of the map. The same argument convinced even Professor Thalmann, for whom the existing tools do not make the academic practice visible in its wholeness. He clarified his thought using a practical example about grant proposals, whose preparation is invisible, especially when it is not successful. The map should become, therefore, a tool to reveal hidden practices by disclosing the variety of daily activities that scholars usually perform.

Current metrics make academic practice visible through quantitative data. With respect to that usage, Ortelli stressed how laboratories cannot be evaluated by size. On the same subject, the sociologist Yves Gingras [2014] writes that quantitative evaluation is dangerous because it marginalizes minor communities, pushing scholars towards arguments of great interest because of citations. It means that publications regarding global warming have to be considered as important as publications about local warming; this kind of research is necessary and has to be preserved by institutions. As a result, the map should display academic practices in the most equitable way possible according to the principle of design ethics, paying particular care to the way in which each individual is represented.

Today, academic performance is mainly measured through publications, but a sole metric cannot fit all the different habits. Professor Brühwiler spoke exactly about this topic, for instance, saying that book chapters cover an area of major importance in structural engineering. Publishing, indeed, changes according to the discipline: monographs have always been greatly considered in architecture and social science, while computer scientists prefer conference papers. Citation analysis is a metric that does not consider this variety, which should be taken into consideration in order to underline the diversity that exists among scientific groups.

If the topics mentioned by the interviewees focused mainly on the academic practice, Ortelli raised the question of mapping research subjects. This issue clearly identifies the need for a semantic cartography of the school, whose space is not regulated by academic practices but rather by the very subjects of research that suggest a metric based on intellectual proximity.

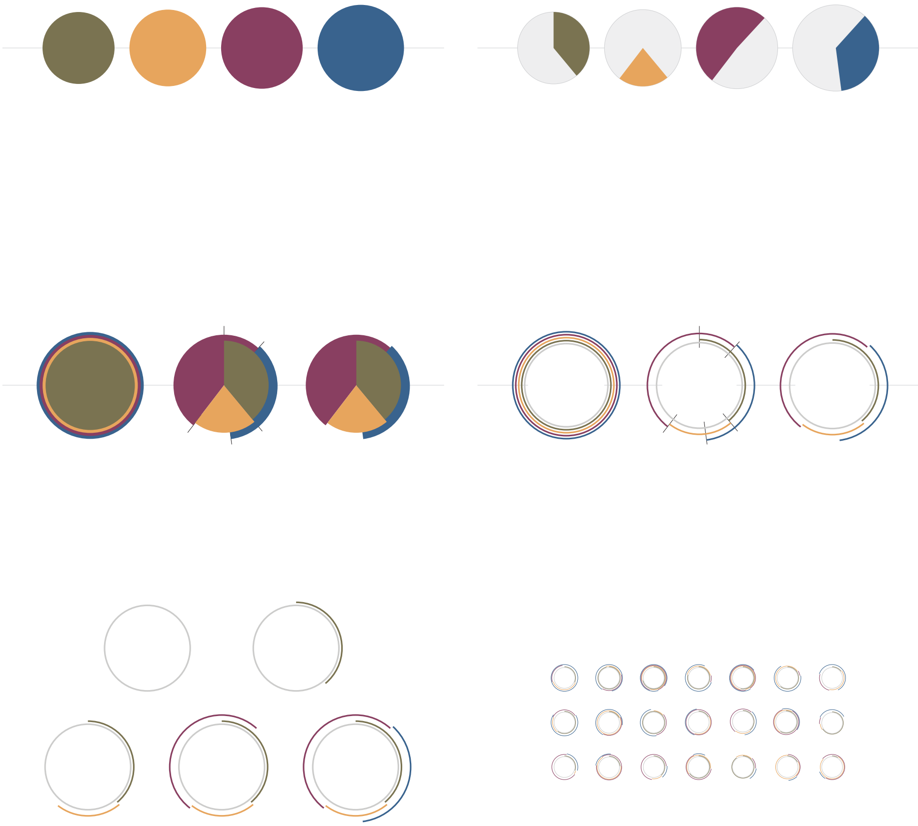
Finally, more respondents reasoned that the map can be used as a communication tool for different audiences; and that the map has to be aesthetically pleasing in order to engage the readers.

These interviews confirmed some aspects that were already taken into account in the first meeting, clearly bringing out the following points:

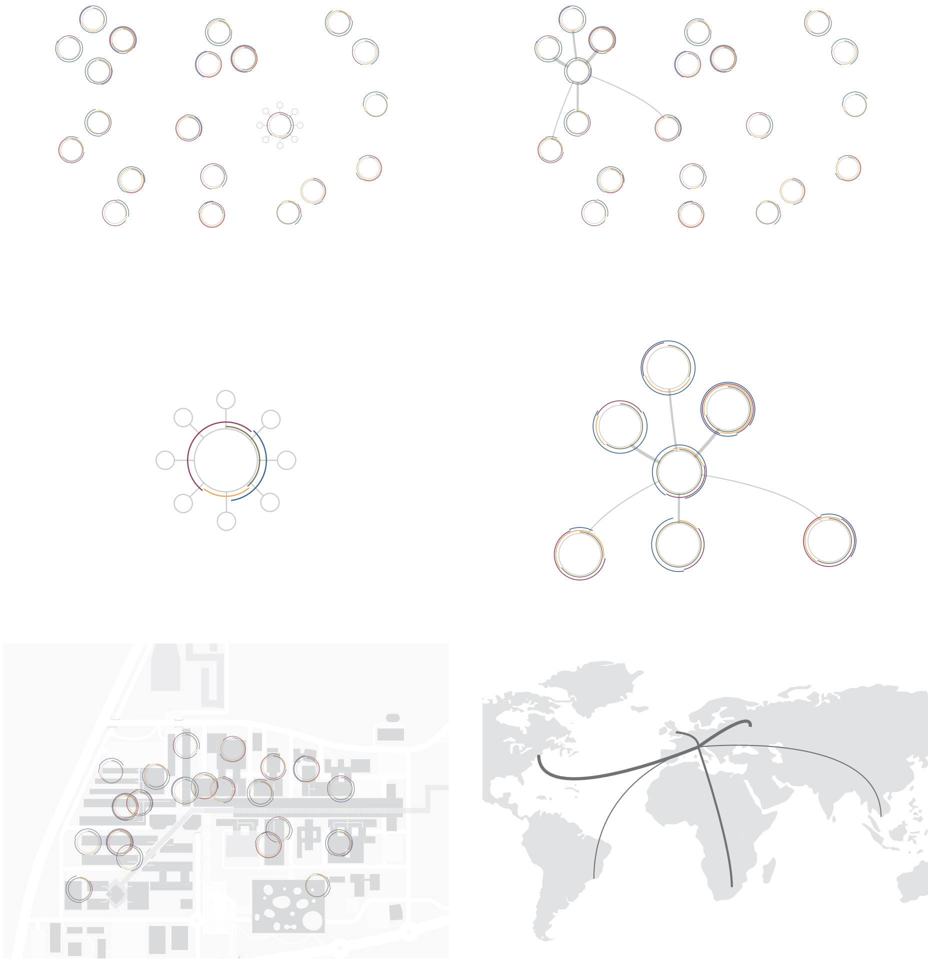
— Consider the heterogeneity of academic practice;
— Make invisible activities visible;
— Pay attention to the evaluation of scholars;
— Show the semantic structure of the school;
— Create a tool for communication.

⬡ EARLY SKETCHES

The second meeting was the perfect occasion to discuss the interviews and present some visual ideas. One key proposal was to use the laboratory as the fundamental unit of the map, like a parametric entity characterized by quantitative data. The idea was to create a geometrical element that changes according to the numbers of peers, publications, classes, and so on. According to this approach, the laboratories are represented by the same visual object, which differs according to a host of values resulting from the digitalization of academic practice; Edward



↑ The sketches show the laboratories according to four potential parameters, which are characterized by different colors; while unlikely, the last sketch illustrates a matrix-shaped arrangement of the laboratories.



↑ The first two rows show different sketches of networks: the last shows two geographical maps respectively at campus and worldwide scales.

Tufte [1990] refers to this precise kind of data visualization as a *small multiple*, which is usually employed to spot similarities and differences between the same type of objects.

These graphical instances have been successively spaced out on the plane by introducing a dimension of proximity. Three proposals were advanced to solve this spatial arrangement: the *matrix*, the *network*, and the *geographical space*. The matrix layout is based on quantitative ranking, favoring comparison. The geographical arrangement works with coordinates that prevent any kind of ranking but is meaningless in a semantic logic. The network configuration favors instead a logic based on similarity, which works perfectly with the concept of affinity.

These embryonal drawings introduced some ideas that have been employed over the years in the mapping process. Once the Affinity Map has been completed, looking at them is somehow astonishing, as some of these features are present in the final version, underlining the importance of a creative approach to the design process.

⬡ DATASET ASSESSMENT

Among the proposals advanced to give shape to the Affinity Map, the network of laboratories was chosen as the main concept to develop. In 2014, a series of data visualizations had been produced to evaluate its feasibility. These tests were useful to check the quality, quantity, and relevance of data at our disposal. The computer software Gephi, which offers an accessible framework to analyze networks, was invaluable during this prototyping stage [BASTIAN, HEYMANN & JACOMY 2009].

The first experiment was conducted to establish the quality of the keywords collected during the audit that took place in 2011 [ENAC]. Professors were asked to compile their own laboratory report, which comprised a short abstract and a set of keywords describing the major research subjects. The network shows the laboratories connected by such keywords. Light and dark grays indicate laboratories and keywords, respectively; unconnected laboratories have been turned opaque to underscore the overall connectivity. Two small clusters are visible: the first is about architecture and urbanism, and shares keywords such as *complex design*, *housing*, *mobility*, and *urbanism*; the second belongs to environment engineering and shares keywords like *climate change*, *disinfection*, *pollutants*, and *oxidation*. Regrettably, the audit database has a low connectivity that does not reflect the potential of schools' interdisciplinarity. It is a problem for keywords that are manually typed: the choice of keywords, when it is not based on an existing thesaurus, is too vast and brings scholars to use too many different terms. The differentiation is so high that very few terms are shared, making the audit database useless for our purposes.

Our examination proceeded by investigating the content of the accreditation system, which stores the affiliations of the EPFL employees; the data of this system allows us to know in which laboratories the scholars work. The network shows the units that share members with multiple affiliations. Scholars, indeed, can work in more laboratories, as in the case of doctoral assistant Jean-Denis Thiry who in 2014 results affiliated with both LTH2 and LIPID units (all the acronyms are explained in a specific section at the book's end). It can also be that secretaries work in different laboratories, such as Luana Huguenin who worked for both CHÔROS and IMAC before the closure of the former. Additionally, scholars may change laboratory during the calendar year, like doctoral assistant Boris Hamzeian who moved from LAPIS to LTH3 during his studies.

The same visualization also reveals a delicate issue about acronyms that needs to be tackled. For instance, the information system handles the EAST laboratory as three different units: EAST-ONE, EAST-TWO, and EAST-CO. What does this mean ? The answer dates back to a political decision, which took place during the presidency of Patrick Aebischer, when the Vice Presidency for Information Systems (VPSI) was commissioned to design a database that would prevent more than one professor from being associated with one laboratory. However, that rule was violated a few years later, when Anja and Martin Fröhlich took the lead of the EAST laboratory, which caused the unit separation in two entities reassembled in a third entity, the EAST-CO unit.

This visualization did not provide useful data but revealed a degree of data inaccuracy that may spoil the mapping quality. Identifying laboratory splits and multiple affiliations in advance made tackling these issues possible.

Another central activity of scholars is teaching. All information related to bachelor, master, and doctoral classes is stored in the information system *IS-Academia*. Its data were used to create a network in which laboratories are linked to scholars and, in turn, scholars to classes. The network plots how laboratories teach together, showing two clearly separated parts: the central one illustrates the connectivity of collaborations, while the outer ring represents isolated classes that do not share teachers.

It is very noticeable how some patterns encountered during this initial trail reappear in the Affinity Map, notably the collaboration between LASUR and CEAT or between LIPID and LAST. The dataset plotting demonstrated, therefore, how relevant teaching is in terms of collaborations. This would later form one of the main axes of the Affinity Map.

Yet another issue is related to the isolation of individuals. Despite the readability of the teaching network, the detachment of some isolated scholars gave a poor sense of collectiveness. Even though this kind of information is useful for managers, being detached from the collective might communicate a feeling of guilt, thus suppressing any will of exploring potential affinities. This issue was seriously taken into account during the design process, especially because the map was imagined for both managers and scholars, avoiding breaking any academic spirit of collaboration.

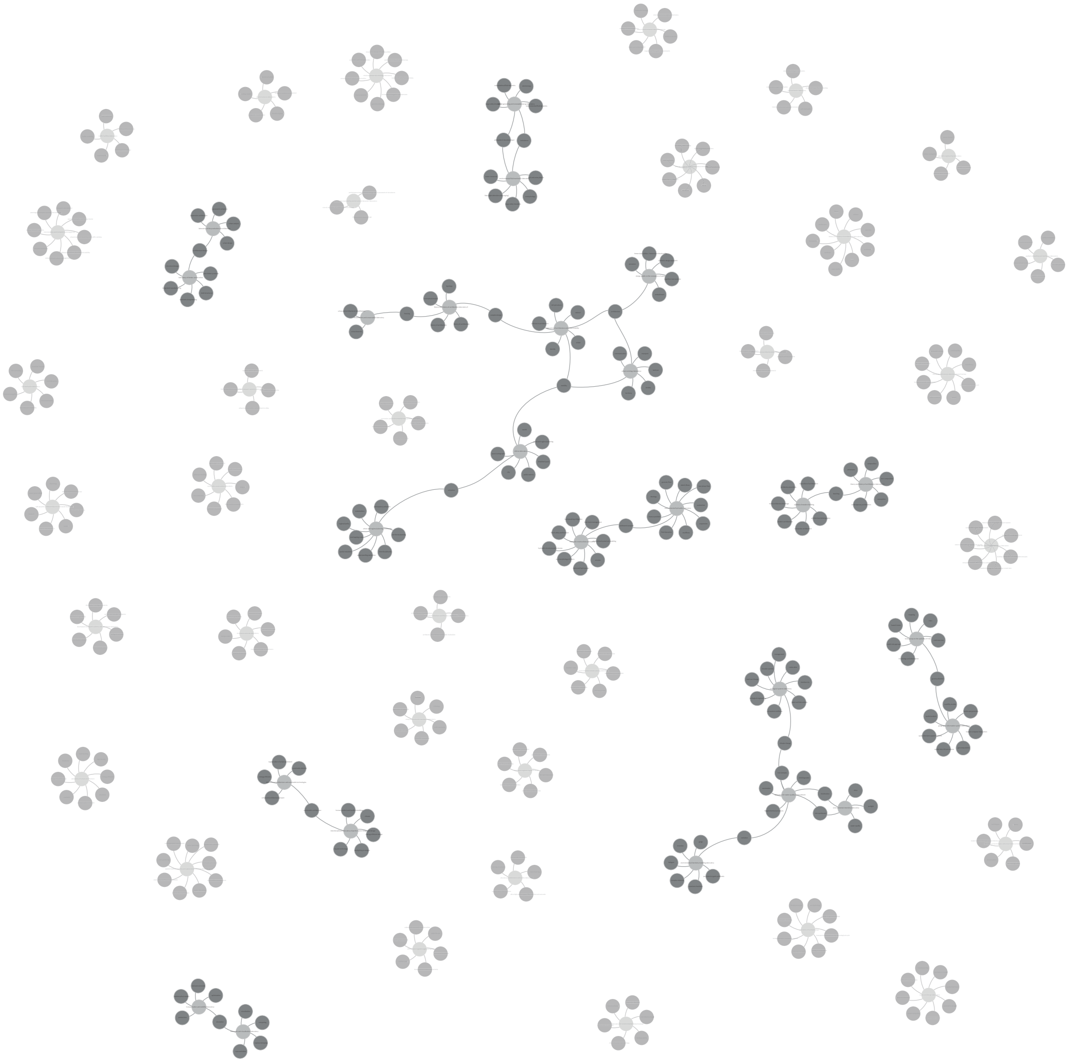
The last dataset tested was part of *Infoscience*, the information system that collects all publications from the EPFL. This system is maintained by the library; it classifies publications through a rich set of metadata. Two of them were relevant for the map, authorship and keywords. The former is usually employed for citation analysis and co-authoring, and the latter are standard for scientific articles. While co-authoring is useful to describe actual affinities, keywords represent key interests for potential affinities.

The Infoscience network shows keywords and laboratories, which are connected by publication metadata. In the network, the uppercase text identifies laboratory acronyms, and colors represent the respective institutes. In green, at the center, is the institute of Environmental engineering; in blue, at the top left, there is Civil engineering; and in red, Architecture is split at the top right and the bottom.

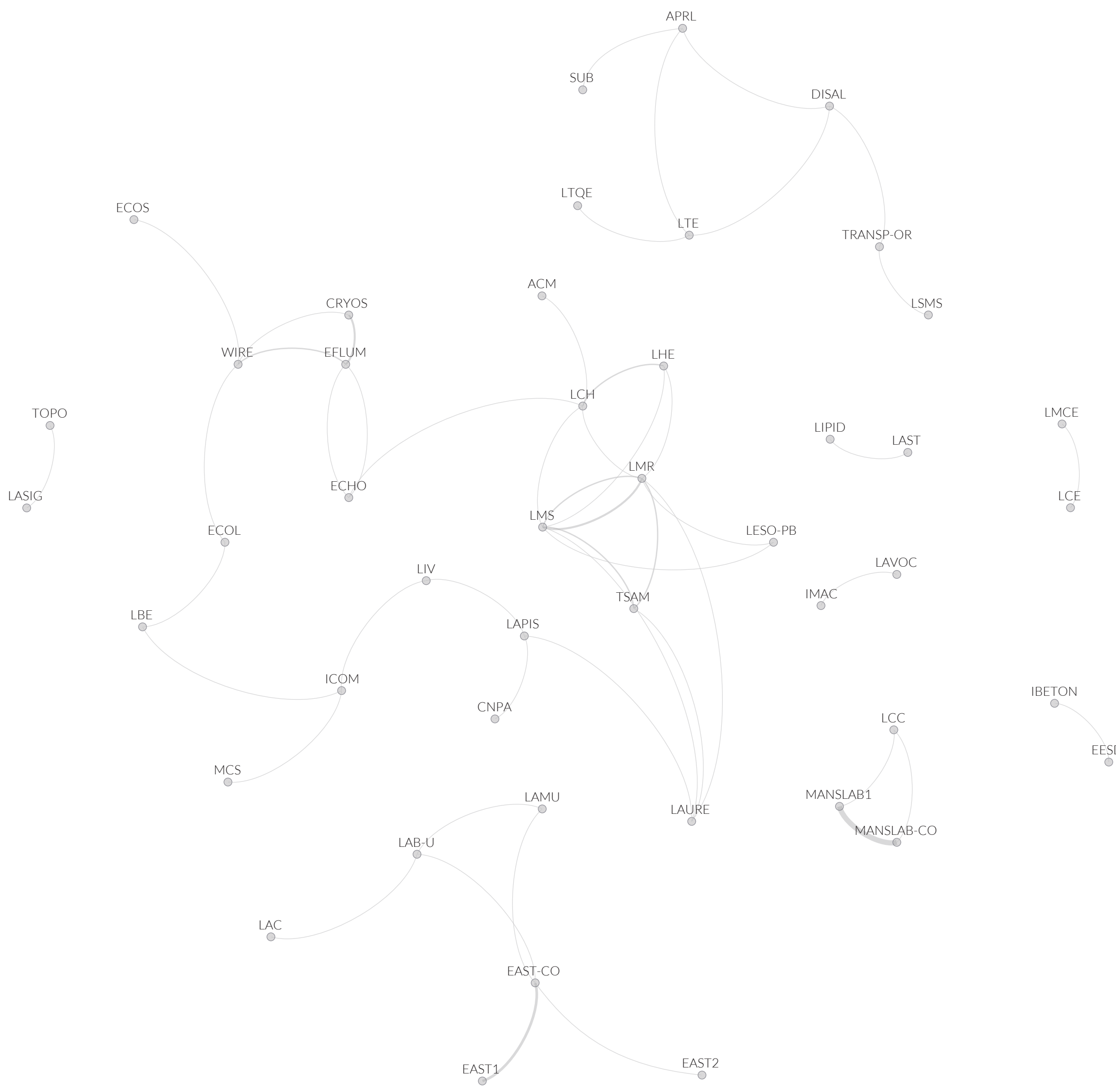
This representation was the first attempt to create a semantic map, which has a two-folded layer of information: the arrangement shows the potential of laboratory collaboration, while keywords bring a semantic meaning to the areas.

However, like the network of the audit dataset, keywords turned out to produce disaggregation because of individual subjectivity and the difference of vocabularies between disciplines. As a result, connectivity is not homogenous and common links are few. Additionally, the number of keywords varies according to the number of publications, facilitating the visibility of active laboratories.

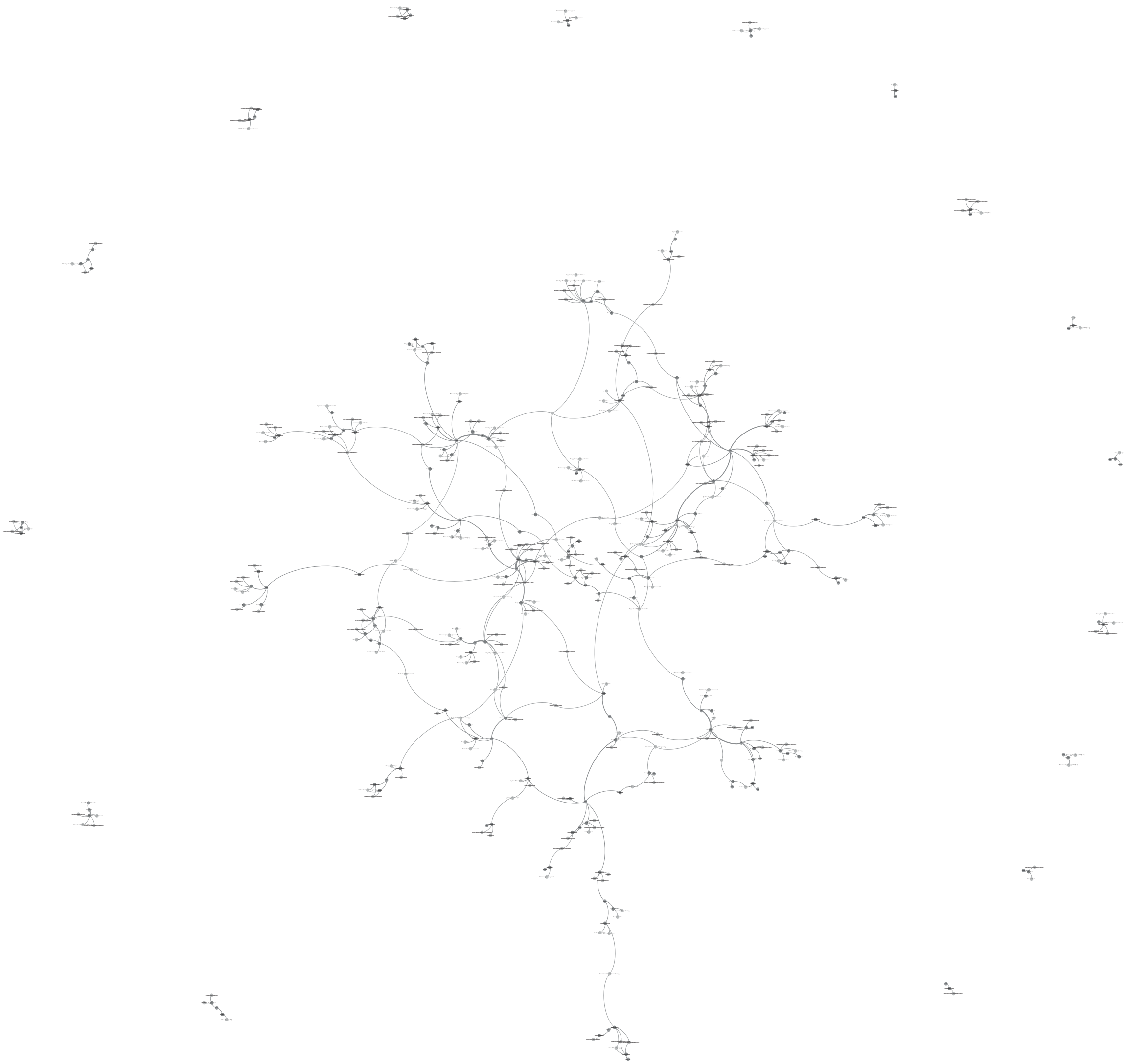
On the other hand, the semantic layer among laboratories proves to be extremely useful to understand the different areas of the network. It represents an exquisitely detailed way to enrich the space between the nodes, enriching network visualizations with a further layer of semantic information.



