Campus of the future

Managing a matter of solid, liquid and gas

TU Delft OPEN Publishing

Alexandra den Heijer

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by

Alexandra den Heijer

“dedicated to whom I cherish and met on campus”

Preface

matter

noun
1 [mass noun] physical substance in general, as distinct from mind and spirit; (in physics) that which occupies space and possesses rest mass, especially as distinct from energy: the structure and properties of matter.
2 a subject or situation under consideration: a great deal of work was done on this matter | financial matters.

verb [no object]
1 [usually with negative or in questions] be important or significant

source: Oxford Dictionary of English, Stevenson 2010

Science-based vision and agenda
In an academic career, an opportunity to publish a personal vision and agenda in a book is rare. My inaugural address, as professor of Public Real Estate, provided such an occasion. With my speech "Campus matters" as a basis, I took the liberty to write this book in the first person (I, me, my) or the collective first person (we, us, our), when I describe findings or projects from TU Delft's Campus Research Team. Consequently, I am grateful to many (see Acknowledgements) for their content, support - either with data or with research budget - and for helping me with this book.

Describing past and present, pre- and post-pandemic
For decades, the campus has been my object of study and my home base at the same time. Describing past, present and future has an academic basis and a personal touch. And while I was about to publish this book in 2020, the corona reality changed the physical campus into a virtual one, world-wide. Ironically, many concluded that "the campus mattered", because it was missed more than ever. Observing from the inside how that affected the university community and scheduling an extra round of interviews with campus managers of all Dutch universities in 2020/2021, enriched but did not change the message of the inaugural speech.

The distribution and publishing process
The first printed version of this book was distributed in 2021, available only for designated education, research and practice networks. In the next years, the content of the book was presented to many universities, providing feedback on the content and confirming that the "solid, liquid, gas" metaphor - as expressed in the subtitle of this book - helped decision makers in their consideration about the future of their campuses. Eventually, the book is also peer-reviewed and officially published in 2025 by TU Delft OPEN Publishing (see Colophon).

Metaphors from physics and a multidisciplinary approach
The campus of the future is a combination of solid, liquid and gas. This metaphor from physics refers to three states of matter (see definitions in text box), resembling the traditional, network and virtual university. This is not the only reference to natural sciences and technology in this book, which shows that I am equally fond of words, images, figures and equations. My approach to campus management, connecting many scientific disciplines, also reflects my broad interest in academia.

Reading guide
While I merge theory and practice in this book, part A of the book introduces the scientific field "public real estate" with definitions and frameworks for decision makers. Part B goes back 25 years to describe the gradual changes on campus. This launches three campus models - solid, liquid and gas - and identifies common strategies, various themes and management challenges from organisational, functional, financial and environmental perspectives. Part C summarizes the research mission with examples of (past) research projects.

Target audience
This book aims at reaching different kinds of stakeholders – policy makers, users, controllers, engineers, designers and other decision makers – by taking (and combining) their perspectives, speaking their language and engaging them all in collectively shaping the campus of the future. While I focus on campuses, the future models and themes in this book are also recognised by other (public) organisations, which I may conclude after many presentations to audiences beyond the higher education sector in the past years. Based on that, I am confident that this book is not only interesting for campus decision makers, but for all who own, manage or use public real estate.

Alexandra den Heijer

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Hofvijver, The Hague (photo Rob Van Der Meijden, Pixabay)

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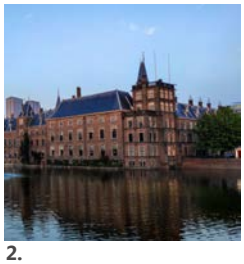
Part A – INTRODUCTION – the campus as PUBLIC REAL ESTATE

"My mission is to support universities and other organisations decisions about (managing) their public real estate portfolios, resulting in (more) inspiring, meaningful, functional, affordable, resource-efficient and sustainable built environments."

This book is not only about the future of (managing) the university campus, which has been my specialisation for decades. It is also about the future of (managing) public real estate in general. My inaugural speech was called "Campus matters", while the title of my chair is Public Real Estate. This requires explanation and that is what I will start with in this first part of the book.

What do these buildings have in common?


1.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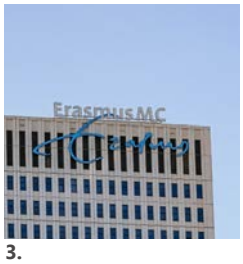


3.


4.


5.

6.


7.


8.


9.


10.

- ☐ they serve a public purpose
- ☐ they accommodate a public function
- ☐ they are funded with taxpayer's money
- ☐ they are publicly accessible

Figure 1: ten examples of public real estate – more background info about these buildings can be found in text box on the opposite page - definitions of "public real estate" tick at least two of these four boxes.

1. University building, Delft (photo AdH)

2. Binnenhof, The