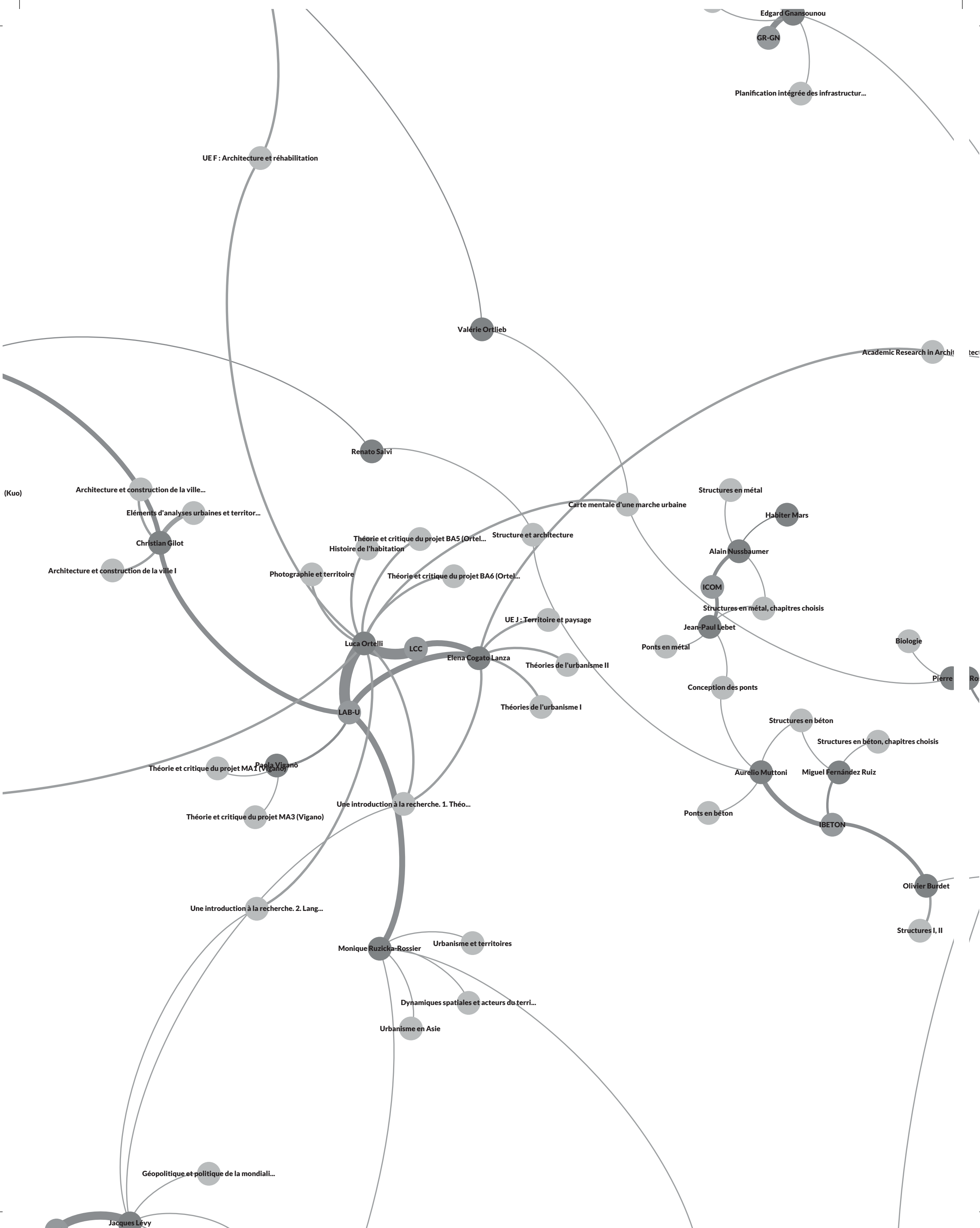
↑ Two types of nodes: the laboratories in light gray, and the keywords in dark gray. The links were created using the activity report that took place in 2011 [ENAC].



↑ Laboratories that share employees. Even if the network is not relevant for displaying affinities, it warns us about the fact that affiliations may introduce some bias in the mapping process.



↑ Professors, laboratories, and courses of the ENAC school. The teaching network is relevant to advance the diversity of academic practice.



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Academic Research in Archit
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(Kuo)
Architecture et construction de la ville...
Eléments d'analyses urbaines et territor...
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Ponts en métal
Théorie et critique du projet BA5 (Ortel...
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Théorie et critique du projet MA1 (Vigano)
Théorie et critique du projet MA3 (Vigano)
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Une introduction à la recherche. 2. Lang...
Structures I, II
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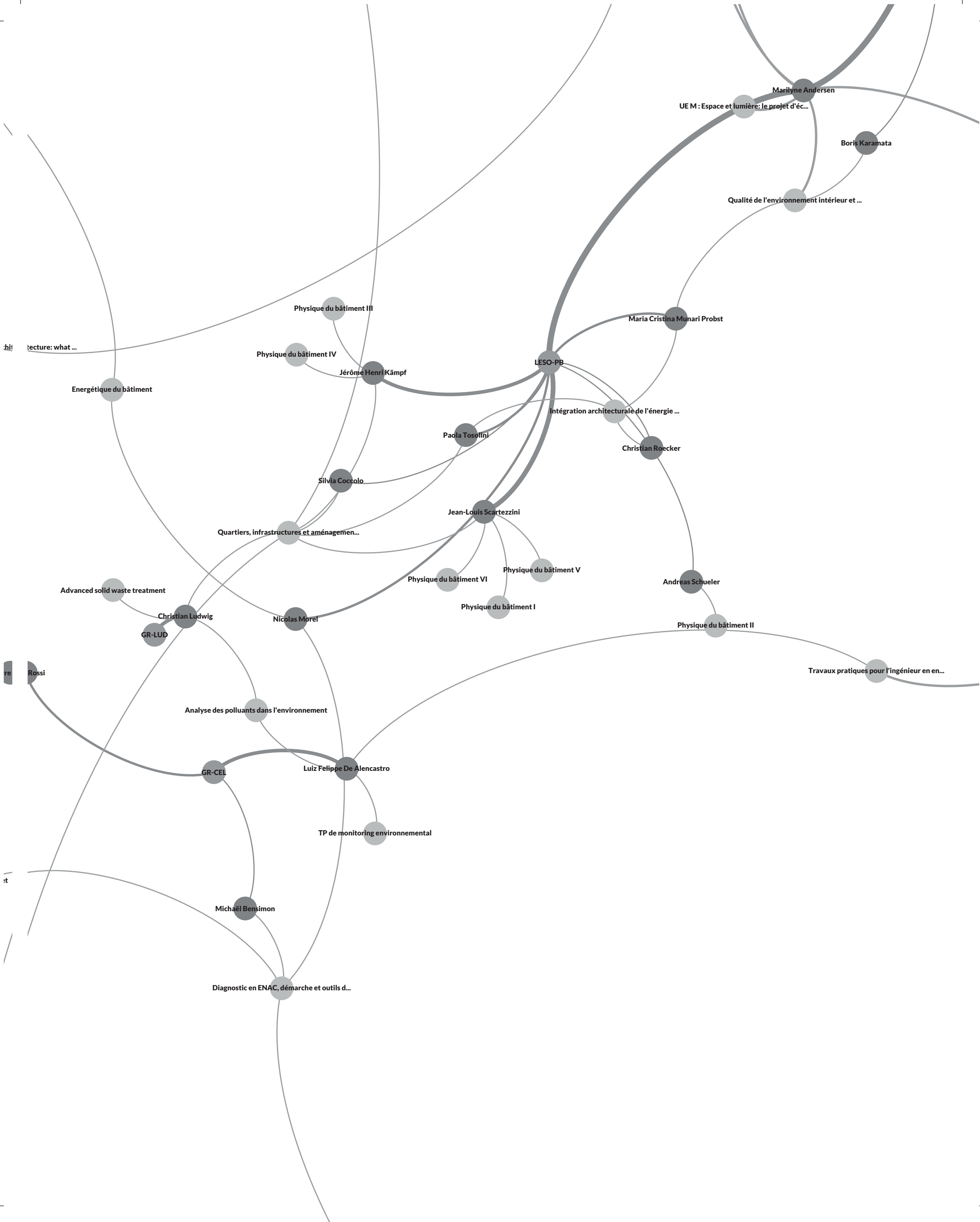

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Boris Karamata
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Physique du bâtiment IV
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Andreas Schueler
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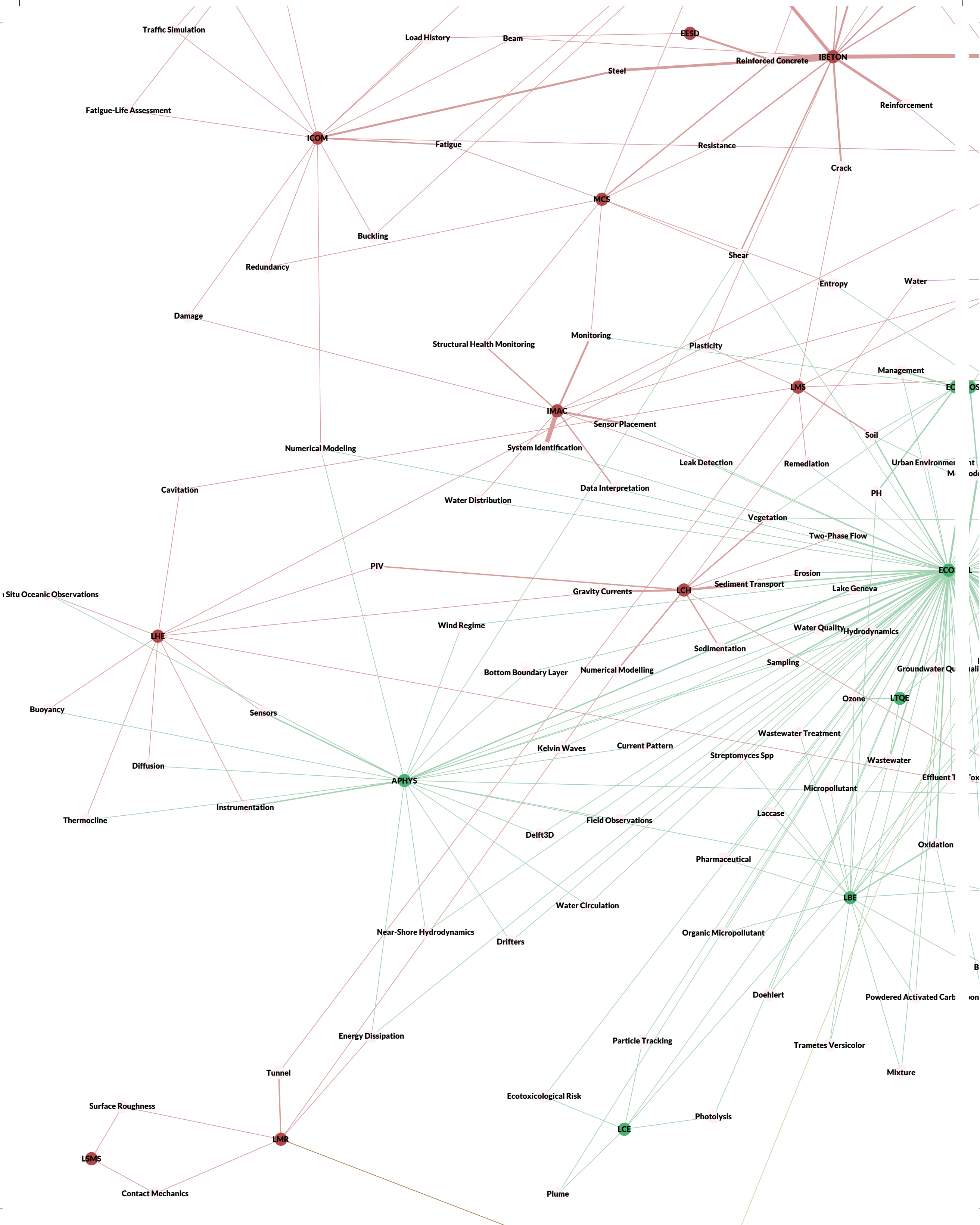
Michaël Bensimon
Diagnostic en ENAC, démarche et outils d...


Traffic Simulation
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Reinforced Concrete
Steel
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MCS
Buckling
Redundancy
Shear
Entropy
Water
Damage
Structural Health Monitoring
Monitoring
Plasticity
Management
LMS
IMAC
Sensor Placement
Soil
Numerical Modeling
System Identification
Leak Detection
Remediation
Cavitation
Data Interpretation
PH
Water Distribution
Vegetation
Two-Phase Flow
PIV
Erosion
Gravity Currents
LCH
Sediment Transport
Lake Geneva
Wind Regime
LHE
Water Quality
Hydrodynamics
Sedimentation
Sampling
Bottom Boundary Layer
Numerical Modelling
Buoyancy
Sensors
Ozone
LTQE
Wastewater Treatment
Kelvin Waves
Current Pattern
Streptomyces Spp
Diffusion
Wastewater
APHYS
Micropollutant
Instrumentation
Thermocline
Field Observations
Laccase
Delft3D
Oxidation
Pharmaceutical
LBE
Water Circulation
Near-Shore Hydrodynamics
Drifters
Organic Micropollutant
Doehlert
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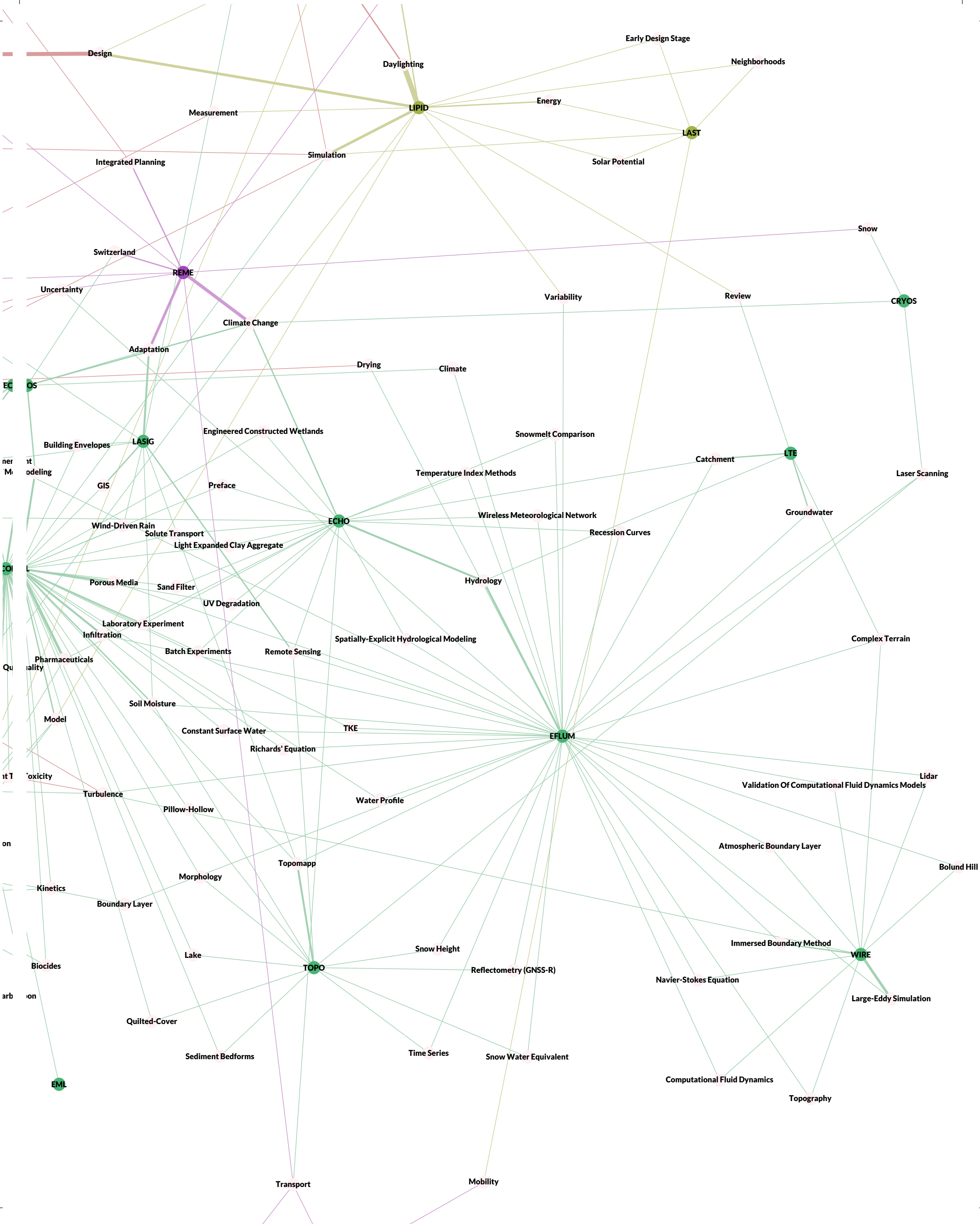
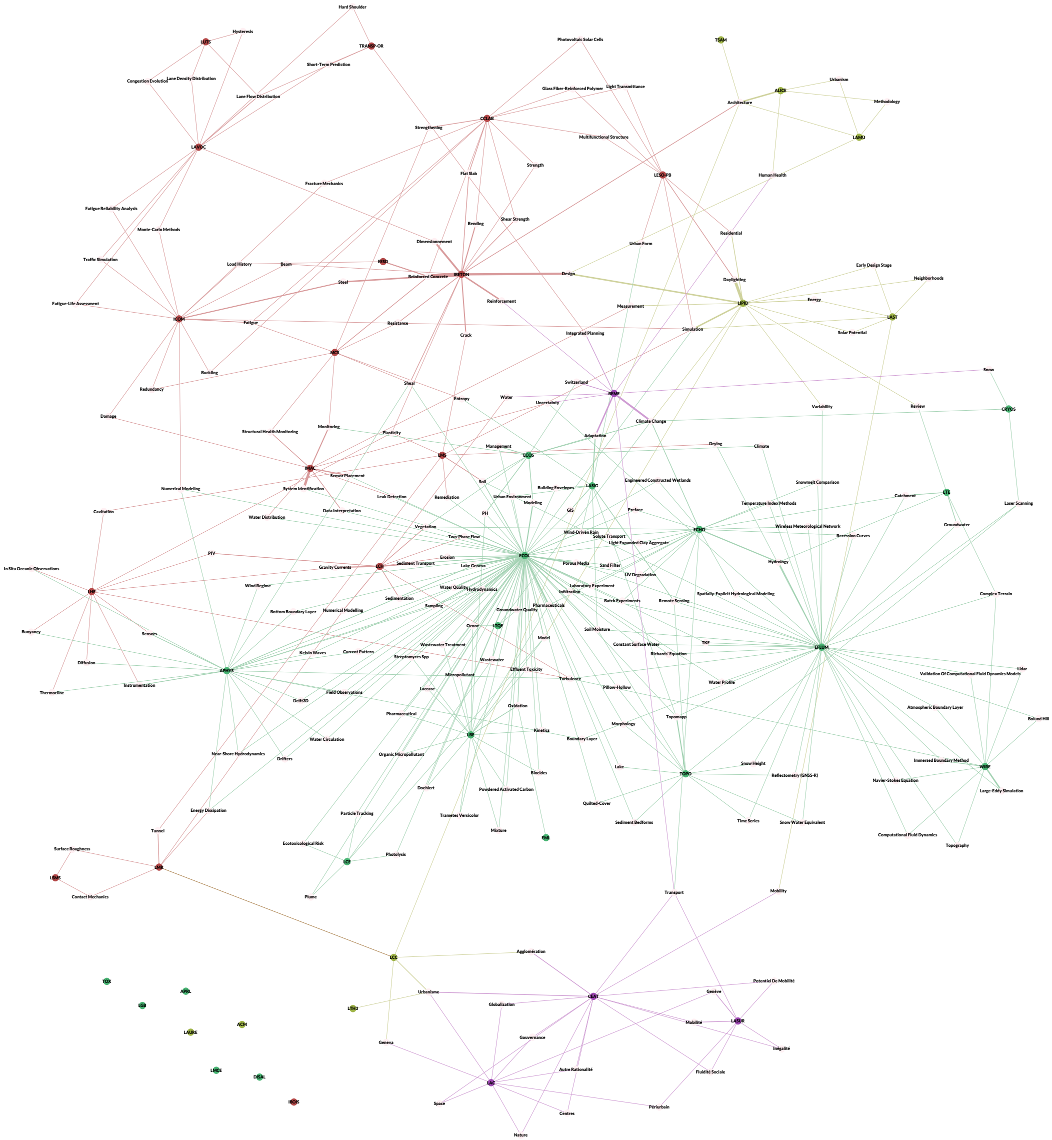


Early Design Stage
Design
Daylighting
Neighborhoods
LIPID
Energy
Measurement
LAST
Simulation
Integrated Planning
Solar Potential
Snow
Switzerland
REME
Uncertainty
Variability
Review
CRYOS
Climate Change
Adaptation
Drying
Climate
Engineered Constructed Wetlands
Snowmelt Comparison
Building Envelopes
LASIG
Catchment
LTE
Temperature Index Methods
Laser Scanning
GIS
Preface
Groundwater
Wireless Meteorological Network
ECHO
Wind-Driven Rain
Solute Transport
Recession Curves
Light Expanded Clay Aggregate
Hydrology
Porous Media
Sand Filter
UV Degradation
Laboratory Experiment
Infiltration
Spatially-Explicit Hydrological Modeling
Complex Terrain
Batch Experiments
Remote Sensing
Pharmaceuticals
Soil Moisture
Model
TKE
Constant Surface Water
EFLUM
Richards' Equation
Lidar
Validation Of Computational Fluid Dynamics Models
Turbulence
Pillow-Hollow
Water Profile
Atmospheric Boundary Layer
Topomapp
Bolund Hill
Morphology
Kinetics
Boundary Layer
Immersed Boundary Method
Snow Height
Lake
WIRE
TOPO
Reflectometry (GNSS-R)
Navier-Stokes Equation
Biocides
Large-Eddy Simulation
Quilted-Cover
Sediment Bedforms
Time Series
Snow Water Equivalent
Computational Fluid Dynamics
EML
Topography
Transport
Mobility

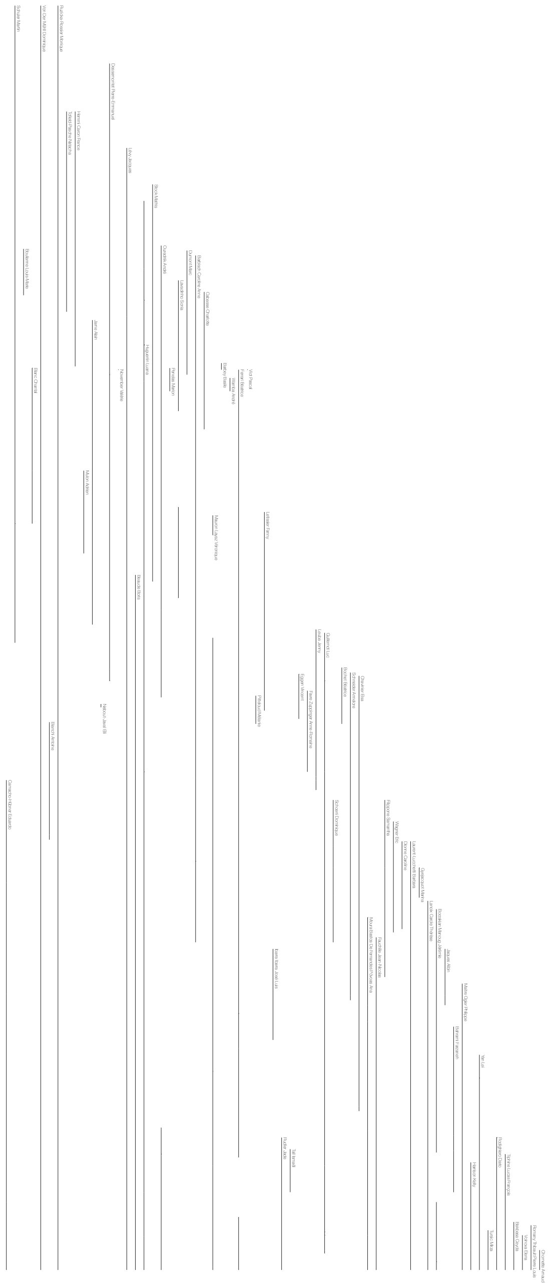


↑ A network of laboratories and keywords, which are extracted from the ENAC publications. The semantic information is useful to explore the research subjects.

INDIVIDUAL TRAJECTORIES

At the beginning, the Affinity Map was intended to be an instrument of evaluation at the disposal of management and thereby the focus was on laboratories to assess professors' productivity. Yet, in 2015, the ENAC General Assembly changed the final audience, transforming the map into a tool of governance also open to scholars. Two major consequences occurred after that event: first, the map was no longer an instrument to evaluate professors; secondly, the smaller unit was changed from laboratories to individuals in order to allow ENAC members to recognize themselves on the map.

The investigation of the accreditation system revealed for the first time a sphere of information related not to the unit but rather to each single individual. It disclosed the image of laboratories as a collection of personal data, which enabled reconstructing laboratory histories by representing the duration of employment contracts through trajectories.



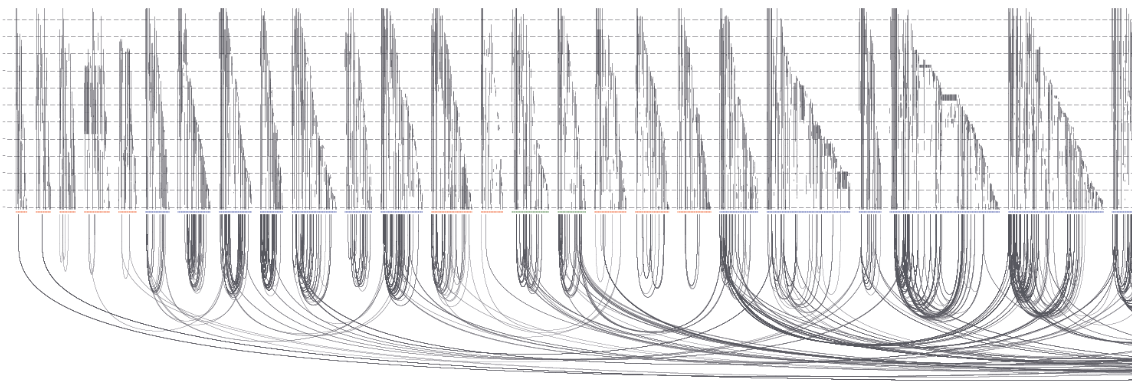
→ This diagram shows the CHÔROS laboratory through the trajectories of its members organized by seniority from left to right. The length of the line corresponds to the member's longevity deduced by accreditations. Looking at the name of the members establishes a more intimate relationship between the visualization and the reader, suggesting that a unit is nothing but a group of individuals.

The visualization below shows ten years of school history through the permanence of members in laboratories. Trajectories represent the individuals through a vertical line that reflects time through employment contracts [RIGAL, RODIGHIERO & CELLARD 2016]. These trajectories are grouped by laboratory and ordered by seniority: oldest laboratories are placed on the left at a macro scale, and senior members are also on the left but at a micro scale, within the laboratories. The result is a progressive arrangement of units and individuals where the line height corresponds to the lifespan and the width to the laboratory size. The curved lines at the bottom, finally, connect individuals by co-authoring.

For the first time in the project, our data visualization reached a level of detail beyond the laboratory unit. At the moment of the presentation, the team was delighted to recognize and look for peers. Comments resembled "I know that guy" and "That lab recruited a lot," or a simple and pretty egocentric "Here I am." Displaying individuals was an unexpected explosion of information. It seemed clear that the laboratory identity is less represented in the publications or its professor, but rather by the ensemble of its members.

The question about the whole and the parts was first brought up by Aristotle [COHEN & REEVE 2020]. His key question was very simple: assuming that a house is composed of stones, when can these stones be called a house? Which is the intimate relation that puts together the whole and its elements?

The Gestalt movement later reinforced the Aristotelian statement. According to Gestalt theory, the universe is dynamic and composed of mutually dependent parts, which

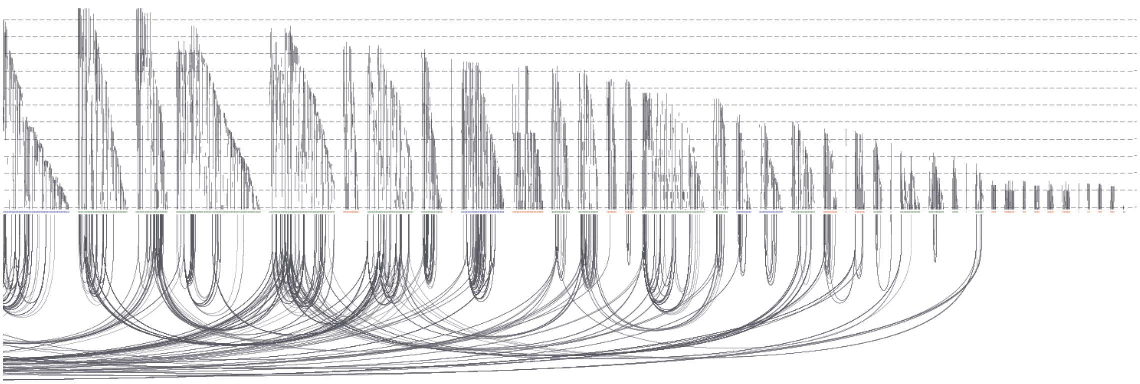


interact synergistically [KING & WERTHEIMER 2005]. The subsidiarity introduced by Aristotle now becomes a complex mechanism of interactive parts that form the whole universe. In particular, Christian von Ehrenfels [1937] reformulated the Aristotelian concept by saying that the "whole is somehow more than the sum of its parts." With respect to scholarly affinities, it can be said that a laboratory realizes its full potential when its members work together, and not when they act separately.

More recently, the same concept has been rephrased claiming that "the whole is always smaller than its parts." This statement is included in an article that is intended to be a tribute to Gabriel Tarde and his concept of *monad*; this dramatizes the contrast with Gestalt theory, reinforcing the theory of an actor-network founded on distinct individualities [LATOUR *et al.* 2012]. In this sense, the importance of laboratories as groups of individuals suggests a network on two levels of representation. The Latourian position is intellectually solid: individuals are important as autonomous actors, and the laboratory is still more important because it makes the most of the collective itself. The famous Gestalt statement might thus be playfully reformulated in turn by claiming that "the whole is equally important as its parts."

The Affinity Map, at this point, introduces individuals to enrich the laboratory representation that was previously reduced to aggregated indexes.

↓ In the upper part, vertical lines show the longevity of employees and relative laboratories. In the lower part, curved lines connect scholars by co-authors. The horizontal axis is ordered according to laboratory seniority, showing for example the most recent units on the right side.



Laboratories are no longer simplified, and their complexity is finally revealed by the presence of their members and the way in which they interact. As Norbert Elias [1991] pointed out, in social science what deserves attention is the distance perceived between the society and its individuals; in data visualization such attention is brought out with personal data. The ENAC school cannot be represented without its members. From now on, the Affinity Map will focus on its members to find its own collective identity.

TECHNICAL AND MORAL CONSTRAINTS

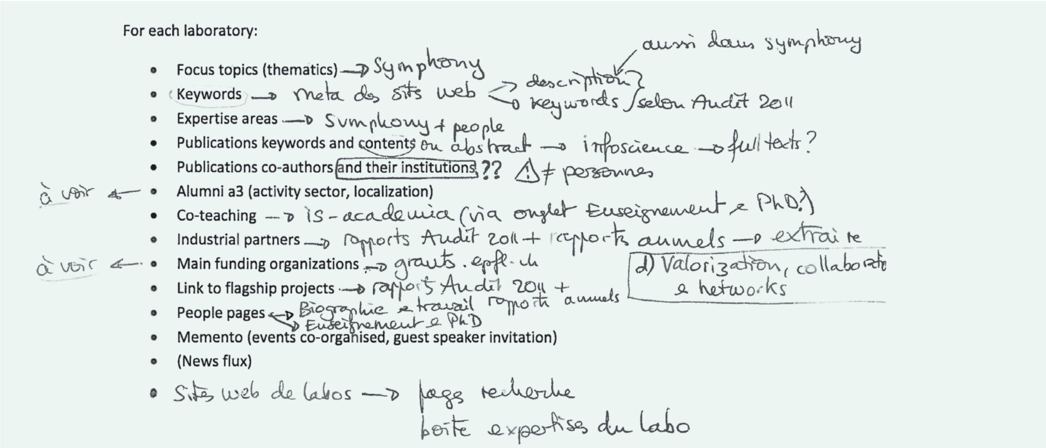
The design of the Affinity Map was delicate, because it is based on a process with a lot of factors that contribute to the final outcome. This section presents the technical and moral constraints, which influenced the transformation of data into graphical form. The sources of information are introduced, explaining how they were managed. Then, moral constraints such as privacy and ethics will be discussed to make the design process as fair and transparent as possible.

INFORMATION SOURCES

The collection of data then took place on the grounds of EPFL, by looking into the offices that are responsible for keeping information safe. There were many advantages in being a member of the organization and being supported by the dean of the ENAC. The same work could be done through web scraping, but this technique—based on extracting data from websites—usually runs into problems of instability, homonymy, and incompleteness [MARRES & WELTEVREDE 2013].

The investigation started in the beginning of 2014 with the help of peer Claire Hofmann-Chalard, who provided a list of repositories. The research was rapidly focused on the following five services. Maintained by the EPFL library, *Infoscience* is the archive that collects all the publications and makes them available on the web. Its database stores a heterogeneous collection composed of journal articles, books, book chapters, conference papers, conference proceedings, posters, reports, patents, presentations, student projects, and so forth. Each record is stored with metadata such as authors, title, abstract, keywords, involved laboratories, and at times a PDF file. Infoscience derives from *Invenio*, an open-source software by the CERN that supports the Open Archive Initiative. Furthermore, the EPFL Library encourages the use of Infoscience to make scientific production transparent and freely available online, and the EPFL [2020] is a signatory of the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.

All teaching activities are managed through *IS-Academia*. This service collects and makes available all the bachelor, master, and PhD classes to the teaching staff and the students. For teachers, it is a useful instrument to manage the courses and the students attending them; for students, it is a tool to organize their study program. The service



For each laboratory:

- Focus topics (thematics) → Symphony
- Keywords → meta des sites web → description ← aussi dans symphony; → keywords / selon Audit 2011
- Expertise areas → Symphony + people
- Publications keywords and contents ou abstract → infoscience → full texts?
- Publications co-authors and their institutions ?? ⚠ ≠ personnes
- à voir ← Alumni a3 (activity sector, localization)
- Co-teaching → IS-academia (via onglet Enseignement & PhD?)
- Industrial partners → rapports Audit 2011 + rapports annuels → extraire
- à voir ← Main funding organizations → grants.epfl.ch
- Link to flagship projects → rapports Audit 2011 + rapports annuels
- d) Valorization, collaborations & networks
- People pages → Biographie & travail; → Enseignement & PhD
- Memento (events co-organised, guest speaker invitation)
- (News flux)
- Sites web de labos → pages recherche; boite expertises du labo

↑ This document, dated August 13th, 2013, illustrates the available data sources on the EPFL campus. ©2013 Claire Hofmann-Chalard

stores classes, evaluations, and profiles of accredited teachers and attending students, including the supervision of doctoral students and postdocs. Advising completes the triptych of *actual affinities* composed of publishing and teaching.

The *GrantDB system* is another relevant database, which is used to manage research projects and laboratory funding. The information system is maintained by the on-campus Research Office. It stores all the external incomes coming from public grants and private fundings, allowing the administrative staff and researchers to access financial resources and authorize payments. The deanship is interested in financial stability and funding is an important index to evaluate the financial condition of a laboratory. Due to the sensitivity of the information, permission to use the dataset was extremely difficult to obtain, even with deanship support.

The *Vice Presidency for Information Systems* (VPSI) is the organization accountable for everything related to the infrastructure of the university. In particular, it is in charge of the *Accreditation Management System*. Its specificity is storing the data relative to the EPFL employees, including the *Sciper*, the EPFL personal ID that is used by all services on campus. This Sciper is associated with laboratories through accreditations, which regulate the affiliations of employees and define the role of employees (i.e., professor, PhD student, and so on). The Accreditation

Management System is the means through which it is possible to recreate the laboratory and scholar history. The information is regulated through the *Lightweight Directory Access Protocol* (LDAP), which ensures a standard application protocol for accessing and maintaining information. More generally, the VPSI manages the organizational hierarchy, which is composed of employees, laboratories, institutes, and schools that are appended in turn to the EPFL.

Last but not least, the *ENAC Annual Report*, developed by the ENAC Computer Service unit was crucial for the project. This service, which has existed since 2013 and has been improved over the years, allows professors to validate the laboratory report through a semi-assisted workflow. Importantly, the ENAC annual report collects the information from the all previous-cited sources and validates it with the help of the ENAC professors. Technically, the Affinity Map relies on a data export provided by the ENAC annual report, which will be described in the following section.

VISIBILITY, VALIDATION, AND CREATION OF DATA

ENAC set up a digital annual report to collect information about its laboratories. The system is specifically addressed to the professors who fill out a report summarizing the work carried out during the calendar year. It is then synced with other information systems on campus in order to provide a draft report that professors can modify as they wish. This report is an official document for evaluation, thereby professors are requested to make their reports as precise as possible.

Professors were also aware that the annual report served as the information source for the Affinity Map. If the annual report is for private use of management, the map will make some of their data public. Professors are requested to check their reports with the perspective of sharing them. And this verification is based on three operations: visibility, validation, and creation.

Visibility concerns privacy: it is a useful mechanism to avoid sharing sensitive information. Professors, for instance, are invited to list all external collaborations that would be useful to figure out the worldwide extent of the school. When collaborations contain sensitive information, as in the case of nuclear research, professors can choose to hide specific information, thus protecting their laboratory's privacy.

Validation is the action that allows professors to validate information. This is relevant for publications, which are uploaded by laboratory members with a few restrictions. Infoscience, indeed, requires a confirmation, which is usually performed by the administrative assistant, and it might happen that incorrect publications are mistakenly confirmed. The annual report offers a supplementary check for all the publications, allowing professors to prevent the visualization of inappropriate information on the map.

Creation is the third operation available in the annual report. It is important to inject information that is missing from storage systems. For example, IS-Academia collects EPFL classes only and external ones have to be manually added through the annual report. Also, external collaborations can be added through a specific form created in 2016. Without such a mechanism, these data would still be missing today.

The three operations listed here are fundamental in order to improve data quality. The idea of using an official source of data makes the Affinity Map more reliable by its users. This is important, especially during a time in which many data visualizations are presented to the audience with little transparency in the design process in terms of the information employed to create them. Where does the data come from ? Far too often, the readers stop in front of a beautiful design, without investigating data sources. Providing the origin of information reinforces the visualization's reliability [VAN ES, COOMBS & BOESCHOTEN 2017], and charges the Affinity Map with a particular attention and respect from its audience.

A DATABASE FOR AFFINITIES

If the annual report provides the Affinity Map with the necessary data, these have to be stored in a database for retrieval. *Neo4j* was chosen because it reflects the graph form, enabling great freedom for data extraction.

According to the Actor-Network theory, the Affinity Map database counts human and non-human nodes, which represent, respectively, ENAC employees and their affinities. Scholars and affinities are linked to each other when a couple of individuals perform a collaborative task. For instance, if a publication has different authors, its node will be related to the nodes of these authors. With this structure, the database is searchable in two directions, from either affinities or scholars.

In 2017, the database collected around 160 000 employees who can be filtered by 500 000 accreditations. The database also included two consecutive annual reports, which provide 24 303 affinities composed of 17 210 potential affinities and 10 674 actual ones. Among the latter, there were 2 256 publications, 1 485 classes, 3 352 supervisions, and 17 210 keywords. It is useful to know that in 2017 the Affinity Map displayed 871 individuals, among whom 830 were unique (scholars appear in more laboratories in the case of multiple affiliations).

The database collects nodes representing individuals and affinities; these nodes are organized in a two-node network, which connects two nodes of the same type through a node of another kind [SCOTT 2000: 40]. A hierarchical structure composed of units is mounted on the network of individuals. These units are maintained for laboratories, institutes, and schools, thus replicating the EPFL organizational chart. Units can reassemble individuals into groups; laboratory members are related to units through accreditations.

THRESHOLD OF INFORMATION PRIVACY

Once data are stored properly in the database, information is ready for extraction. However, reassembling the data also means facing the issue of privacy. What is the appropriate threshold of data use?

Open data, open source, and open hardware are recurrent topics of discussion in academia today. Although practices like open archives are increasingly common, not all data can be shared. The philosopher Jacques Rancière [2000] opened the debate about privacy, introducing the notion of "the distribution of the sensible." For Rancière, data privacy is an aesthetic threshold between the visible and the invisible, which sets the limit for what is shareable and what is not. The threshold results from several decisions, usually made by the political class in the interest of citizens and their country. For example, a nation fighting against terrorism has to avoid any data leaks that might compromise its efforts; diplomacy, stability, power play, and safety are elements that contribute to maintaining data open or closed in sensitive situations [BIRCHALL 2016]. Privacy is therefore a concept that relies on political acts.

The ethical problems that are implied by recording, processing, and the dissemination of data [FLORIDI & TADDEO 2016] equally concern organizations and their members. For example, EPFL has a transparent approach to information: data regarding publications, classes, and affiliations are public data, but some information is on the other side of the threshold. Funding is a very sensitive issue in the sense that the EPFL salaries are not entirely transparent: if doctoral students and postdoctoral students rely on precise grids for their salary, the same is not true for professors. For example, the university is allowed to offer generous amounts of money to a professor who has a high probability of receiving a Nobel prize. Additionally, some employees have private activities running concurrently with their academic practice. If the total amount of money required to run the institution or school is transparent because of public funding, the more that financial information is tied to individuals, the more it becomes inaccessible.

Among the collected information sources for the Affinity Map, only the grant database, which stores the precise amount of money obtained from public grants and private donations, was extremely sensitive. Why is this database so important? Today, about 30% of the EPFL funds are collected from external resources [EPFL 2020] and financial aid makes a real difference for relatively small units. Funding means more PhD students, more outcomes, more publications and also more recognition for the laboratory. However, funding may be very different according to the discipline, especially if a unit requires expensive machinery as is the case of civil and environmental engineering. Making this information public can lead to laboratory comparisons and create general resentment against the richest laboratories. The EPFL keeps part of financial data private from its public audience, even though they are accessible internally: for example, the ENAC deanship can access financial data relative to its laboratories.

In conclusion, a publicly accessible map cannot display financial data, while a private version for the deanship might do so. The data policy employed for the Affinity Map is clear: only public data are visualized in the map. Although the data flows throughout a private service such as the annual report, the data employed by the map are publicly available on the Internet. For example, publications are accessible on Infoscience for spreading research; teaching activities are visible on the institution's website to organize their semesters, and supervised PhD students are listed in the professor's personal web pages.

ETHICS OF DESIGN

The Affinity Map has to be contextualized in the design process. Designing is a very personal practice, as it does not exist as the sole way to create an object. For Enzo Mari [2001], designing corresponds to the personal ability of planning to complete a job. The outcome is always the result of constraints, decisions, and negotiations, which include many variables such as peers, users, and means. Constraints vary in accordance with the type of object: the creation of lamps does not encounter the same difficulties as the creation of software does, yet software is an object of design for all intents and purposes as well. Digital artifacts arise from a different design process that demands specific attention [ARMSTRONG 2016].

Terry Winograd [1996] was one of the first to become aware of the importance of design for software. The interest he fostered around scholars contributed to making computer scientists sensitive to concepts such as interactivity and social consequences. Jacques Bertin [1981] was also aware of the importance of design ethics, in particular visualizations, underlining how creation may carry a weighty responsibility.

Design ethics are related to the type of object produced. Among the various issues that the ethical question might comprise, one relevant aspect is the social impact that follows the product release. The social impact is part of a comprehensive discussion that stems from product design. This can be summarized by asking the right questions. Who am I working for ? Who is the final user ? Will it be useful ? What is the scope ? Is it fair to create such an object ? What is its impact ? Is the product sustainable ?

In general, the ethic of design relies on the awareness of constraints and powers influencing the outcome, and the consequences when the product is released publicly.

It was evident that the Affinity Map was a sensitive artifact presenting different risks. One risk was the creation of a visualization that did not represent social reality. A lot of effort was put into improving the data quality to overcome this issue, and the concept of affinity was extended as much as possible to give the most heterogeneous representation of all activities that scholars perform daily. Another risk was the creation of an instrument of management, which did not adhere to the principles of governance. In response to that, great care was given to translate data into map graphic design devoid of any comparison between individuals. Thoughtful graphic design is the way to create an honest result, focused on collaboration rather than performance-based indexes. Funding sources have been excluded from the map because the contribution was pointless in terms of collaboration. Out of awareness that design really influences our lives [LÖWGREN & STOLTERMAN 2004], the Affinity Map was conceived as a fair object based on solid visualization principles.

VISUAL PRINCIPLES

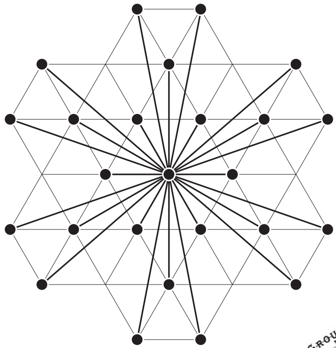
The Affinity Map introduces some features that improve network visualizations [LIMA 2011], whose visual grammar is often limited to very few elements: lines, circles, and labels. Networks still use a basic vocabulary to display the relational structure, which Moreno [1934] had drawn for the first time almost a century ago. Although many research efforts focus specifically on the algorithms that arrange the nodes [BARABÁSI 2002], few experts are interested in displaying networks with elements different from lines, circles, and labels. This section introduces some key aspects that have been developed during the design of the Affinity Map; some of them are innovative to the world of network visualization and shed new light on novel opportunities to display relational data.

Maps are the result of strict operations of codification, which are executed by the cartographer. Network visualizations are not an exception, and their shape is codified in a regulated representation [KAPLAN 2012]. The visualization principles introduced here represent henceforth the rules to modeling the Affinity Map. Defining these principles allows designers to create and replicate the same model, a practice also followed in cartography [JACOB 2006]. The Affinity Map results from the translation of collaboration metrics through a set of graphical principles that integrate aesthetic design and topological rules, as in the case of cartographic objects [WOODWARD 1987].

HEXAGONAL PATTERNS

"Geometry is first the map itself: it molds the earth in conformity with its image, which imposes a formal and a priori perfection. As this perfect form changes with the development of geographical knowledge, geometry becomes a grid, exterior to the earth, its order organizing the unthinkable disorder of the real." [JACOB 2006]

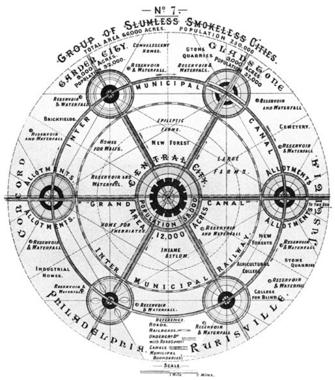
The Affinity Map organizes nodes in hexagons to create order in the chaos of laboratories. The hexagonal pattern designs a regular grid that optimizes space by utilizing equal distances, also structurally present in honeycombs [THOMPSON 1945] or Islamic tessellation [CRITCHLOW 1976]. Such a pattern tiles the space, forming a never-ending arrangement that may potentially be used to draw infinite networks. Using the hexagonal pattern for force-directed graphs brings some unexpected outcomes.



←The hexagonal grid connects the central node to twenty-four others with no overlapping; tessellation improves the readability of network visualizations.

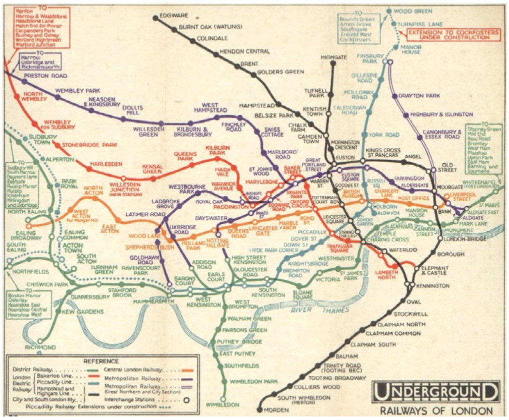
When nodes are close to each other, they are difficult to discern and text labels are impossible to read. Additionally, the links that join distant nodes are hidden under other nodes because of overlapping. The more the network is connected, the more reading it becomes a serious issue. The use of an hexagonal grid reduces this visual noise and facilitates reading. Snapping force-directed graphs to a hexagonal grid enhances readability in situations of high connectivity. Hexagonal patterns allow one node to clearly reach twenty-four other nodes without any overlap. Although such a solution may appear new, regular distances in networks have been previously applied, even though with different patterns [FRUCHTERMAN & REINGOLD 1991].

In addition, the hexagonal grid allows to apply a gravity force to the network without collapsing it. Reassembling the laboratories fosters a proximity, which can lead to the identification of new collaborations with more ease by the members of ENAC. The isolation of a laboratory from the network would prevent potential collaborations and damage the unity between institutions. Although a force-directed graph with a well-defined metric would be a great tool for management, the visual unity of the Affinity Map plays an important role in giving a sense of belonging to the scientific community.

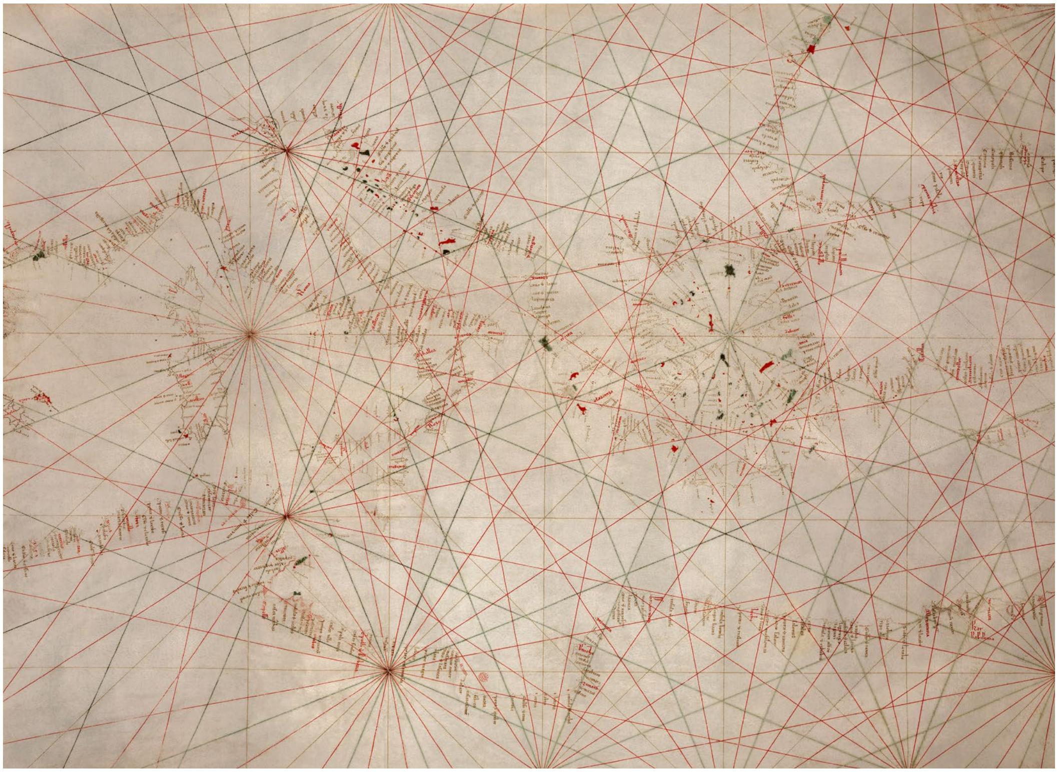


→The urban planner Ebenezer Howard employed hexagons to organize utopian cities in which nature and urbanization can coexist.

Does reading really improve when a network follows a regular grid ? A famous experiment shows that it might be the case. In the early 1930s, Harry Beck, an English technical draftsman working for the London Underground, drew an atypical map [SPENCE 2014]. The idea was to solve an issue of readability with the map of the London underground whose network had grown rapidly. Harry Beck's solution was structured in two distinct steps: one, he equally spaced out stations, as opposed to using their real positions, which were closer at the city center and further in the suburbs; two, he drew rails in four different inclinations (horizontal, vertical, 45 and 145 degrees), giving a geometrical order to the whole image. The public appreciated the map so much that Beck's concept is still used today, not only in London, but also in many cities around the



↓↗ Both maps represent the London underground in 1932 and in 1933. The second one presents Harry Beck's modifications, which enhance the visual comprehension of the transport system. ©1932-1933 Transport for London



↑ One of the oldest cartographic artifacts of the ©Library of Congress is a portolan chart representing the Mediterranean Sea and its routes during the second quarter of the fourteenth century.

world. This demonstrates how regular patterns not only improve map reading, but also beautify their aesthetic, making the use of the map pleasurable [NICOLAI 2009].

Since the fourteenth century, the grid has also been used as the background of navigation maps with *rhumbline networks*. Although their precision was less accurate than present tools, rhumblines were of great help for navigators to identify the course to take, indicating all the ship's possible directions [JACOB 2006]. The *portolan chart*, for example, employs the rhumblines to suggest the path towards major harbors. In that sense, we envisioned the Affinity Map as the portolan chart of scholars, pointing out the potential collaborations that scholars may consider. Like sailors, scholars are invited to explore new paths to foster interdisciplinary opportunities that would not be visible otherwise. The Affinity Map is a network of actual and potential affinities that makes use of a regular system of grids in order to measure collaboration. The distance becomes less precise in favor of an improved readability, empowering scholars with an instrument to explore scientific communities. Visual distance is easier to read because of the grid system: one step for peers who share affinities, several steps for peers whose interests are opposed.

⬡ PHYSIOGNOMY OF LABORATORIES

Nodes can be more complex objects than they usually appear in network visualizations. They hide a latent potentiality that can be expressed using an advanced graphic vocabulary.

Since the very beginning, the Affinity Map focused on the laboratory as the central element of the mapping. Laboratory complexity was revealed by the accreditations database, when data showed laboratories as units composed of individuals. The potential of representing laboratories through their members was an inspiration to design nodes as complex graphical objects. Immediately, collaborations have been seen on two levels, between laboratories as well as between their members. Network nodes became graphical elements to represent laboratories through their members.

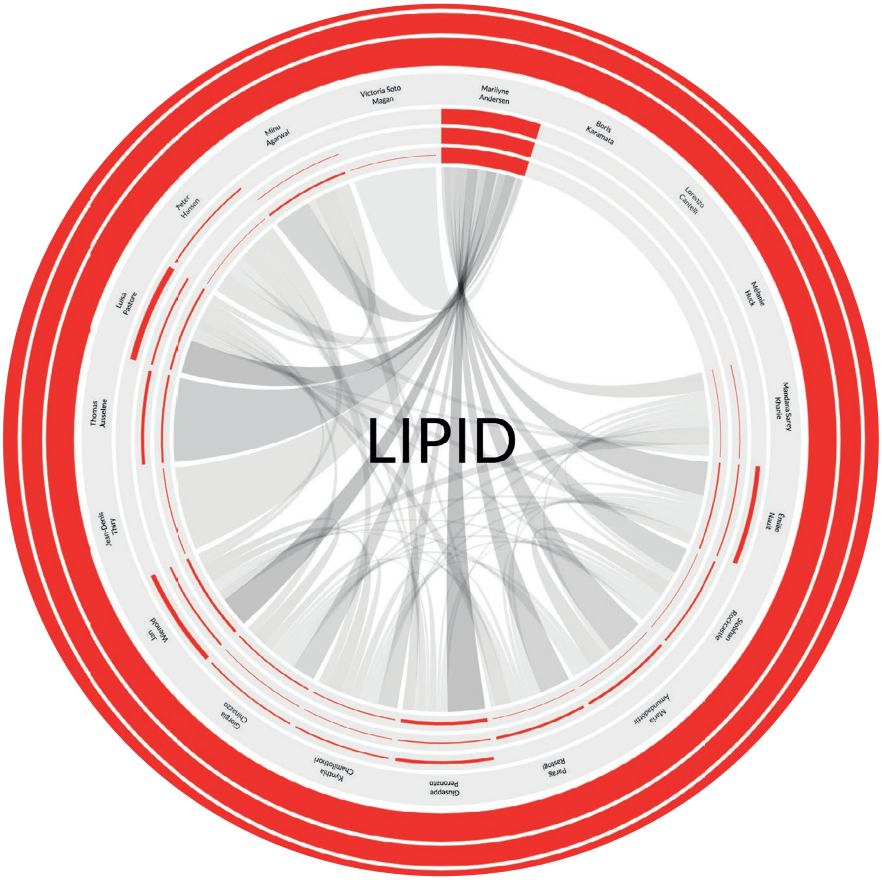
The graphical elements, which separate the space of individuals from the one of laboratories are the rings. Rings surround laboratory members: inside the rings, the visualization is scaled for individuals, while outside the rings it is scaled for laboratories. Rings do not have the same appearance: they change color according to the institute—red for Architecture, blue for Civil engineering, and green for Environmental engineering. The chromatic choice was developed with the Lab system, which is based on a color-perception scale that maintains intensity to create balanced palettes from different hues [HOMANN 2009].

Rings also represent the academic practice of laboratories through their thickness. The affinities of advising, publications, and teaching are quantified into the three rings, respectively from the inner to the outer. Thickness is normalized according to the average laboratory to balance smaller values, meaning that the average laboratory has three rings of the same thickness. Rings summarize the academic practice: the first and third rings quantify educational activity, while the second ring represents research. This means that a laboratory is oriented towards research when its middle ring is thicker; a thickness of the inner and outermost rings clearly indicates a propensity to education. It is fundamental to stress that rings do not allow a comparison between laboratories, as the total thickness is the same for all laboratories. It is impossible to determine which laboratory has more publications with this graphical representation.

↓ The LIPID laboratory is shown as a node embodying individuals and collaborations; Marilyne Andersen is situated at noon as its most senior member.

This graphical choice demonstrates how some ethical issues were tackled to avoid the Affinity Map becoming an evaluation tool.

The ring has a twofold role as it works as a shell, creating an envelope to protect laboratory members. It is a shield professors bear, as they are the only eligible person accountable for laboratory productivity.



Additionally, rings make impossible any kind of evaluation between scholars of different laboratories by relativizing their representations; inside laboratories the hierarchy is always clear, and comparisons are allowed.

Scholars appear in a circular layout. They are arranged by seniority through Sciper, the progressive personal identifier that indicates the recruitment date at EPFL. The most senior member is situated at noon in the circle, while more recent peers follow a clockwise direction. Individual positions are interesting to observe, especially with respect to the member role: professors are usually situated at noon because of their seniority. However, sometimes professors may also appear further if their laboratory members have been previously registered, such as in the case of postdocs previously enrolled as students.

The academic practice of scholars is graphically represented though rings' thickness, which represent the total number of classes, publications, and supervisions, whose values are normalized with respect to each laboratory. They are represented through a triad of arcs, which represent—from the inner one to the outer one—advising, publications, and teaching respectively. Arcs are a very effective tool to identify individual roles: very thick arcs usually identify professors, and a slightly lower thickness identifies senior scientists. Doctoral students cover different levels of evolution during their studies: they have one supervision at the beginning, but over the years they get publications. On the contrary, secretaries, teaching assistants, and technical assistants often appear completely empty. That does not mean that their contribution is equal to zero, but rather signifies that data do not give an exhaustive representation of academic practice.

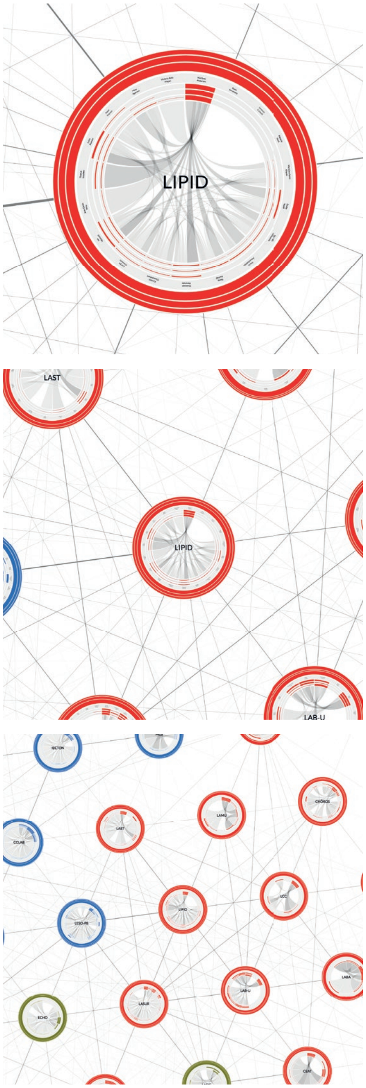
One interesting ethical issue of design affected the display of full names. Although billions of individuals make their identity public through Facebook, Google, or Twitter [GEORGES 2009], the same identities are hardly represented in data visualizations because of privacy. Privacy is justified in academia because scholars are frequently assessed in various forms, from their peers to management, and in different settings, from public talks to private reviews. In addition, the more a scholar is well-known, the more his work is judged by others all over the world. The Affinity Map was therefore released in two different versions, one private and one public, which differ just in the displaying of names. The private version is available inside EPFL and shows the identity of scholars; the public version, instead, displays only the name of professors along with the laboratory acronym. This decision was taken after the disclosure at the school of the beta version, which provoked criticism in some scholars. The core of the node shows laboratory collaborations through a chord diagram, also called *Sankey diagram*, which belongs to the family of flow diagrams [MEEKS 2015]. The Affinity Map employs it using D3, a web-based visualization library written in Javascript [BOSTOCK, OGIEVETSKY & HEER 2011]. The chord diagram is a circular network representing nodes as arcs around the circumference. Arcs are connected by chords, whose stem is weighted in percentages and transparency is proportional to the number. It is interesting to note that the arcs of a standard chord diagram usually have different sizes, according to the number of connections. In the Affinity Map, all the members of a laboratory are evenly represented as their arcs have an equal length, giving them the same importance in terms of space. In addition, this solution makes the laboratory size very easy to read.

⬡ ZOOMING AT DIFFERENT SCALES

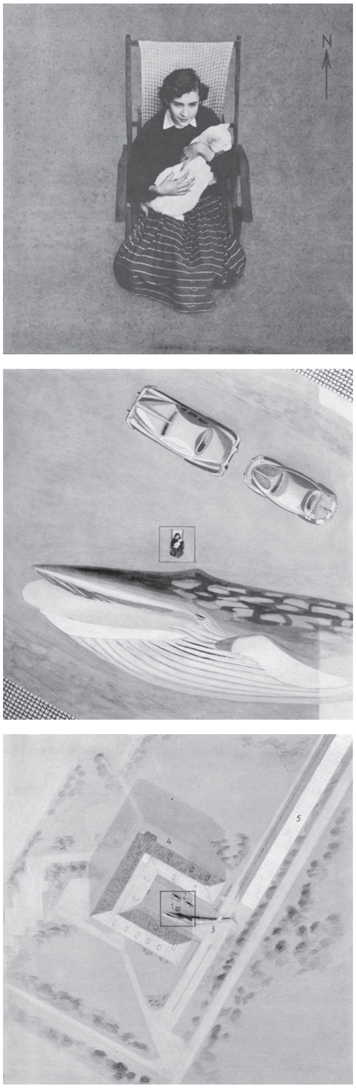
When merging the hexagonal grid with the node layout into a unique visualization, zooming becomes the function that moves the focus between these elements. The map becomes a collage regulated by a visual hierarchy composed of laboratories and individuals. Zooming moves between these edges: the laboratory where collaboration exists at individual scale, and the school where collaboration happens between laboratories. An infinite number of zoom levels exists between these extremes, and the map reading changes according to the elements visible in one's window. The Affinity Map presents an information overload that is managed through zooming: the more you peer into the details, the more in-depth information you get. This follows a famous concept of Ben Shneiderman [1996], called the information-seeking mantra, "Overview first, zoom and filter, then details on-demand."

Bringing this concept to its limit, we can think of a map as an informative space where an infinite level of zooming returns never-ending details. Kees Boeke's *Cosmic View* [1957] and Charles and Ray Eames' remake *Powers of Ten* [1977] give us a perfect idea of how zooming should work.

Yet there exists another movement of zooming, which belongs to the panorama of data visualization. A few years ago, Franco Moretti [2005] introduced the concept of distant reading, popular in the discipline of digital humanities. According to Moretti, distant reading is "a process of deliberate reduction and abstraction" that empowers scholars with new points of view. In addition to the common practice of studying in front of books, called close reading, synoptic visualizations appear as new



↑ An example of zooming out from the LIPID laboratory to a larger context. It noticeably resembles the work of Kees Boeke shown here.



↑ Three different moments of *Cosmic View* in which images grow by a factor of ten. Its visual language is used to explain the size of the universe. ©1957 Kees Boeke ways to approach corpora of texts. The research becomes a back-and-forth movement between the corpus and its books, in which the synoptic view is the door leading towards the book and vice versa.

Likewise, the Affinity Map does not replace the individual perception of academic practice: rather, it is an instrument to move back and forth between the representational dimension of the map and the true academic society of the school. The ENAC scholars have at their disposal two zooming movements. One takes place within the interface boundaries, where readers move between individuals and laboratories. The other one takes place between the Affinity Map and the ENAC school. Readers can move across these levels in order to structure and advance their own knowledge.

ORBITING SATELLITES

Two issues still affect links in network visualizations, homogeneity and overlaps; connection type is not displayed and overlapping lines cause problems of readability despite the hexagonal pattern. Jacob Moreno's visual model for drawing networks has not developed further over the decades: circles, lines, and arrows are still the only graphic elements available. *Satellites* are intended to extend network visual grammar.

Satellites are graphic objects that orbit around nodes, indicating all the connections toward other laboratories in the map. A satellite layout recalls the laboratory one in a simplified way: the chord diagram and the individuals are no longer visible to raise the profile of the laboratory acronym and the rings. The three rings correspond to advising, publications, and teaching, from the inside out. Differently from the laboratory layout, their thickness is not normalized to the maximum value, but it is proportional to the number of collaborations.

Satellite position is directed toward the related laboratory, and satellite distance from the mother node indicates the distance to the related laboratory: the smaller a satellite orbit is, the closer the subtended node is in the map. Satellites describe an ego-centered network [SCOTT 2000] that outlines all the connections without following the lines. Yet, contrary to the ego-centered networks that are drawn individually, the Affinity Map is a host of ego-centered networks arranged within a bigger network.

Satellites situate themselves in a transitional space between a global map and local laboratories. In a way, they connect the two zoom levels through a third one, which can be seen as hybrid.

Satellites indicate the number and the type of connections, as well as the level of

↑ The laboratory LIPID features eight satellites, which correspond to its external collaborations. The satellites indicate that the laboratory has several collaborations with all the institutes of the ENAC. In particular, these collaborations concern education, which is represented by advising and teaching activities — respectively shown by the inner and outer rings of the node.

interdisciplinarity through the ring color, corresponding to one of the three ENAC institutes. In addition, satellites show us if laboratory collaborations focus on research rather than education, or if they take place within or outside the institute.

Satellites are a great solution for network visualizations with high connectivity. When many links run into each other, reading the network would be difficult otherwise. As links are tangled up in highly connected networks, the nodes' position is the only readable information. Satellites are a way to read a network though the nodes' position.

Additionally, satellites are a great way to interact with the map: clicking on a satellite triggers a jump onto the connected node. This kind of interaction is not applicable to standard links, which would not be able to focus on the right node.

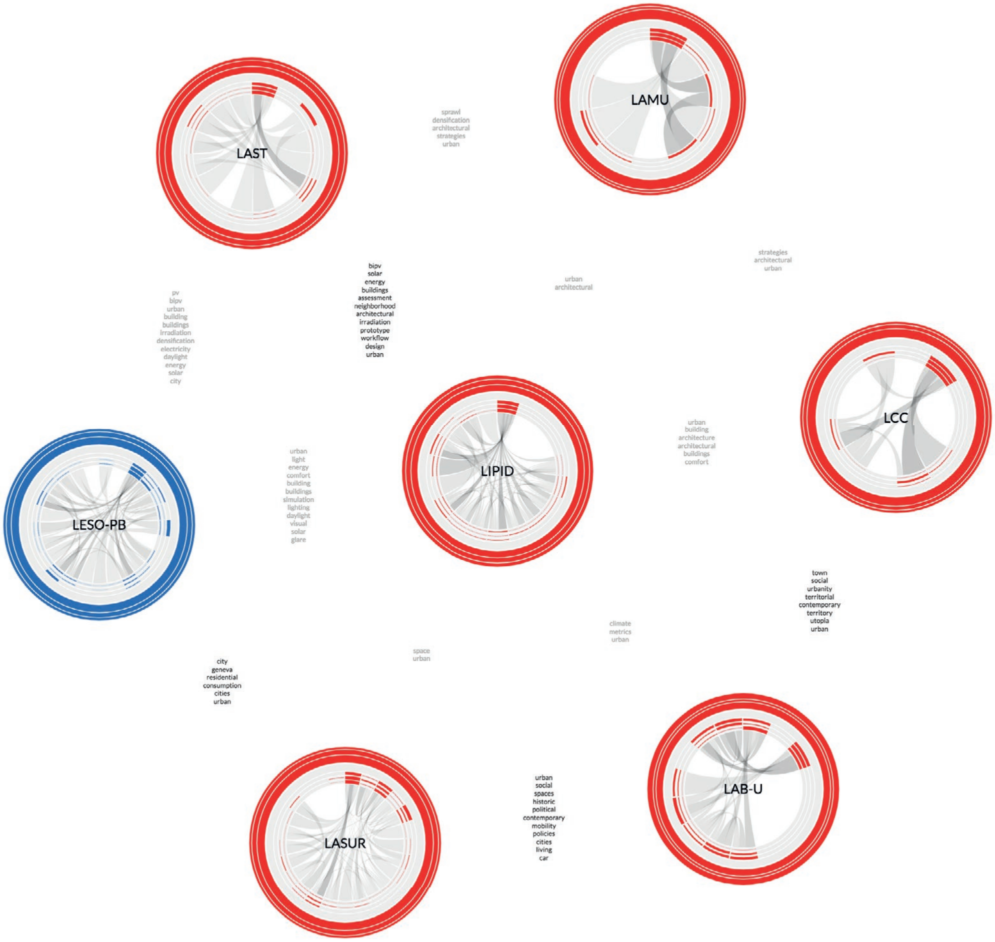
SEMANTIC BACKGROUND

In addition to actual affinities, an important effort was given to measure potential affinities. These correspond to all the possible collaborations that a laboratory may consider. The idea was to measure potential collaboration through the similarity of language.

Using current methods of text analysis on the corpus of ENAC publications, stored on Infoscience, enabled us to extract the most relevant terms for each laboratory. Although it was not possible to run the text analysis on full texts because of the diversity and low quality of PDF files, the keyword extraction gave good results with abstracts.

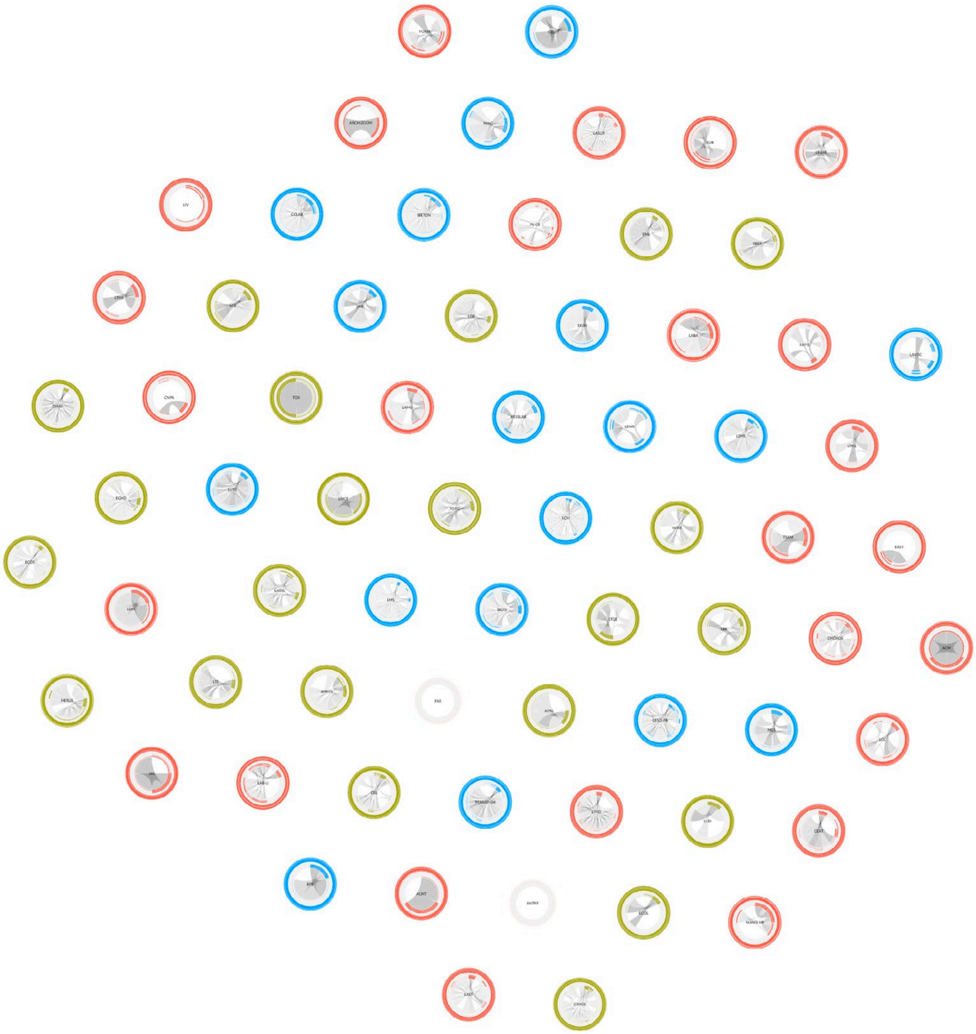
Abstracts were collected by laboratory into long strings of text, which were successively analyzed to calculate the frequency of use of each word for each laboratory; then, the frequency of these words was inverted according to the corresponded frequency of words with respect to the entire corpus of texts. This process, based on the TF-ID algorithm, resulted in different sets of keywords that differentiated each laboratory with respect to the others. Moreover, this method removes the most common words, such as articles, and keywords come along with a weight value that indicates their relevance. This measure was then translated into a network, using keywords like weighted relations between laboratories.

Nominal data whose core is composed of the extracted words are crucial to enrich the meaning of data visualizations [MEIRELLES 2013]. Once nominal data for potential affinities were created, the next challenge was how to visualize keywords on the map. The hexagonal grid that regulates the position of nodes offers triangular spaces where keywords could be accommodated. The idea was to show these keywords that all the pairs of laboratories share. When laboratories are close

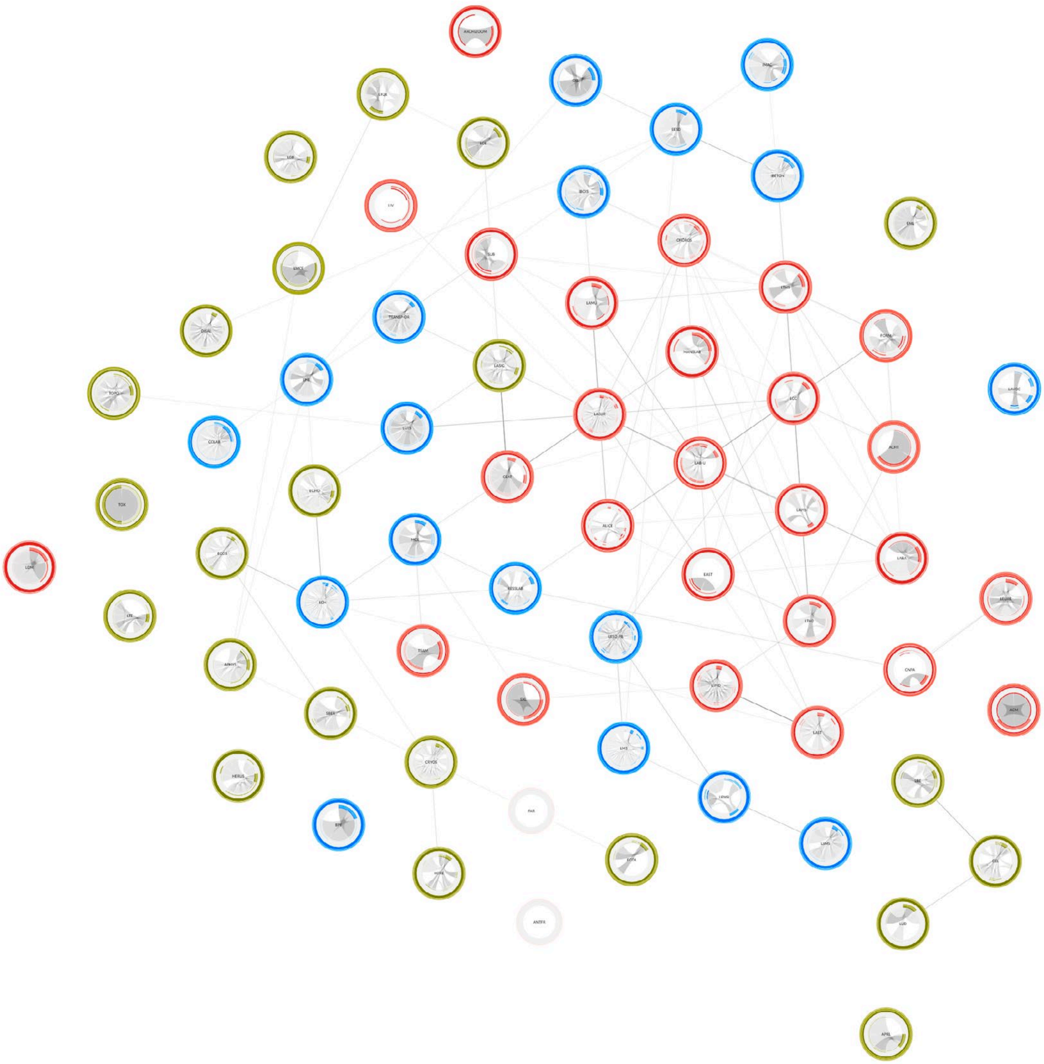


↑ The image shows the LIPID laboratory in its neighborhood, which is composed of six other laboratories in a hexagonal pattern. The space between a pair of laboratories is filled with shared keywords, which are represented in black for ongoing collaborations and in gray for potential ones.

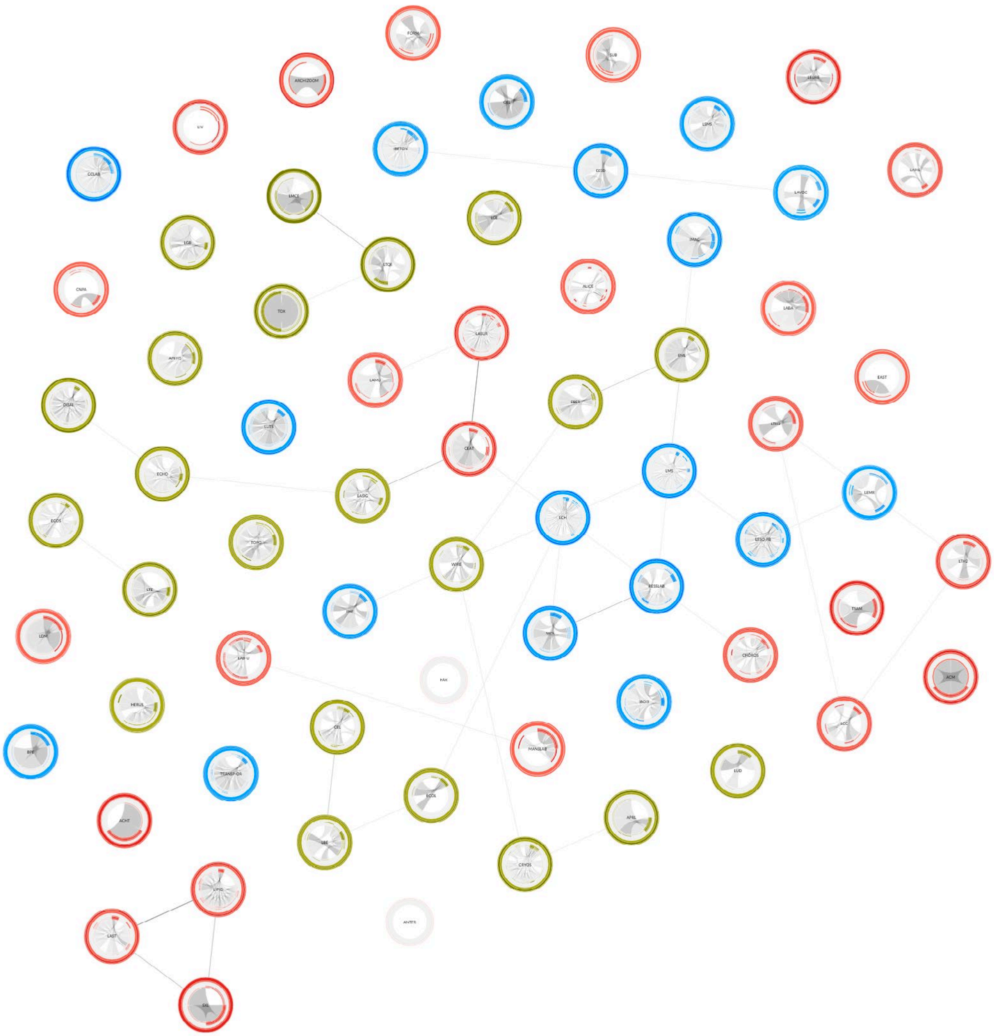
↓ ENAC constellation without links.



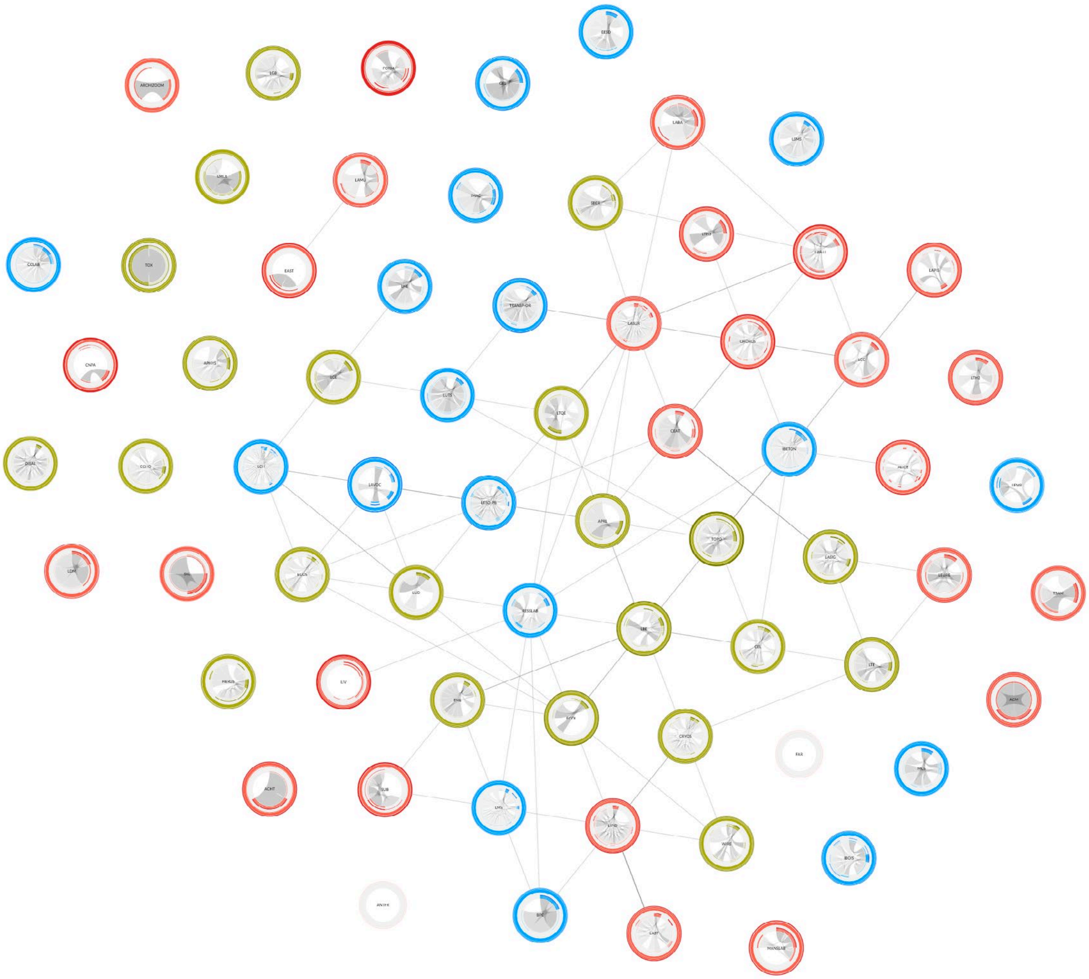
↓ ENAC constellation of advising.



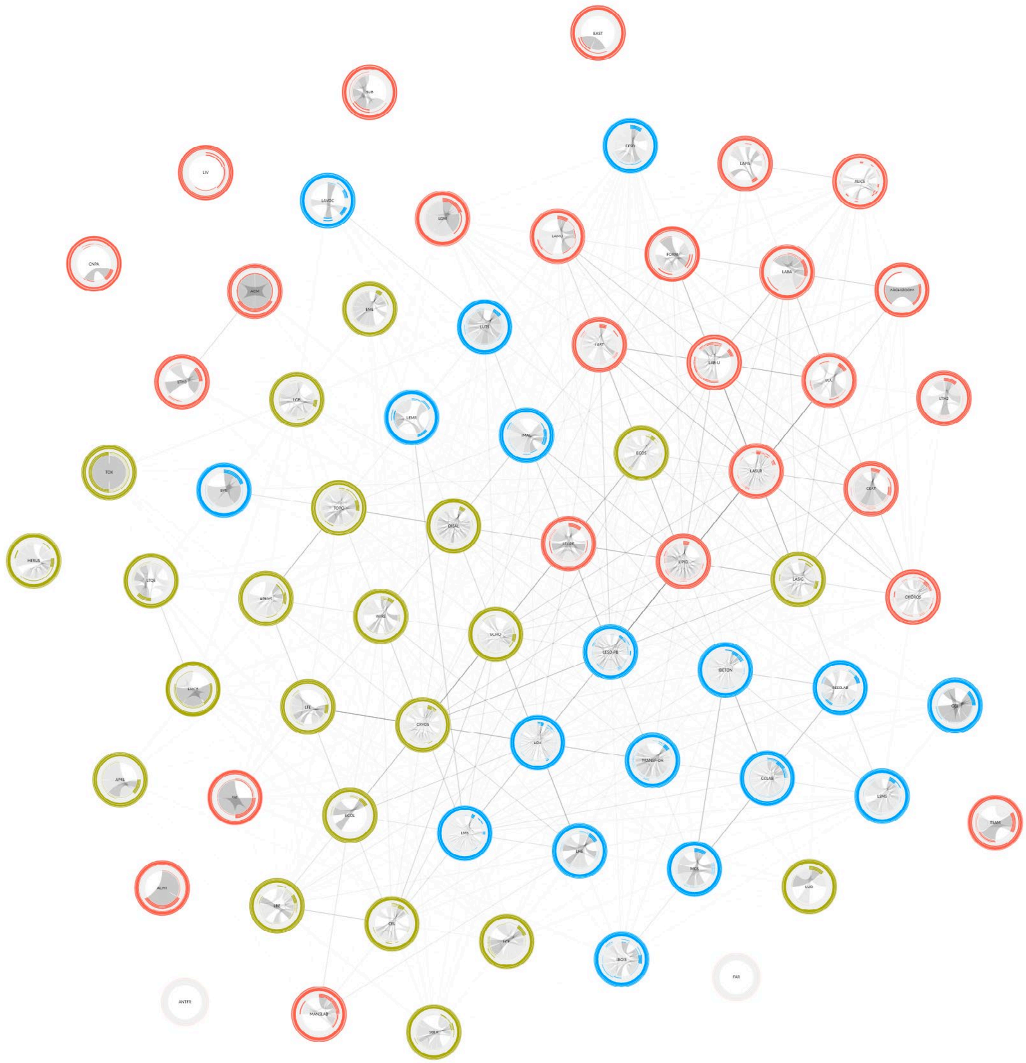
↓ ENAC constellation of publications.



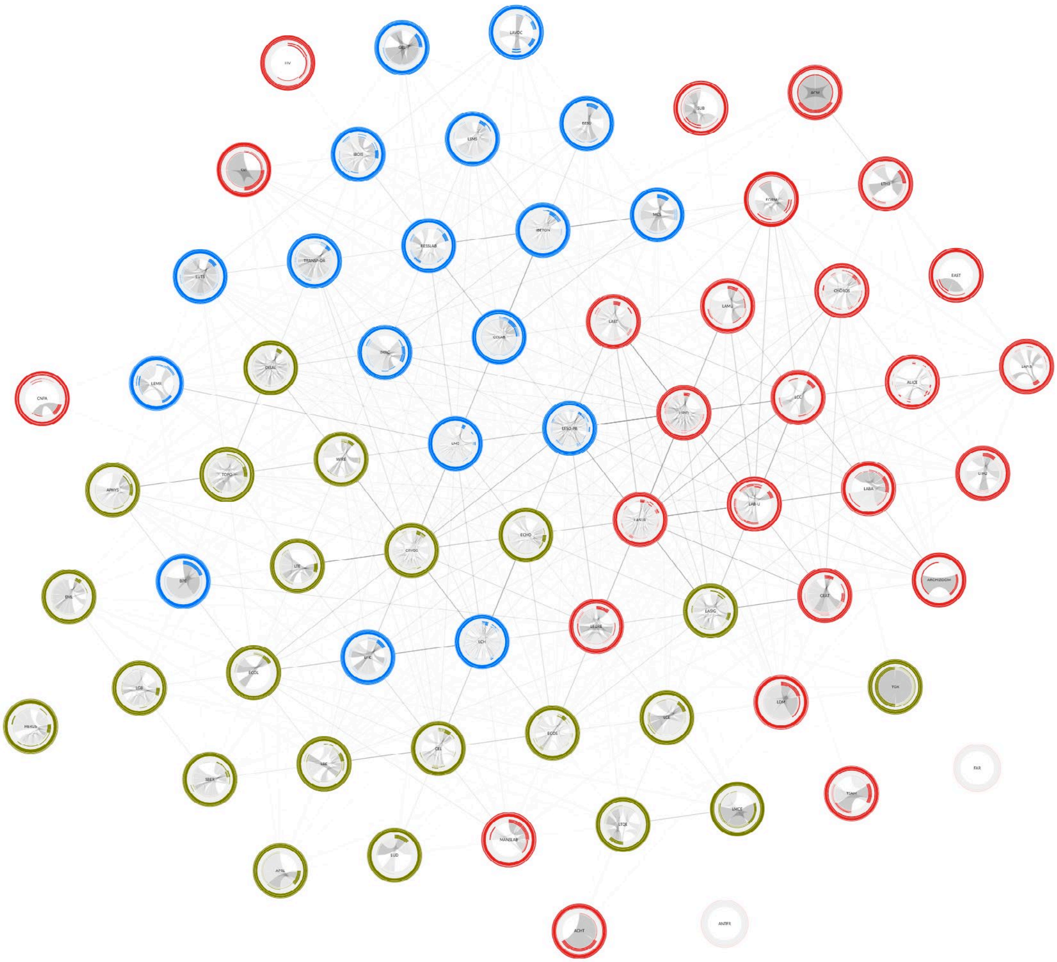
↓ ENAC constellation of teaching.



↓ ENAC constellation of keywords.



↓ ENAC constellation with all affinities.



to each other on the map, the most relevant common keywords are displayed between them. The richness of these keywords is multiple: they not only indicate that two laboratories have a language in common, but they also give a semantic context of a specific area of the map. Looking at the map, the reader will not see only the arrangement of laboratories according to a specific metric, they will also be able to recognize the subject matters across the various areas of the map. The semantic background given by words is an innovation in the domain of social networks and needs to be explored further.

Also, font color changes according to the type of affinity: black for actual ones and gray for potential ones. Collaborations are thus easy to identify and the map benefits from a further layer of information.

CONFIGURING CONSTELLATIONS

Between the sixteenth and the eighteenth centuries, a large number of star atlases were printed [KANAS 2012]. These atlases were organized by constellations. Each page displayed a particular configuration of stars, making the book a long series of constellations. Yet constellations were just a method to recognize stars, used for sea navigation. Ancient cultures also believed that star alignments were patterns adopted by gods to tell a story. In a broader sense, a configuration of stars, cities, or laboratories is still a way to identify these elements and tell stories about them.

The Affinity Map can thus be seen as an instrument to visualize stories. Laboratories and scholars have different stories to tell, like Shakespeare's characters who make an account of themselves. And these stories can be different, according to the various constellations that the Affinity Map can create.

Selecting the affinities that readers want to see through a control panel, the Affinity Map changes like constellations according to position and intensity. Forces of attraction based on the affinities change the position of nodes, while the chosen affinity will in turn have more brilliant colors to show which rings are activated.

A JOURNEY FROM MICRO TO MACRO

The best way to understand the map is to handle it as an instrument. The Affinity Map is available at [HTTPS://AFFINITYMAP.EPFL.CH]. Properly preparing to read the map is recommended as it presents a high level of information. As expected from sophisticated instruments, it takes time to become familiar with its workings, and this process demands diligence. The following section is a short handbook for its use. The working of the Affinity Map is presented by zooming out from Professor Jacques Lévy to the whole school. This movement goes through the

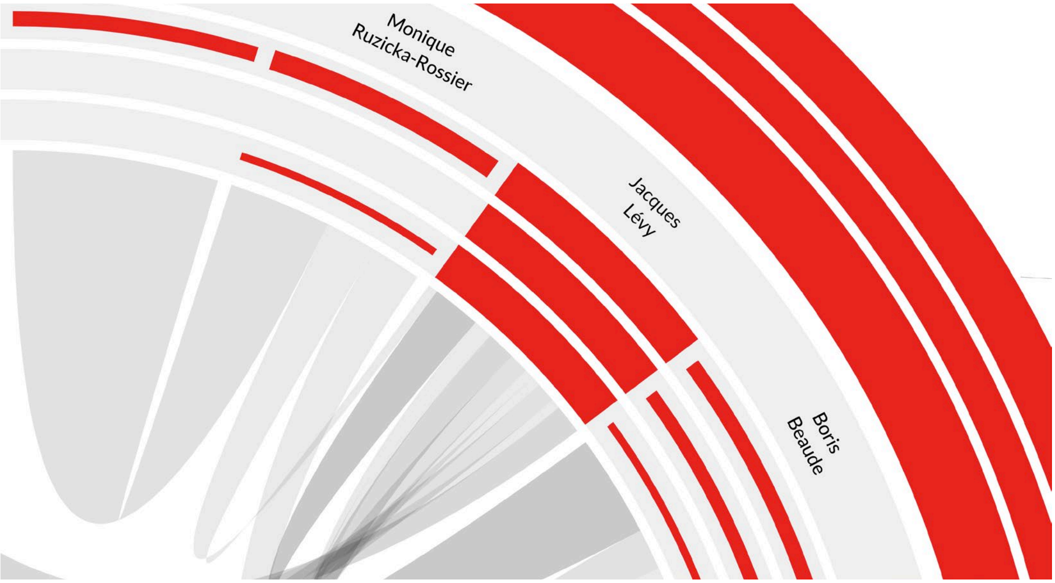
CHÔROS laboratory and the Institute of Architecture, showing a progression from the individual to the whole organization.

LOOKING AT LABORATORY MEMBERS

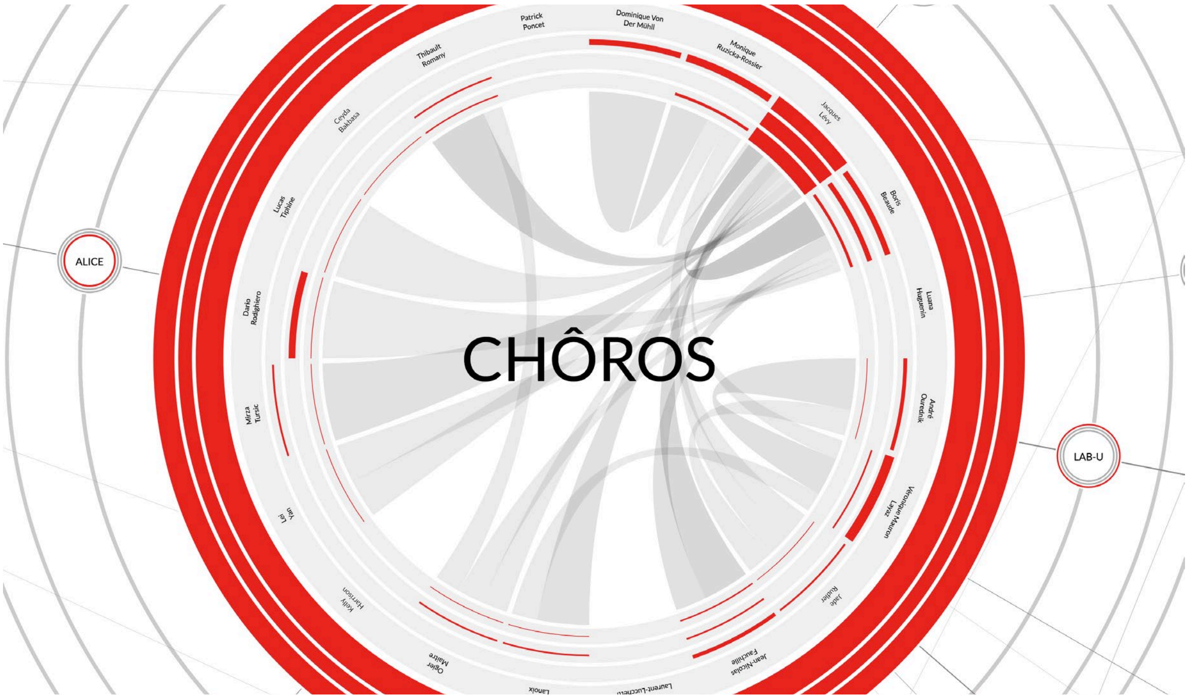
Professor Jacques Lévy is represented through three arcs in red, the color used by the faculty of Architecture. From the inside out, the arcs represent the number of advised scholars, publications, and classes for which Lévy has a full score. He is situated between Monique Ruzicka-Rossier and Boris Beaude who follow a chronological order of service life by clockwise disposition: Ruzicka-Rossier joined EPFL before Lévy, while Beaude enrolled after. The arc configurations reveal that they cover different roles in CHÔROS. Ruzicka-Rossier is very active in education, Lévy appears as the laboratory director, and Beaude performs as a senior scientist. Quantitative data are used to recognize individual roles, and not for evaluation purposes. Arcs, indeed, do not present any tabular data and are normalized at the laboratory level, making any comparison with other laboratories impossible.

ZOOMING OUT TO CHÔROS LABORATORY

Laboratory nodes are composed of individuals, arranged in a clockwise order starting at noon according to their first institutional



enrollment, meaning that Dominique von Der Mühll and Patrick Poncet are respectively the first and the last employees that joined CHÔROS. Looking at the individuals arranged around the circle, it is noticeable that different practices exist in the laboratory. Further, these practices—quantified by arcs—help to identify the unit roles. Professors usually collect the maximum score in the quantitative indexes, and senior scientists have slightly lower values. The other scholars are postdoc and PhD candidates, collecting at least one advising affinity towards their director/s. These scholars generally publish scientific articles at a certain point of their career as is the case for Carole Lanoix, or they teach like Mirza Tursić. Their practice may also consist of the whole range as it is the case for Jean-Nicolas Fauchille, who changed his status from PhD student to senior scientist over the course of 2016. However, some practices are not represented: this is the reason why the secretary Luana Huguenin's indexes appear empty. It is also the case for the teaching assistants whose indexes are empty



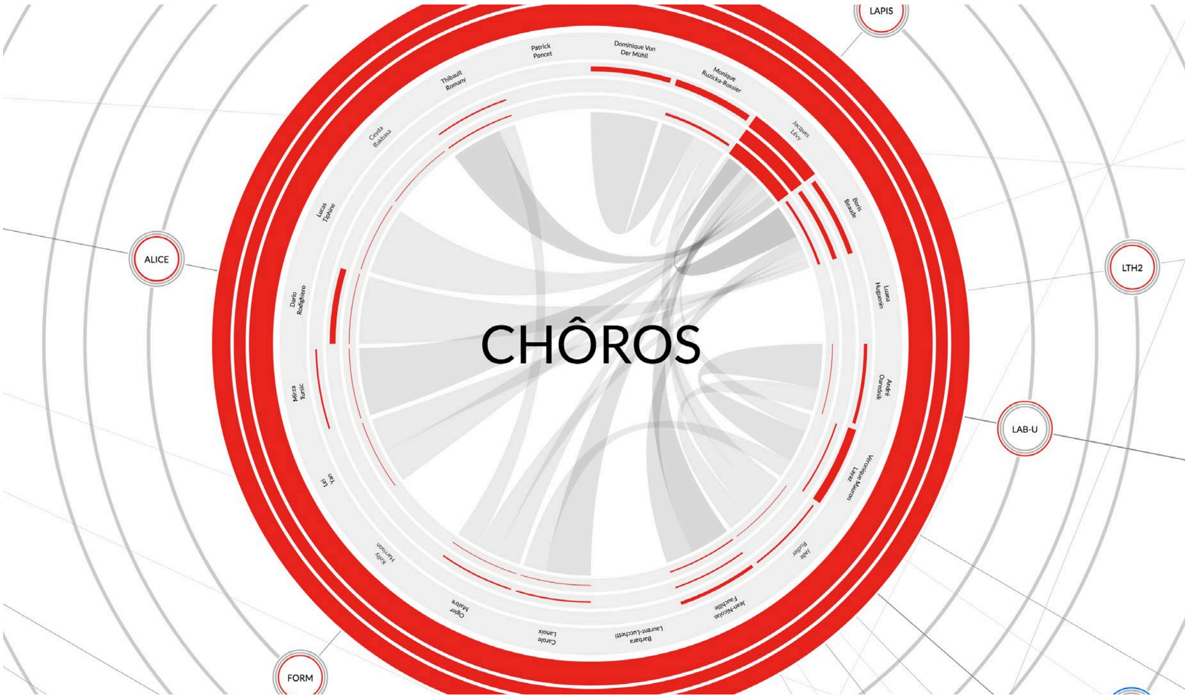
even if they contribute to teaching. This indicates a precise choice by EPFL not to record their presence in IS-Academia, the information system that stores teachers and students.

INTERNAL ORGANIZATION

Internal collaborations are visible through the chord diagram occupying the very center of nodes. Looking at these chords, Jacques Lévy and Boris Beaude appear particularly collaborative. Additionally, the opacity of the chords shows how Lévy also shares affinities with Jean-Nicolas Fauchille, Mirza Tursić, and Thibault Romany, with whom he has more collaborations. CHÔROS collaborations seem particularly distributed compared to other laboratories that focus on the professor only. One reason might be the high presence of senior laboratory members who supervise younger ones.

PROTECTIVE CHRYSALIS

The rings show us that CHÔROS is inclined towards education, a characteristic specific



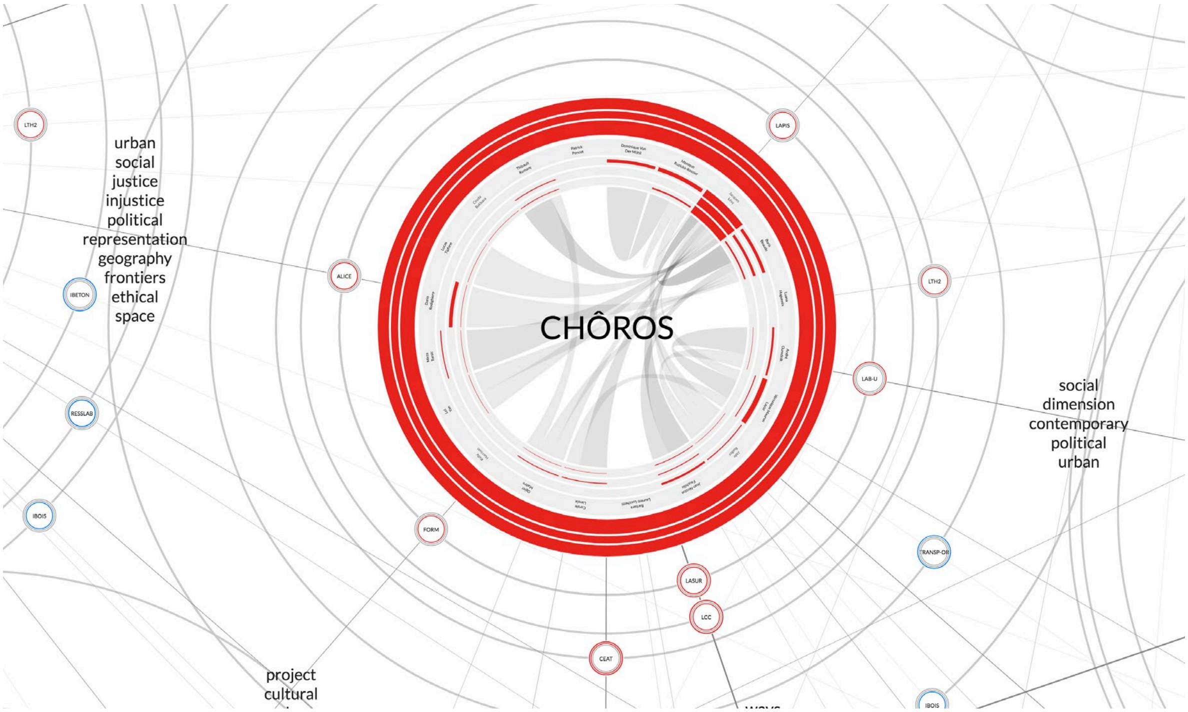
to the laboratories belonging to the Institute of Architecture. As can be deduced from the thickness of the inner and outer rings, advising and teaching are more intense than publishing.

EXTERNAL COLLABORATIONS

The flying objects orbiting outside the rings are satellites, which represent the collaborations between laboratories. Satellites show here that CHÔROS cooperates with ten different laboratories mainly belonging to the Institute of Architecture. Looking more carefully at the rings that characterize each satellite, it is evident that collaborations are based on advising and teaching activities, which reaffirm the information given by the node's rings.

NEIGHBORHOOD

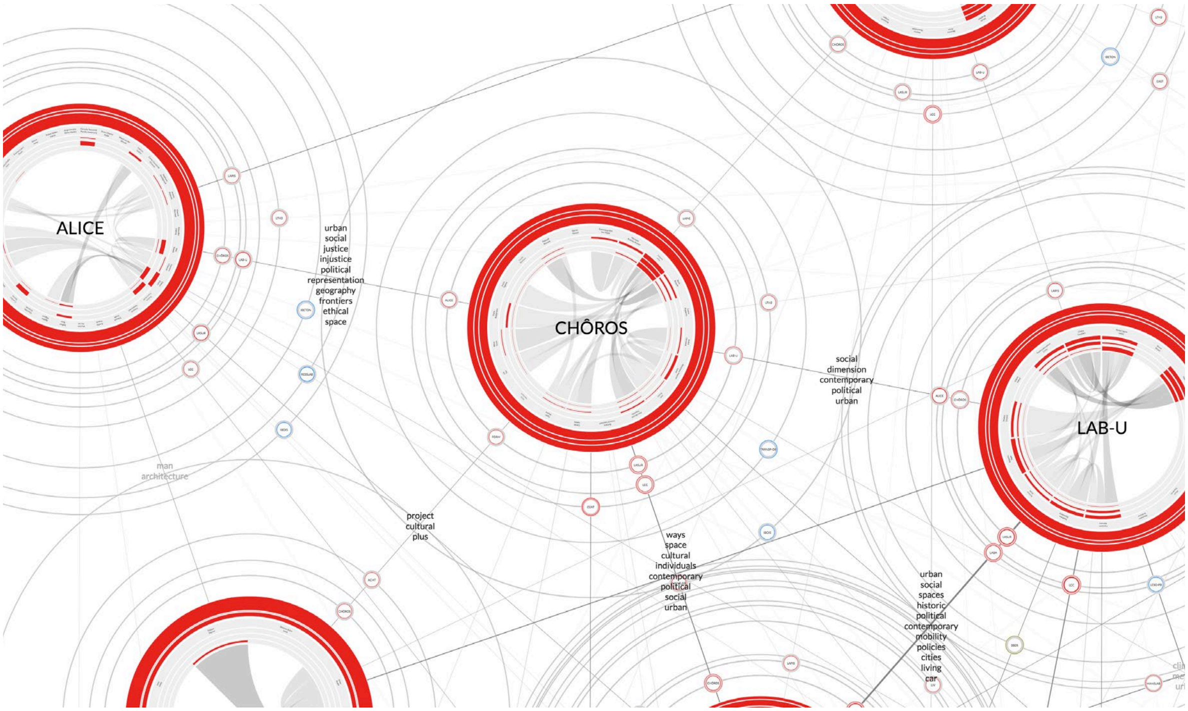
Zooming out allows to localize CHÔROS within the context of the ENAC school. Its neighborhood consists of six laboratories, all associated with the Institute of Architecture. This



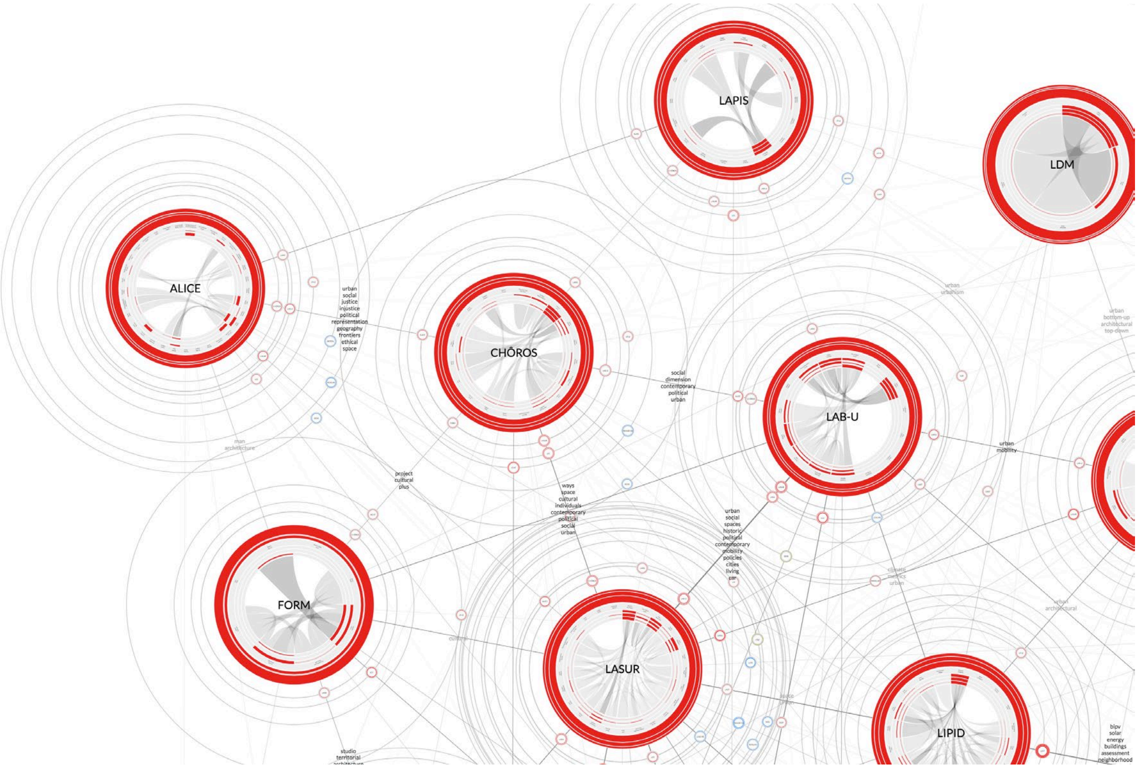
situation confirms what was visible through the satellites, i.e., that CHÔROS is well situated inside the Institute of Architecture. The space around is defined by keywords that represent the shared dictionary with neighbors. CHÔROS shares keywords with other five laboratories: LAB-U, LASUR, ALICE, LTH-2, and Archizoom. The space between CHÔROS and LASUR, for instance, is populated with the following keywords: *ways*, *space*, *cultural*, *individuals*, *contemporary*, *political*, *social*, and *urban*. It is interesting to note that keywords have two slightly different colors to spot actual and potential affinities. It means that CHÔROS collaborates with LAB-U, LASUR, ALICE, and LTH-2, while there is a potential collaboration with Archizoom.

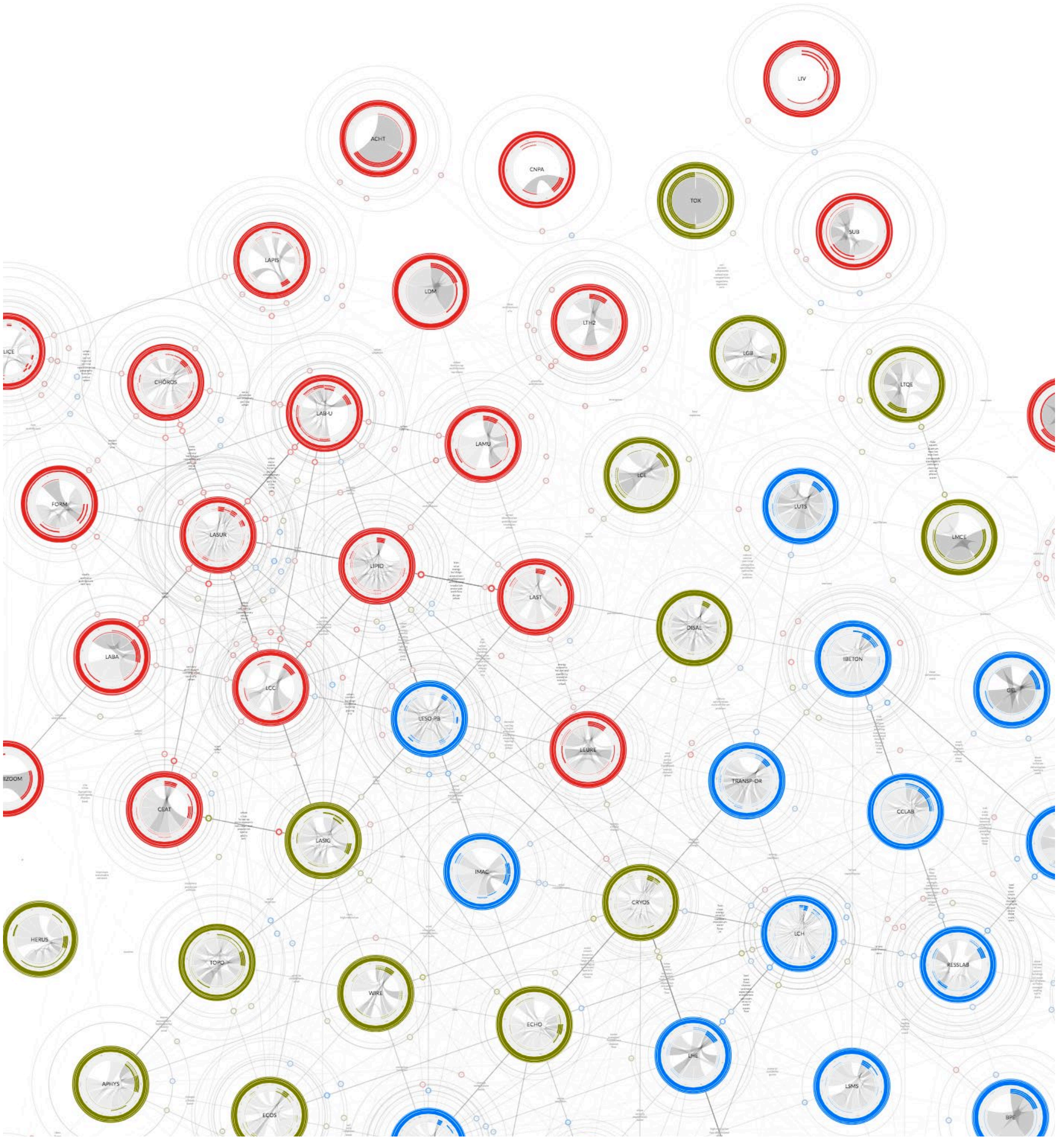
LOOKING AT THE WHOLE

Zooming out to the whole ENAC, it is appreciable how well CHÔROS is situated within Architecture. Satellites are now tiny and the focus shifts to laboratories. Four forces of attraction regulate the layout: three actual



affinities plus the keywords for potential affinities. These forces can be activated and deactivated through the control panel, generating new network configurations. At the level of publications, CHÔROS published just one paper with another laboratory, which does not mean, however, that CHÔROS is not publishing with other schools or universities. This said, looking at ENAC in general, very few laboratories have co-published in 2016. Regarding student supervisions, the map shows that CHÔROS, as all the institutes of Architecture, is particularly active in co-supervising students. The institutes of Civil and Environmental engineering do not practice the same. The teaching network is particularly mixed. CHÔROS confirms itself as an active member within the scientific





community, showing its strongest connections with LCC and CEAT. Finally, the keyword network situates CHÔROS in a network of potential affinities identifying possible collaborations with LABA, LAST, and LAMU. These observations were as objective as possible, yet every reading of the Affinity Map is different.

The next section is dedicated to its readers and their perceptions, insights, and their capacity to recognize themselves in the map.

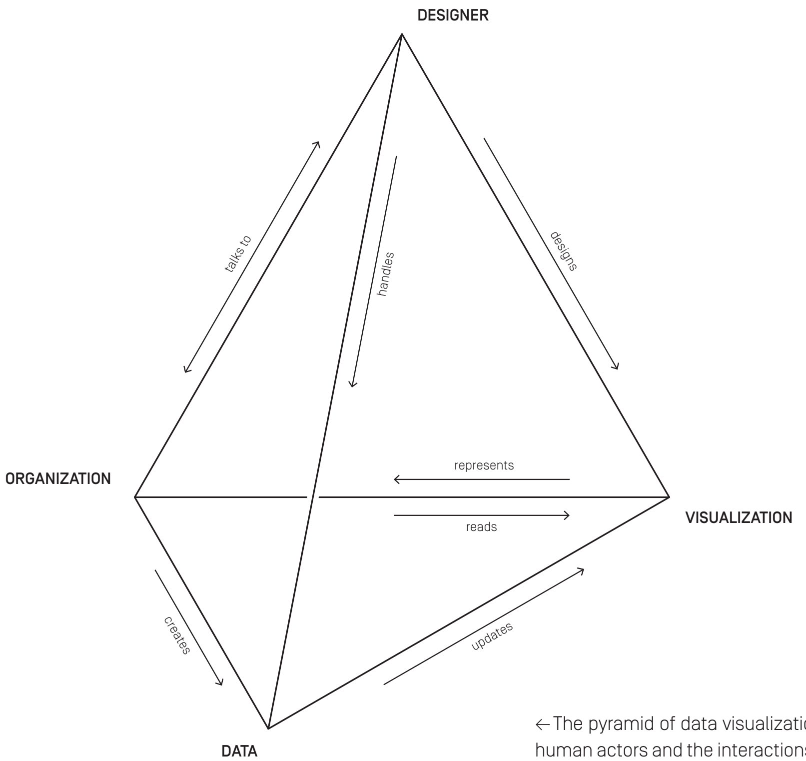
INTRODUCING THE READER

Human and non-human actors play different roles in data visualization. Previously, the impact of designers and technical/moral constraints has been discussed; now, it is time to introduce the *reader* as another human actor.

As texts can be read as much as images, the reader is that individual who tries to interpret the data visualization. Readers are the reason for designing visualizations: they are their consumers. Their role is as important as the role of the designer; both equally contribute to making the visualization alive. Marcel Duchamp [1994] was also aware of the importance of the reader; he refers to the essence of art as the relationship between artwork and spectator. Keeping artworks locked away means preventing this relationship and depriving them of meaning. Likewise, visualizations have a sense of this relationship, making the reader one of the actors of the representation. Without the reader, the visualization becomes pointless.

However, the art of reading is not confined into this duality, the context is larger and richer. Roland Barthes loses himself in the analysis of the pictorial representation of photography, which has many similarities with data visualization. In *Camera Lucida* [BARTHES 1981], he describes the act of looking at a photograph taken with Napoleon's youngest brother. This photograph caused interest and curiosity in Roland Barthes who observed, "I am looking at eyes that looked at the Emperor."

The essence of Barthes' exercise was in breaking down the photographic object into its constituents. Tracing back his phrase, it is possible to reconstruct the context of the photograph. The first term he uses is "I"—corresponding to the observer who looks at the picture. Then the word "eyes" refers to Napoleon's youngest brother, the subject of the photograph. And finally, Barthes' attention shifts to the "Emperor," which had been reflected in the eyes of his brother, just like all the faces Napoleon's brother encountered in his life. Among these constituents is also the photographer who took the picture. The elements that compose the photographic interpretation are therefore composed by the *spectator*, the *spectrum*, and the *operator*; with respect to data visualization, these actors correspond to the reader, the subject of concern, and, finally, the designer.



←The pyramid of data visualization shows human and non-human actors and the interactions that occur between them.

These roles also work for more interchangeable actors with the same function: the designer, for example, is not necessarily the visualization maker; they could also be the mapmaker, the engineer, or the software developer. The designer is not an individual but can also be represented by a team. The very same also happens for the reader: thinking about the reader as a unique individual interacting with a visualization is reductive, especially because a visualization is a tool at the disposal of an audience. The Affinity Map, for instance, is designed for a scientific community that is represented by the visualization itself. Imitating Roland Barthes, the interest of readers looking at a photograph representing themselves is tangible.

The pyramidal diagram above shows the context of data visualization, taking into account the creation as well as the consumption. In clockwise order from noon, the figure includes the designer, the visualization, the data, and the organization, illustrating how these actors are intertwined.

The designer remixes available data [MANOVICH 2007], transforming them into visual language. Also, the term "remix" identifies a manual skill with data, employed as raw material in the creation act. The designer manipulates, transforms, and modifies such data. This operation might be more effective when the designer creates a dialogue with the organization that produces data. In fact, in the case of the Affinity Map, data correspond to the academic practice that scholars perform daily and are a direct production of the organization. Through this dialogue, the designer improves his comprehension of data and helps the organization improve their quality and richness.

The organization interacts with the designer, taking part to the process of designing with comments and remarks, as well as to improve the quality and the richness of digital traces through the data. Once the visualization is released, the role of the scientific community changes: it assumes the role of the reader. The scientific community recognizes itself in the map, as it represents the academic practice of the organization.

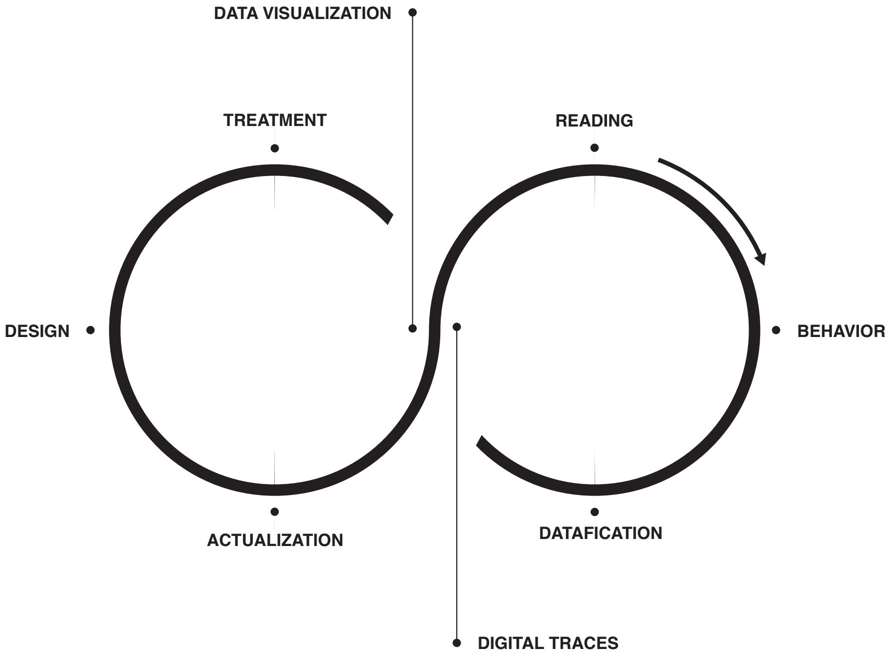
Non-human visualization and data are fundamental characters in the visualization pyramid, as they are pivotal elements in the process of translation. Data and visualizations coexist almost like in a symbiotic relationship, representing the connectivity between the social reality of the scientific organization and its representation. The next section will disentangle the profiles of the designer and the reader in two cycles, which can converge towards a unique and continuous movement that illustrates the lifecycle of visualization.

VISUALIZATION LIFECYCLE

Bruno Munari [2019] identified the steps of design in a process composed of problem definition, constraints, data analysis, creativity, models, tests, and solution. These steps may be turned totally or partially into an iteration to improve specific parts. For example, the pencil used to take notes is the result of centuries of design iteration.

Likewise, data visualizations result from a design process that can be described by a few steps. They are summarized in the left circle of the following figure, which is organized in four phases: A/ the collection and the treatment of all the data associated with a specific subject, B/ the design that shape these data into a precise concept, C/ the actualization that transforms the concept into a digital or physical form, and D/ the visualization that arises from this cycle.

Then, this outcome is interpreted by the reader. On the right side of the image, the reading cycle is organized into four steps: A/ the data visualization reading is



↑ The cycles of design and reading, on the left and the right of the image, are mixed into a unique diagram showing their mutual influence.

interpreted by the reader, B/ their understanding enriches the reader and modifies his daily practice, C/ such a practice is translated in traces, and D/ these are employed to update the data visualization.

In Cultural Studies, the latter cycle is commonly used in order to depict the relation between the visual representation and its interpretation in advertisements and television [HALL 1997; JOHNSON 1986].

This approach consisting in joining the two cycles in a unique diagram reinforces the duality that exists between design and reading, identifying an overlap between the digital traces and their visualization, which represent two sides of the same coin. If the designer gives a visual form to the reader's daily practice, the reader might change habits when they are influenced by the visualization of data. And these habits, in turn, modify the digital traces that affect the data visualization in the next lifecycle [RODIGHIERO AND ROMELE 2020]. This double-directed connectivity creates an alignment between the mapmaker and the reader, creating a continuity that brings together the two cycles like a hiking trail and its representation on the map [LATOUR 2013].

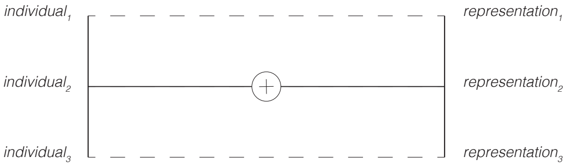
The Affinity Map charges its signs with *a priori* connectivity that associates the representation with personal data [RODIGHIERO 2015]. This correspondence gives emphasis on the individuality of readers who recognize themselves in the map through unique performances.

A HUMANISTIC APPROACH TO INTERPRETATION

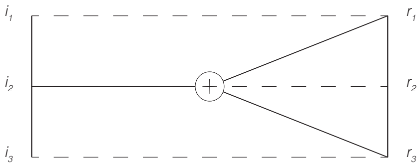
Representation and data create a correspondence that runs in both directions. One direction originates from the design process, and the other is the consequence of reading. The interpretation takes place in the space embraced by visualization and readers. Because of its performativity, there is not just one way to look at a visualization. Reading is not about the object readers look at but rather, as John Berger [1972] states, "at the relation between things and ourselves."

There is therefore more than one way to interpret a data visualization and there is no absolute right or wrong way to read it [ROSE 2016]. Each reading differs from the others because individuals have different ways of understanding and different cultures, even if some of these are common. Hal Foster refers to reading using the term "visuality." In the preface of *Vision and visuality*, vision is described as the physical operation that human beings perform when they look at something, whereas visuality is a sociocultural construction that is employed to understand an image [FOSTER 1988]. As such, Foster divides nature from culture and body from psyche, and creates the duality composed of vision and visuality, even if such a threshold is difficult to identify. An experiment going back to the Fifties, for instance, demonstrates how frogs' eyes are capable of basic cognitive operations by perceiving specific movements [HALPERN 2014]. As body and mind cannot be clearly divided, exactly as eyes and brain work in synchronization, vision and visuality represent two meanings of the same acts of looking and interpreting images.

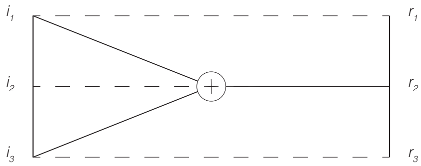
This emerging question about the meaning of interpretation has captivated scholars from different disciplines, ranging from cartography to digital humanities, all over the years. The geographer John B. Harley [1989] claims that the map is not rooted in scientific positivism because the representation does not correspond exactly to reality and the reader has to be aware of that mismatch. The reading thereby becomes looser and imperfect, leaving room for personal interpretation. In the same vein, the visual



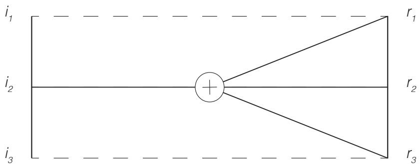
One reader recognizes theirself



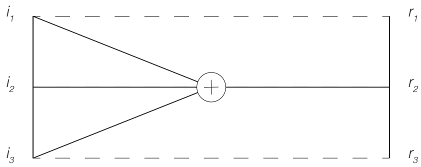
One reader recognizes two members



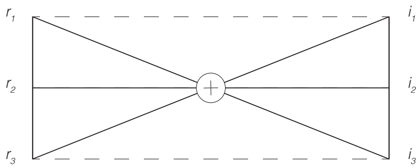
Two readers recognize one member



One reader recognizes their group



The group recognizes one member



The group recognizes itself

↑ The simplest example of a reader and object relationship is when the reader looks at theirself. There is the example of when a collective looks at itself. All the other possible configurations are shown when the subject is an individual or a collective, and the object might be an individual or a collective.

theorist Johanna Drucker [2011] refers to the interpretation as a "subjective expression of perceived phenomena," stating that subjectivity—or individual culture, as Hal Foster [1988] writes—influences the approach to any visualization. A sensitiveness for reading is needed for graphic design [DONDIS 1975] as well as for data visualization [LUPI 2017].

⬡ SELF AND COLLECTIVE RECOGNITION

One major aspect affecting the Affinity Map is represented by self-recognition, the operation of reading that happens when the reader is represented within the data visualization itself [RODIGHIERO & CELLARD 2019]. As tourists look at their own position in a city map, for the reader it is natural to locate themselves within the data visualization.

Roland Barthes [1981] was fascinated by the role of the subject in photography, which can transform individuals into images in which they can recognize themselves. The photographic portrait, however, differs from one's mirror reflection. When the mirror reflects back an image of oneself, one is in control of it because one decides when, where, in which position, with which lighting, which duration, and so on. When one becomes the photographer's subject, one does not have any control: one is facing a practitioner who decides the general setting of the shot. Likewise, a visualization is a third-party production in which one does not have any control, even though one may understand the mechanism behind it. Such a mechanism of reproduction can be transparent when one understands the metric that regulates the image. Barthes was disappointed because he did not feel represented by his portrait, but the portrait became clearer by understanding the point of view of the photographer. This transparency of intention is fundamental to create mutual understanding between the reader and the designer.

Once intentions and metrics of the data visualizations are clear, the reader can look at their image and contemplate it. Is the reader's representation appropriate? This is a legitimate question for both readers and designers. The recognition of one's own position is important in order to establish a relationship between the map and its reader.

The Affinity Map, however, is more complicated; it represents a collective composed by one thousand scholars, which makes each of them a potential reader of the map. Additionally, the recognition not only impacts individuals and the whole collective, but also the laboratories. Thereby, self-recognition happens at three different levels through different configurations.

VALIDATION OF THE VISUAL METHOD

Maps are objects of great accuracy and precision, but their intrinsic value is only accessible through their use, which becomes crucial when the readers are the subject of a representation. Maps are often conceived for a specific audience [BERTIN 1981] with the aim to create a common vision [BERLIN 2013] or social consensus [JACOB 2006].

The Affinity Map is not an exception, being specifically addressed to the ENAC scholars with the objective to foster collaboration. The following section illustrates the three potential types of audience that have been identified: the scholars, the management, and the public external to the school. Then, this section focuses on the validation of the Affinity Map through a series of interviews with faculty members. In particular, the scholars have been asked to relate themselves to the map in an effort to understand their insights.

This is an obligatory step for reading intrinsic information and making further elaboration possible to obtain what Bertin [1981] called *extrinsic information*, which corresponds to all the information that is not shown by the visualization but can be inferred by readers to fulfill their own needs. Hereinafter, these audiences are introduced along with their needs, discussing how the map is addressed to them and how they are supposed to infer extrinsic information.

SCHOLARS

The scholars are the main readers of the Affinity Map. This group corresponds to all the individuals that appear on the map, and is composed of professors, senior scientists, postdocs, and doctoral candidates belonging to the ENAC school. They have varying needs according to their role, but the most sensitive job is taken by the professors who are responsible for their own laboratories.

In front of the map, professors have to localize their laboratory first of all. The laboratory representation should help them to reflect on the current situation in terms of affinities. The laboratory is positioned according to its actual and potential affinities that can be activated and deactivated through the interface, allowing the professors to study not only the general arrangement but also specific configurations relative to each affinity. This operation enables them to estimate the laboratory centrality in the organization with respect to the type of affinity. For example, a laboratory can be central in terms of education and marginal in the activity of research as it is often the case in the Institute of Architecture. Furthermore, the laboratory can be evaluated according to its potential affinities, suggesting new collaborations with other units to make its position more central. The laboratory can also be observed through its keywords, which define its lexical context. This verification is fundamental because it can provide useful information about the quality of text analysis that measures potential affinities.

Then, the reading can focus on individuals: the professors can look within their laboratory to see the distribution of tasks, the number of members, and the collaboration in the unit. Even if such a process could appear unneeded for professors as they usually collaborate with each laboratory member, looking at individuals might be more helpful to the other members who have a partial view of the laboratory, especially in large units. If the professor is the laboratory hub, a doctoral assistant may use the Affinity Map to understand more obscure parts of the laboratory. For example, he might realize that he can write an article with a colleague other than the professor or observe how other doctoral assistants work. Comparison is important for a doctoral student to understand academic practice and imitate it.

At the same time, all scholars are invited to compare laboratories to grasp the diversity of units. Professors are always the reference point within laboratories, but senior scientists might also have coordinator roles. Laboratories can be big or small, disclosing their fundraising capacity.

MANAGERS

ENAC management corresponds to a small group that makes decisions about the school. The majority of them are also scholars, thereby with a double standpoint on the map. As scholars, the directors have different duties that depend on their position. For example, a director can be interested in research activities for the institute, in education for the section, or in the whole school as is the case with the dean. As previously discussed in the participatory design, the ENAC dean Marilyne Andersen was deeply involved in the design process, probably representing the most important user among the group of managers.

The very first desire the dean had was an instrument to see the internal organization of the school. Since the very beginning, she was interested in seizing the ENAC at a glance through the use of the chief feature of maps. Visualizations, as maps, provide the opportunity to step back and become detached from any social context [JACOB 2006].

The Affinity Map offers a synoptic view of the school, without being an instrument of control on the school [FOUCAULT 1975].

The needs of management are different from those of scholars: they consist of planning, anticipation, and decisions. In this sense, the Affinity Map is an instrument shedding light to extrinsic information and supporting decision-making [BOECHAT & VENTURINI 2016; HOYNINGEN-HUENE 1987]. Every decision, however, does not involve a single individual but rather a team in which there are discussions aimed at reaching an agreement. In this context, the map is a useful instrument to share insights to support proposals and foster discussions. Visualizations work as mediators in the decision-making process like a non-human actor [LATOUR 2005].

In addition, for the deanship, the map can suggest the creation of a new laboratory because of the empty space; it can justify the closedown of a unit, even though this is a rare event, or it can predict the split of a unit to help with the rapid increase of a certain research subject.

Although the Affinity Map is first and foremost an instrument for exploring collaboration in all its forms, evaluation cannot be totally avoided. With that in mind, it is easy to form an opinion in terms of collaboration, but there are a few major things to keep in mind before assessing a laboratory. First, new laboratories do not have many affinities as it is a lengthy process. Secondly, the map represents one calendar year only; judging over a larger time span would give us a more precise opinion. Thirdly, the focus is on collaborations internal to the school, but a laboratory may have developed a partnership with units outside the school or the institution. For a proper use of the Affinity Map, it is important to remember the benefits of the visualization but also its limits.

PUBLIC EXTERNAL TO THE SCHOOL

The last audience for the Affinity Map is external to the school organization: the ENAC students, the EPFL scholars, and the academic scholars. Even if the map has been developed for the interests of ENAC scholars, some considerations can be weighted.

The interest of ENAC students is to orientate themselves in the academic environment, which appears complex at the first glance. It is important for them to have an instrument that arranges their professors in a semantic space to explore research topics, for example to choose an internship.

EPFL scholars need to have a deeper understanding of the ENAC to consider interdisciplinary collaborations. The other deans, in particular, might be interested in having the map as a tool to discuss potential bridges between the schools and the presidency. Academic scholars who work outside the EPFL might benefit from a general presentation. For example, there exists today an effort to incentivize collaborations between the EPFL and the ETH Zurich, and the map might indicate the right partners for specific inter-institutional collaborations, especially through the search panel in the user interface available on the website.

⬡ FINAL INTERVIEWS

A series of interviews with ENAC members allowed us to assess the Affinity Map. Nine scholars were selected according to their institute and role: the full and tenure-track professors who equally direct a laboratory, and the senior scientist who is often the closest collaborator of the professor. The main reason for this choice was the seniority, which ensures a better knowledge of the school and more relevant feedback. The table introduces the interviewees in a grid organized by roles and institutes. Their names are represented by letters to ensure their privacy.

Interviewees were aware of the Affinity Map from the beginning, as well as all the ENAC members. Indeed, the project was introduced to the scientific collective, and each year an update illustrated the further developments in official events such as the ENAC Research Day and the general assembly, which took place respectively in May and October. In particular, during the ENAC Research Day of 2016, a static version of the Affinity Map was introduced and, one year later, the interactive version was published online and made available to the whole ENAC collective. When interviews took place, between June and July 2017, the interviewees were informed about the current developments, and they had had access to the digital version of the map for several weeks.

	Full Professor	*Tenure-track Professor*	*Senior Scientist*
Architecture	A	B	C
Civil Engineering	D	E	F
Environmental Engineering	G	H	I

↑ Interviews are aimed to assess the Affinity Map. This table summarizes the ENAC scholars chosen for these interviews.

Meetings were organized so that even when scholars did not interact with the visualization a conversation could still take place. Two objects were used during the meetings, a laptop featuring the most recent version of the Affinity Map and a sheet with a set of questions to drive the conversation. Interviews took place in the individual scholars' offices to facilitate a comfortable setting, and they were conducted by myself.

The interview structure followed the next table, which is organized in four sections.

	Questions
Individuals	1. Did you see yourself ?
	2. Do quantitative indicators represent your role ?
	3. Is the laboratory structure appropriate ?
Neighborhood	4. Do satellites represent ongoing collaborations ?
	5. Do you collaborate with surrounding units ?
	6. Are keywords appropriate ?
Organization	7. Is your position appropriate ?
	8. And your institute's position ?
	9. Is the map accurately representing the school ?
Usage	10. Is the map useful for you ?
	11. Is it an instrument of governance ?
	12. Is it useful for a generic public ?

↑ Interviews were organized through a precise schema in four parts: the first three parts regard the graphical representation and the assessment of information, and the fourth part focuses on the map usage.

Three sections focus on different map levels: respectively for the individuals, the laboratory neighborhood, and the whole organization. The last section dealt with audiences and the possible use of the map in different contexts. The first part of the interview was structured in order to understand whether the information displayed on the map was appropriate, while the second part was left intentionally open to have more personal feedback.

The next table illustrates the results of the interviews. There, questions intersect the answers in order to indicate whether the scholar's general satisfaction was positive or not. Further, asterisks correspond to specific remarks related to these answers. These tables summarize the global outcome

	Questions	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Individuals	1. Did you see yourself?	✓	✓	✓	✓	✓	✓	✓	✓	✓
	2. Do quantitative indicators represent your role?	✓	✗*	✓	✓	✗*	✗*	✓	✓	✓
	3. Is the laboratory structure appropriate?	✓*	✗*	✓	✓	✗*	✓*	✓*	✓	✓
Neighborhood	4. Do satellites represent ongoing collaborations?	✓	✓	✓	✓*	✓	✓	✓*	✓	✓
	5. Do you collaborate with surrounding units?	✓	✓	✓	✓	✓	✓	✓	✓	✓
	6. Are keywords appropriate?	✓*	✗*	✓*	✓	✓	✓	✓	✓*	✓*
Organization	7. Is your position appropriate?	✓	✓	✓	✓	✓	✓	✓	✓	✓
	8. And your institute's position?	✓	✓	✓	✓	✓	✓	✓	✓	✓
	9. Is the map accurately representing the school?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Usage	10. Is the map useful for you?	✓	✓	✓*	✓	✓*	✓*	✓	✓	✓
	11. Is it an instrument of governance?	✓*	✓	✓	✓	✓*	✓	✓	✓*	✓
	12. Is it useful for a generic public?	✓*	✓	✗	✓	✓	✓	✓*	✓	✓

↑ Questions and interviewees are organized in order to get a general view of interviews. Asterisks correspond to relevant commentaries, which are shown in the next table.

of the interviews, and specific commentaries that enriched the general feedback with relevant reflections. The following text analyzes the results question by question.

Scholars have no problem finding themselves on the map (see Question 1). However, some of them did not agree with their representation due to two different problems (see Question 2). In one case, an error of metadata caused disagreement with a professor (E-2). Indeed, his personal literature referred to his string name rather than his Sciper number. As a consequence, the Infoscience system did not return any of his publications and the relative measure on the map was zero. During the talk, we traced the problem back to the laboratory member that was accountable for the data input. Once the error was fixed in Infoscience and the map updated according to the new values, the professor agreed with the representation. In two other cases, we came across an exception in the academic practice (B-2 and F-2). Indeed, the two scholars did not have many publications because during the previous year one was writing a book, while the other spent a lot of time in programming. Although the visualization was correct, two limits of the graphical representation were pointed out: one was about the equivalence of publications that are very different from them as between books and articles, one was about programming not being considered to describe the academic practice.

Question 3 is about the laboratory structure. Although the laboratory diagram correctly represents individuals and collaboration, different issues emerged. First, some individuals do not correspond to their representation because, for instance, the position of teaching assistants is not translated into traces: only professors and external lecturers are associated with the courses. As a result, teaching assistants are not quantitatively represented by data (see B-3). Second, the programming and committee affinities are not visible on the map. In the first case, we did not make the decision to use these traces; in the second case, digital traces do not exist (see F-3 and H-3). Third, a problem with programming was solved (see E-3). Fourth, a professor brought up the question of synchronization since the current map corresponds to the previous year (see A-3). Despite that limitation, we have concluded that a delayed but validated visualization was still better than a not validated real-time visualization.

Question 4 confirmed the data quality used for affinities, since no major remarks concerned the satellites. It is interesting how, again, the map allows scholars to spot a problem related to sources, specifically in the Is-Academia repository (D-4).

Furthermore, a scholar stressed the fact we only showed affinities within the ENAC (G-4). This issue will be tackled in a future development, in which the context will shift from the school to the entire EPFL, showing collaborations with laboratories external to the ENAC. From a technical point of view, metadata of EPFL collaborations have been already collected to show affinities within EPFL in a future version of the map, thus enriching the overall context and the interdisciplinary potential.

While Question 5 confirmed the correctness of actual affinities, Question 6 generated a commentary concerning keywords. In general, the interviews validated the keyword method we employed, confirming a special interest in them. A couple of interviewees complained about the approximation of information (A-6 and B-6). However, it has to be said that the two cases correspond to laboratories that usually publish in French, when the keyword extraction works with the main language, which is English. Unfortunately, we have not been able to solve this problem since natural language processing works in perfect conditions with a large quantity of information. Despite this technical limit, scholars encouraged us to improve the keywords quality with several suggestions we will consider for the next developments (C-6, H-6, and I-6).

The positions of laboratories and institutions, and the global organization, are correct (see Questions 8, 9, and 10). Although there were no major comments about that point, it is very important to underline that the map fulfilled one of its major objectives, situating laboratories according to their affinities. Finally, interviewees demonstrated interest for the three audiences, who interact with the map differently (see Questions 10, 11, and 12). It is important to identify that scholars see the Affinity Map as a tool for governance, remarking about its usefulness for scholar evaluation (F-10) and self-evaluation (C-10). Then, a group of scholars focused on the arrangement based on potential affinities, which relies on a sort of serendipity and can really foster collaboration (E-10). They recognized, without any doubt, the benefits that such a map might bring for management (E-11, H-11 and I-11), suggesting improvement that might see the map adapting to incorporate directors (A-11). Finally, they appreciated the map as a public way to present the collective to an external audience (G-12 and I-12), maybe simplifying it so it is more easily understood (A-12).

	Commentary
A-3	The laboratory structure is appropriate even though it belongs to the past
A-6	Keywords are appropriate, but too generic
A-11	A map of one unique institute would be useful
A-12	A simpler map can be useful for the general public
B-2	Although the publication indicator is right, it does not represent the exception in which a book publication took a lot of time
B-3	Teaching assistants are not represented by quantitative indicators
B-6	Keywords are generic
C-6	A dynamic version more focused on keywords would be great
C-10	The carpet was a beautiful way to show personal contributions
D-4	A missing collaboration with an external institute was immediately spotted
E-2	The publication index was missing due to a problem of metadata that was identified and repaired
E-3	The laboratory was merged with the previous one working on the same topic; the problem was fixed
E-10	The keywords map is more useful because unexpected compared to the ongoing collaborations
E-11	The map is more useful to management, even though its value to spot errors on the data sources is visible
F-2	The fact there are no publications that year does not mean the scholar did not publish at all
F-3	It would be nice to see collaborations through programming
F-10	It is a tool for scholar's self-evaluation
G-3	The map represents quantity and not quality
G-4	There are no external collaborations
G-12	The map is a very nice way to present the school
H-3	Jury committees might represent another type of effective affinity
H-6	It would be nice to see keywords at EPFL scale
H-11	Evaluation is unavoidable for tenure-track positions
I-6	Potential collaborations are relevant
I-11	It is useful for the creation of interdisciplinary groups
I-12	Favorable to the map publication for public use

←The interviewees' most relevant commentaries are summarized here, extending the meaning of the previous table.

INTERACTION IN PUBLIC SPACES

Visualization are complex artifacts that involve human and non-human actors alike. Among them, there are mapmakers, readers, and data, and the list could be longer. The more the design process is deconstructed, the more the intricate pattern of actors becomes visible. Through the design process, the information contaminates the method and the designer works to stabilize the visual rules that govern the overall arrangement. The visualization successively takes shape into an intelligible object, entering the actualization phase in which an object is created to make the information intelligible [DELEUZE & PARNET 2007]. The actualization is the process through which visualizations are transformed into objects of interaction. Through actualization, the object that the readers will interact with is chosen among the virtuality of all the possible shapes. Although *virtuality* is employed today to describe the immaterial universe of the Internet, its meaning corresponds to the infinite shapes that visualization can assume. Actualization is thereby the way in which visualizations materialize themselves in society, becoming instruments at the readers' disposal.

Tangible objects make the interaction possible. The reading happens through the intimate relationship between object and reader. Although reading might sound like a cerebral and abstract behavior, it is actually physical. When reading takes up space, it has to be contextualized. The environment where reading happens is a matter of great importance, especially when data visualizations are addressed to specific audiences and uses. The designers should not only have control of the object they crafted but also of the context in which reading happens. A private or a collective reading may be an ideal fit for, respectively, a private office or a public space. In addition, the same data visualization may change according to the installation site, the environment playing a key role in highlighting its affordances.

It is important to notice that, according to the ecological approach of James J. Gibson [2015], employed to describe the mechanism of human vision, data visualizations are always contextualised into an environment driving user interactions during the reading.

INTIMATE, PERSONAL, SOCIAL, AND PUBLIC DISTANCES

Once the visualization is actualized, the reading becomes possible, as the visualization finally becomes a tangible object readers can interact

with through indirect and direct actions. Indirect actions make use of data visualization as a mediator to a final goal, which can be a decision or a demonstration. Some of these goals belong to the private sphere, but more of them are social acts of communication between individuals. Indeed, indirect actions are used by groups of readers to communicate during meetings or conferences. On the other hand, direct actions extend the reader's ability through data visualizations by accessing information, pointing fingers, jotting down notes, underlining texts, and so on. Direct actions are the way through which readers can accomplish indirect actions; the gesture of pointing fingers, for example, is related to the intention of making someone else aware of a specific insight.

Both direct and indirect actions change according to their actualization in their physical environment. There, the interaction between readers and actualizations takes place in a definite, physical space. The combination of actualization and environment defines the reader's capacity. The Affinity Map, for example, was actualized as a browser application whose natural environment is represented by the office. Readers modify the map through various controls to re-actualize it according to their needs. The individual relation with the data visualization implies an intimate distance [HALL 1990] where the reader is so absorbed by the screen that they have the sensation of being alone [KAPLAN 2015]. This is the case for smartphones, tablets, and also desktop computers whose use implies a short physical distance. Such a configuration promotes a personal exploration that limits interactions with other readers.

↖↑ Mobile phones and desktop computers are designed for intimate reading. Personal computers can be used simultaneously by small groups of individuals; pointing a finger becomes a standard gesture of personal reading. ©2016 Alain Herzog

↑ Media dimension affects the size of the group that can interact simultaneously. A poster can easily be placed at the center of a conversation between four readers, which is an example of social reading. ©2016 Alain Herzog

↑ A moment of discussion that took place during the ENAC Research Day in 2017. Cyril Veillon, the director of Archizoom, discusses the representation of his unit with some peers. ©2017 Alain Herzog

But when the device is shared among multiple readers, the interaction becomes collective and fosters a dialogue between individuals. A few readers can talk together in front of a data visualization on a computer screen, which plays the role of mediator between them. The readers and the visualization mutually interact at a personal distance. In this scenario, both direct and indirect actions favor the circulation of information among the actors and foster discussion. When a reader points out a detail, for instance, the group refocuses the discussion.

More readers can join the discussion if wider screens are used. Large media such as posters augment the social interaction. Although desktop computers are commonly used by one single user or two individuals in a moment of conversation, posters open the scene to larger groups of readers. Posters can be hung on the wall or laid down on a table to create different settings in which individuals interact. Many meetings for designing the Affinity Map were organized around a table where visualizations were laid down on the table with the team gathered around. In settings like this, gestures cover a key role in the communication between readers and the physicality of the poster encourages written-on notes, highlights, or sketches. Even though it may sound obvious, when data visualizations leave the screen of the personal computer for larger settings, the interaction between readers completely changes, especially when the individuals can walk in a room.

During the ENAC Research Day in 2017, a large television was used to showcase the Affinity Map. The setting was particularly interesting as a means to present the digital version of the map to the school for the first time. ENAC scholars were invited to locate themselves on the map and share their thoughts with the design team. It was a crucial day in the design process, as there were plenty of useful discussions, and it was an opportunity to observe users interacting with the interface. Contrary to the static nature experienced during the meetings, there was a briskness of movement between ENAC members: throughout the day, groups of readers were changing and being replaced by new ones, allowing the collection of many pieces of advice. The Affinity Map was at the center of an exhibition with various scientific experiments. Readers were allowed to stroll among the installations, stop for a while and then keep moving again. The environment empowered them to step back from the discussion and look at other readers from the outside, introducing the public distance where external observers can look at the readers in an environment open to everyone. That position allowed the reader to be a passive actor within the discussion and hear what others were saying. The reading setting is therefore defined as the forms that the actualization, the environment, and the reading distance take.

⬡ WALKING VISUALIZATION

The ENAC Research Day was revitalized in 2016 with the idea of creating an event that would involve the scholars. The deanship's determination to recreate the spirit of cohesion made use of the concepts of interdisciplinarity and collaboration. In these terms, the map had a central role to address such spirit, especially in terms of public engagement, but, in order to understand that, we need to take a step back.

During the Digital Humanities conference in 2014, which took place in Lausanne hosted by the EPFL and the University of Lausanne, the logo of the event was a network visualization actualized in posters, book covers, flyers, t-shirts, and mugs [RIGAL & RODIGHIERO 2015]. The network arranged all the conference speakers by authoring and common keywords [RODIGHIERO 2015]. One original actualization of the logo took the form of a walking visualization. The round sticker that measured five meters in diameter was placed in front of the conference entrance on the first day. It was so large that it could display hundreds of speakers on a single surface. The speakers' names were key for the social interactions that happened in that special setting. Attendees were invited to walk the network visualization to explore the scientific community, searching for their own self or for the peers they knew. Speakers were able to find themselves by locating their names on the data visualization, which became a space to socialize and develop a sense of collectiveness among the members of the same community.

The idea was to reproduce the collective experience of DH2014. A version of the Affinity Map, measuring 225 square meters, was printed for the ENAC Research Day. The map featured almost one thousand scholars and around seventy laboratories. The walkable visualization was composed of three tarpaulin prints measuring 5 by 15 meters each, produced by a company specializing in large printing located in Lucerne.

The actualization of the Affinity Map was a site-specific installation designed for the SG building, which hosts all the activities of the Institute of Architecture. The building features different facilities such as classrooms, workshops, and meeting spaces allowing for the circulation of many students and scholars. In addition to this high attendance assured by the constant flux of people, the building also features a large foyer of 300 m^2 surrounded by three tiers of balconies that provide an overall overview. As visible in the rendering below that simulates the installation, the Affinity Map was designed to occupy the entire foyer, offering

↓ The rendering shows the Affinity Map carpet situated in the SG building foyer. ©2016 Claudio Leonardi

↑ The large floor and the balconies offer specific affordances for reading the visualization. ©2016 Claudio Leonardi

its viewers the opportunity to look at it by walking through or from balconies above.

Looking back at the past, there are a few examples of floor maps like the one created by the astronomer Giovanni Domenico Cassini during the seventeenth century [JACOB 2006]. This large planisphere was created at the French Academy of Sciences in Paris to invite the scholars of the time to try out a new method of measurement of the known world by walking over it. Like the Affinity Map, it was a way to present a new metric in an innovative way and ask the visitors for feedback. The topographical installation was so successful that it was worth the honor of a visit from the king of France, Louis XIV. It is interesting to note that, although horizontal visualizations might discourage detached contemplation because of their closeness [ARNHEIM 1982; JACOB 2006], the balconies offered an alternative point of view, like when Indiana Jones, searching for the Grail Knight's tomb indicated by the number ten in the Venetian library of Campo San Barnaba, was only able to identify the tomb from the library balcony, as the number took up the entire floor.

The interaction with the map floor happened at different scales, like Lemuel Gulliver's travels among real and imaginary worlds [SWIFT 2005]. At one scale, the reader is small and walks on the map; at another scale, the reader is big and grasps the whole map at a glance from balconies. Details are visible when reading is close, while the whole map appears when the reader is far from it. The two scales coexist in the same environment, allowing for both close and distant reading. The reader can thus decide if they want to be a human actor walking on the map, a spectator looking down at the arrangement of the readers on the map, or both, as the open environment encourages them to move around.

⬡ ENAC RESEARCH DAY 2016

The ENAC Research Day was organized in order to foster interdisciplinarity and collaboration across different activities: this included the discovery of the Affinity Map. School members were divided into groups and encouraged to read the map on rotating shifts. The design team was there to explain to each group how the information was selected, treated, and projected to clarify the design process. ENAC members were informed that the project was open to the whole school and the map had to be validated by them before the official release.

As illustrated in the following figures, the carpet was finally presented to the public, who was invited to read it. Scholars selected their positions on the carpet and balconies.

As the photograph below shows, reading became a social activity. Individuals were free to move, changing standpoints according to their will by walking through the environment. In this special setting, the scholars on the balconies were able to look at the whole view and the arrangement of other readers on the map.

This allowed for an overlap between two spatial systems: the laboratories visually arranged in the map, and the readers physically distributed on it. The walkable installation therefore led to two standpoints: one focuses on the visual representation of the scientific collective, and the other on the performative representation of the interaction of scholars on the map.

During the interviews, a school member said, "I found the carpet wonderful because

↓ A legend for reading the map was on the wall to help clarify its visual grammar. ©2016 Alain Herzog

I see that I am involved in the scientific community; it makes me amused and encourages playing.” This statement is relevant not only for the visibility of the academic practice, but also for the encouragement of establishing new collaborations. The most interesting aspect of the walkable data visualization consisted of all of the conversations that happened. Looking at the photographs, it is evident that the real value was brought in by scholars who contributed to making the event successful. As these conversations were not traced, the photographs are the only way to recreate again the atmosphere of that day.

↑ The tarpaulin was reemployed for the production of approximately one hundred and fifty bags, as a gift for ENAC scholars. As one bag could bear more names, the distribution of certain bags triggered a discussion. Above is the bag for architect Dominique Perrault. ©2016 Martin Gonzenbach

↑ The Affinity Map carpet was presented to the scholars during the ENAC Research Day that took place in May 2016. ©2016 Alain Herzog

↑ This photograph shows the Affinity Map just after we combined its three parts. The reader on the map is situated according to the laboratory affiliation, represented by the big red circle under his feet. This photograph clearly illustrates the ratio between the reader and the data visualization. The map size fits the foyer dimensions, making the most of the printer's width of five meters. The photograph also shows the two tiers of balconies that surrounded the foyer. ©2016 Alexandre Gonzalez

⬡ CONCLUSIONS

This book illustrates a design-driven solution to the problem of governance. The visual method of the Affinity Map solves the issue of charting large organizations, which arose when the dean tried to understand the dynamics of the ENAC school at EPFL.

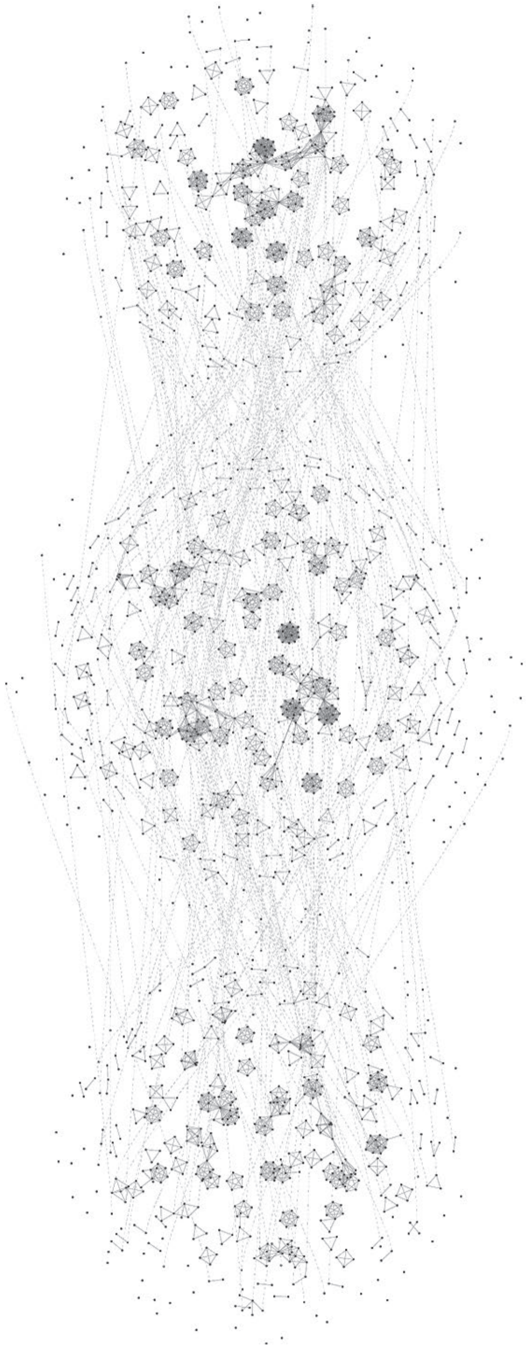
Visualizing how the daily practice is performed within organizations is a problem that concerns academic institutions as well as private companies. The concept that was introduced in these pages is intended to reduce unfair evaluation and encourage collaboration. Although visual methods for charting have existed for nearly a century, this research represents an attempt to push the boundaries further and think about organizational mapping in an ethical way.

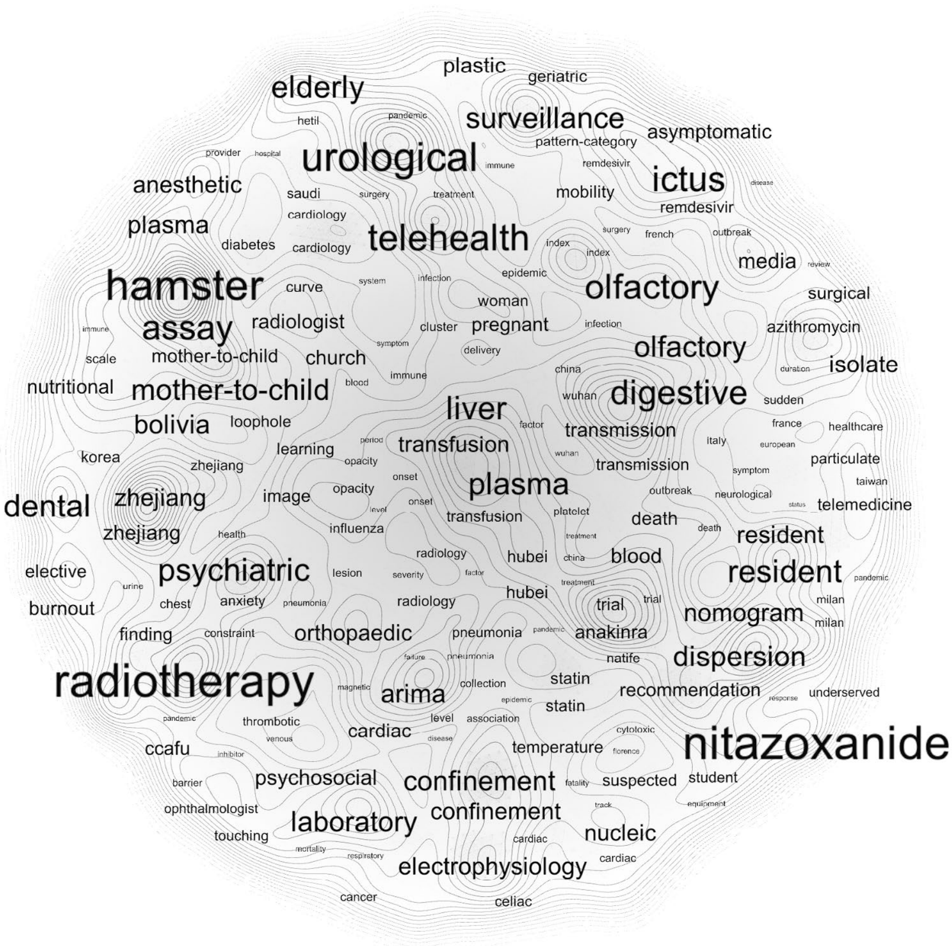
With respect to the current metrics that exist in academic and research environments, measurement cannot be limited to the scientific publications and a few other activities scholars engage in. Both academic and scientific practices rely on a collaboration network that is largely hidden from view. This study underlines how these practices are translated into data only partially and efforts of tracing these activities must go further than just solely considering publications and citations. The concept of affinity revealed the plurality of collaborations between members of the ENAC schools, following the social dimensions of personal supervision, scientific publications, and teaching activities. The goal was to make visible the academic practices that are normally hidden, pointing out the short distance between actual and potential affinities: the former depicts the current state of the collaborations, and the latter focuses on predicting the future.

The creation of a visual method to display affinities required particular attention because of their multi-scale and multi-dimensional nature. The visual quantifiers represented by rings, for instance, were aimed to overcome the mono-dimensionality of links that network visualizations usually represent through lines. These rings quantify and qualify laboratory connections, showing whether a laboratory is more involved in education or research activities. Furthermore, the visual hierarchy of the Affinity Map was enriched with colors, nodes, and arcs to represent institutes, laboratories, and scholars respectively. And the visual structure is twofold, representing laboratories or scholars according to the zoom level. These visual principles illustrate the richness of the school's practices, reflecting the individual contributions without implying any kind of evaluation. Also, the satellites reduce all the relations around each laboratory so that readers do not lose the perception of the whole network by focusing on one node. The Affinity Map was built on a structure of single ego-networks that describe the activity of laboratories. The Affinity Map relies on a hexagonal pattern, which simplifies the network arrangement and improves its readability. In addition, the homogeneous space between nodes is useful to display the common keywords that clarify the semantic proximity of laboratories.

The Affinity Map was released in various actualizations among which the walkable one was the most notable. Specifically created for the ENAC Research Day 2016, the Affinity Map was printed on a 225-square-meter surface of tarpaulin that scholars were invited to explore. Interactions with such

→The temporal dimension of network visualization is still an open issue. The concept of *trajectories* has been developed with my friends Alexandre Rigal and Loup Cellard, with whom this visualization [*Trajectories*] has been developed. The idea is that trajectories could connect nodes from different time frames that are arranged in a series of individual network visualizations [RIGAL, RODIGHIERO & CELLARD 2016; RODIGHIERO & CELLARD 2019]. ⬢





↑ The lexical metric that stemmed from the Affinity Map is under development with more sophisticated techniques. This network visualization shows the most active scientists during the COVID-19 pandemic, which appear when the user zooms in through the digital interface available at [https://rodighiero.github.io/COVID-19]. Their disposal is based on the text similarity of scientific articles, which is explicitated through the most relevant shared keywords. At first glance, these keywords are presented similarly to a word cloud in which pertinence is given by font size. The elevation contours are reprised from cartography in order to display the area of high density in terms of number of publications [MOON & RODIGHIERO 2020; RODIGHIERO, WANDL-VOGT & CARSENAT 2021]. ⬢

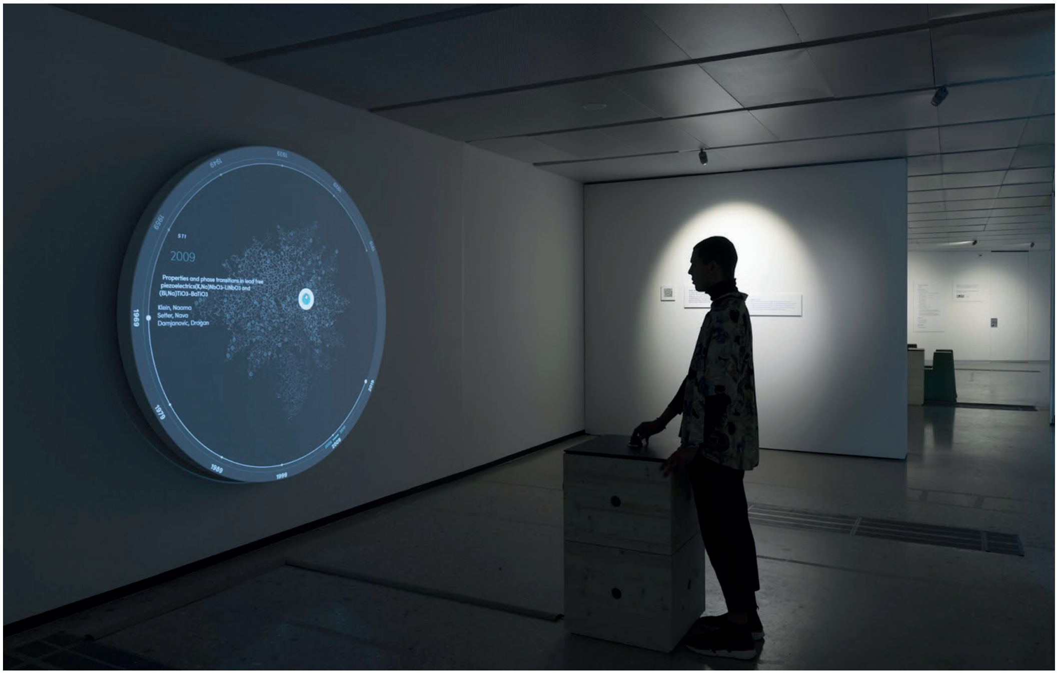
a data visualization were classified in four modes: A/ intimate reading when scholars look for themselves, B/ personal reading when two scholars discuss a specific detail, C/ social reading when more discussions happen at the same time, and D/ public reading when scholars are part of the data visualization, being observed by others.

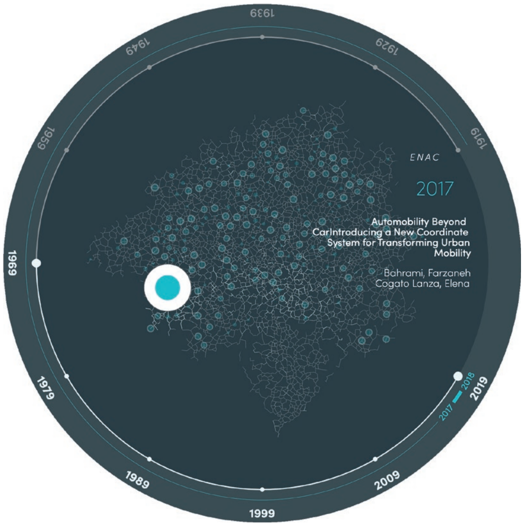
This work stresses the importance of design, defined as the sensitive and personal ability of solving a specific problem. The participatory approach was important for studying and representing the academic practice. Also, the design was important to weight datasets and discover affinities. The design method encouraged the evaluation of data through visual results and helped us choose which further steps to take. Design also covered a crucial role in the actualization of the map, driving us to experiment with different solutions to make it available to the readers. In a very special sense, the design of the map was a way to acquire, evaluate, translate, and visualize academic practice.

The design process put the spotlight on the importance of the individual, who was barely considered at the beginning of the project. This is specifically relevant with respect to the twofold function of individuals in the Affinity Map: they are represented in the map, for which they are the readers. The importance of the individual arose when the school was observed through the laboratory affiliations, while the importance of the readers arose when the collective reading took place on the walkable visualization. Designing and reading are two sides of the same coin, to which designers and readers are asked to contribute. Designers, scholars, managers, organizations, technologies, materials, data, and actualizations are all actors in the visualization lifecycle.

The Affinity Map can thus be used by all the organizations that match the following three parameters. Firstly, the organization has to rely on the social ties that bring individuals to collaborate together. Secondly, individual behaviors have to be described in terms of actual collaboration and potential affinities to embrace the diversity of practices as much as possible. Thirdly, individuals have to be arranged in an organizational structure like an arborescence that is represented by colors and units.

The Affinity Map is a tool designed to visualize the ENAC collaborations in order to stimulate new ones. Yet, the map was also created to develop a sense of belonging among the ENAC scholars. This is the reason why the Affinity Map was open to the entire scientific community, whose interviews and discussions have been seriously considered during the design process. Arguably, including all the ENAC





↑ *Super-vision* is a project that focuses specifically on the doctoral thesis and its evolution during EPFL history. Carried on in collaboration with Philippe Rivière and Patrick Donaldson for the Infinity Room II exhibition organized by Sarah Kanderdine at the EPFL Pavilions, *Super-vision* maps more than 8 000 doctoral theses defended over fifty years. The project further develops the impact of science mapping in public spaces [RODIGHIERO 2019].

← This data visualization featured a circular-shaped timeline through which the user can navigate over the years by using a 3D mouse. The theses' arrangement is given by lexical distance: the more two theses are close in space, the greater their similarity is in terms of language. By selecting one thesis, it is possible to see its metadata and highlight the extension of the faculty in the background. ⬢

members in the design process to create a feeling of collective recognition was the most ambitious goal of the entire project.

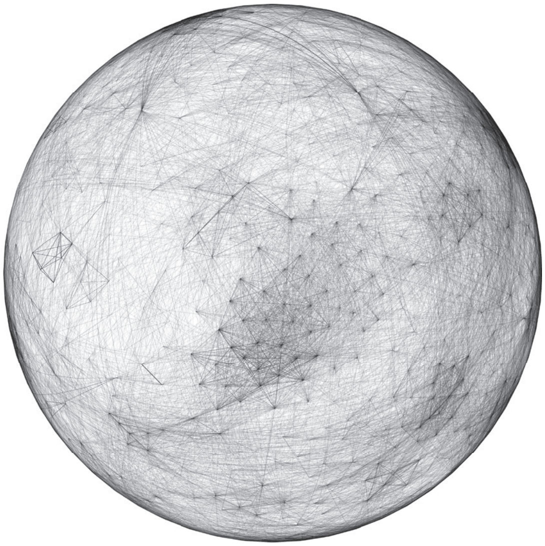
The participatory design was characterized by constant communication with the school members for four years. Such a constancy was ensured by regular updates and public events during which scholars could provide suggestions and remarks. Scholars also contributed to the design process through private interviews and public conversations. Interviews were organized at the beginning and at the end to discuss the expectations and the final work respectively. Conversations occurred mainly during the ENAC Research Days. While interviews were a formal way to collect feedback, public debates were ground for more visceral opinions. They were not just a way to observe reactions but also to stimulate conversations between scholars about the evaluation methods and their public selves. Is the visual representation appropriate ? Is the school correctly represented ? Does the map assess the academic environment ? Which data are relevant to visualize academic practice ? What is the threshold of privacy to respect ?

The process of design therefore becomes a political action. Scholars are invited to participate in the design process and be active in the creation of the map. If the idea of a city-state was based on the active contribution of citizens to political life, likewise scholars were called to draw their own image. During the ENAC general assembly of 2015, the scholars were asked if they agreed to be considered as potential users of the map; the deanship agreed and relaunched the offer involving the scholars in the design process. The laws that drive the construction of the map are the result of an open negotiation between all of its actors. All the proposals and suggestions were not only considered, but also implemented during the development. The result is a map that is based on the principles of equality and fairness.

The Affinity Map was so appreciated by school members that the project is still going on. This last section illustrates some limits encountered during the project, introducing new perspectives and enabling us to think about further future developments.

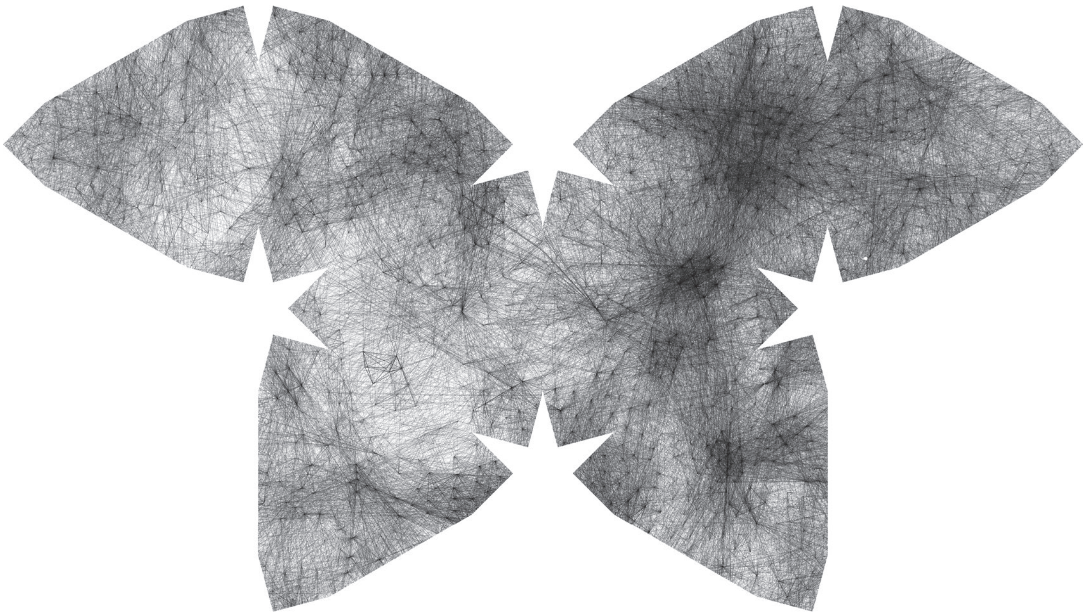
The original wish was to collect as much affinities as possible, but only the most relevant and accurate datasets have been considered to assure high-quality affinities. However, collected data were more than what was actually employed as grant collaborations, for example, were not used.

Describing academic practice can be a neverending exercise, thereby it is important to define limits. For example, the collaborations based on committee memberships were not translated into data.



← The spherical cartography comes from the ideal of a fairer representational space. If the individuals shown at the margins of the Affinity Map were unhappy because of their marginalization, situating individuals on a spherical surface without borders eliminates this problem. ⬢

↓ Successively, the spherical network visualization is brilliantly unfolded by Philippe Rivière using cartographical projections to make the surface visible, like in the Butterfly of Waterman [RODIGHIERO 2020].



Indeed, doing that was too expensive in terms of time. On the other hand, some affinities based for example on personal emails were digitized and ready to use, but privacy issues prevented their use.

Also, potential affinities might be enriched further: library loans, for example, could be useful to discover common interests. Even text analysis algorithms used for potential affinities can drastically improve through the access to full texts, but currently the low quality of PDFs as well as copyright issues make this solution difficult to implement.

It would be very interesting to apply the visual method of the Affinity Map to other scientific communities to check its adaptability. The hexagonal pattern is a valuable approach for arranging a large number of nodes as its structure is limitless. Satellites are innovative elements that solve the problem of overlapping network lines and, in addition, represent nodes' connectivity.

In any case, network visualizations have a limit *a priori*: for example, the use of a flat surface is a great limitation. Highly connected networks, indeed, present a serious problem, which affects two nodes that are opposite but connected. The reason this happens is because network visualizations are drawn on a non-continuous space. The idea is to project the network visualization on a spherical surface, which allows for a neverending projection space. By doing that, network boundaries will be removed. It would therefore be interesting to design an Affinity Map on a spherical surface in order to prove that a network without boundaries is a more democratic space [RODIGHIERO 2020].

Another visual element of the Affinity Map that works properly is the chord diagram, which highlights how network nodes can be represented as complex objects. However, this specific type of Sankey diagram might not be appropriate for larger units. With that in mind, it might be worth further experimentation to design recurrent hierarchical structure in which nodes are equally represented by a hexagonal arrangement. This visual method would allow for redefining the shape of the nodes, which will not just have to represent the laboratories but also the institutions.

Available data are enough to move the Affinity Map back and forth in time. Studying the trajectory of a laboratory through the years, for example, is a very interesting idea. Did this laboratory change position ? Does that depend on specific collaborations ? Will this laboratory endure over time ? All these questions are very relevant in terms of governance because they concern institutional decisions and expectations.

Another interesting subject to explore is the generic public. Although the efforts by the design team focused on the school members, the impact on an external audience still has to be explored. Two possible ways of doing so were isolated. One way is identified in the walkable visualization: does it represent a proper way to present scientific communities to a general audience? Did the map have to be simplified in order to make it more readable? Another way is to analyze the impact of the map on the Internet. That will lead to new observations and certainly to more results.

The names of the scholars were hidden on the public map. Such a decision was made in order to avoid any kind of evaluation, bearing in mind that the Affinity Map is a reduction of academic practice. However, professors' names will always be visible at the center of their laboratories.

The boundaries of the scholar's desire for privacy are still blurred. On one hand, there is a fear of public judgment, but on the other hand, there is a pleasure in seeing one's own name publicly visible. Obviously, the general opinion is to keep sensitive data within the organization and use public ones for sharing.

Last but not least, it would be interesting to study the impact of the visualization on scholars, as the academic practice has been already modified by current metrics. Today, professors are recruited if they published in journals with a certain Impact Factor, if they have a considerable h-index and a sufficient number of citations. Even scholars use the same indicators in their curricula vitae, validating the same evaluation metric that they may often critique. Although our efforts focused on finding the right balance of the visual representation, an evaluative use of the map cannot be prevented. In that sense, it would be interesting to see if a visual method will be further explored. If a metric of interdisciplinarity will be employed for selecting new employees, will the scholar use it? Otherwise, might the map be used to demand promotions at work? Maybe time will tell us the answer to these and other questions, but, for the moment, it is important to understand how the presence of these metrics might also negatively affect research. The fact that the literature and public image are more central in recruiting scholars show that the activities such as teaching, and supervision are underestimated. One of the interests of the Affinity Map is to underline the various dimensions of academic practice, giving proper weight to the variety of tasks that academia implies.

In ten years, it will be quite interesting to observe the social impact of visual models in academia, and more generally in our society. We are witnessing an increase of data visualization and open data, which will lead, without a doubt, to more sophisticated metrics for academic evaluation. The Affinity Map is first of all a global reflection on issues of ethics and privacy that affect the datafication of society. The ways in which data are used for commercial purposes already need new regulations, and it is possible that the visual form of data will need to be regulated in the future as well. In this respect, academia still misses hybrid profiles capable of putting together into a comprehensive structure technical skills and humanities, in what would be a contemporary version of the Bauhaus School. ⬢

LABORATORY ACRONYMS

ACHT Architecture, Criticism, History and Theory

ACM Modern Construction Archives

ALICE Design Studio on the Conception of Space

ANTFR Fribourg unit

APHYS Physics of Aquatic Systems Laboratory

APRL Atmospheric Particle Research Laboratory

ARCHIZOOM Archizoom

BPE Bioenergy and Energy Planning Research Group

CCLAB Composite Construction Laboratory

CEAT Urban and Regional Planning Community

CEL Central Environmental Laboratory

CHÔROS Chôros (Laboratory of Geography)

CNPA Laboratory of Digital Culture for Architectural Projects

CRYOS Laboratory of Cryospheric Sciences

DISAL Distributed Intelligent Systems and Algorithms Laboratory

EAST Laboratory of Elementary Architecture and Studies of Types

ECHO Laboratory of Ecohydrology

ECOL Ecological Engineering Laboratory

ECOS Ecological Systems Laboratory

EESD Earthquake Engineering and Structural Dynamics Laboratory

EML Environmental Microbiology Laboratory

FAR Laboratory of Construction and Architecture

FORM Laboratory for Architecture as Form

GEL Geo-energy Laboratory

GR-LUD Joint Professorship on Solid Waste Treatment

HERUS Laboratory on Human-Environment Relations in Urban Systems

IBETON Structural Concrete Laboratory

IBOIS Laboratory for Timber Constructions

IMAC Applied Computing and Mechanics Laboratory

LAB-U Laboratory of Urbanism

LABA Laboratory Basel

LAMU Laboratory of Architecture and Urban Mobility

LAPIS Arts of Sciences Laboratory – Archives of Imaginary

LASIG Geographic Information Systems Laboratory

LAST Laboratory of Architecture and Sustainable Technologies

LASUR Urban Sociology Laboratory

LAVOC Traffic Facilities Laboratory

LBE Laboratory for Environmental Biotechnology

LCC Construction and Conservation Laboratory

LCE Environmental Chemistry Laboratory

LCH Hydraulic Constructions Laboratory

LDM Media and Design Laboratory

LEMR Laboratory of Experimental Rock Mechanics

LESO-PB Solar Energy and Building Physics Laboratory

LEURE Laboratory of Environmental and Urban Economics

LGB Laboratory for Biological Geochemistry

LHE Environmental Hydraulics Laboratory

LIPID Laboratory of Integrated Performance in Design

LIV Informatics and Visualization Laboratory

LMCE Environmental Chemistry Modeling Laboratory

LMS Soil Mechanics Laboratory

LSMS Computational Solid Mechanics Laboratory

LTE Environmental Remote Sensing Laboratory

LTH2 Theory and History of Architecture Laboratory 2

LTH3 Theory and History of Architecture Laboratory 3

LTQE Laboratory for Water Quality and Treatment

LUTS Urban Transport Systems Laboratory

MANSLAB Laboratory for Spatial Manufacturing

MCS Structural Maintenance and Safety Laboratory

RESSLAB Resilient Steel Structures Laboratory

SBER Stream Biofilm and Ecosystem Research Laboratory

SUB Laboratory of Underground Architecture

SXL Structural Exploration Lab

TOPO Geodetic Engineering Laboratory

TOX Laboratory of Environmental Toxicology

TRANSP-OR Transportation and Mobility Laboratory

TSAM Laboratory of Techniques and Preservation of Modern Architecture

WIRE Wind Engineering and Renewable Energy Laboratory

This list describes the structure of EPFL in 2017, when the Affinity Map was developed.

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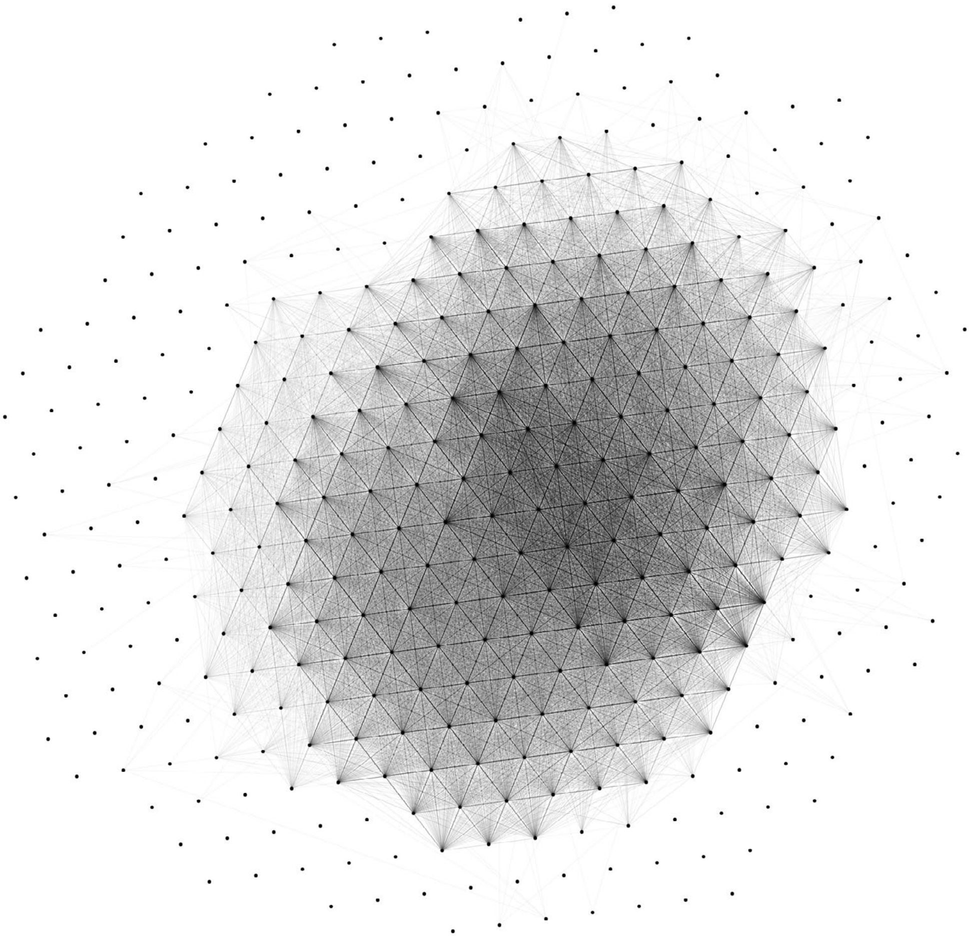

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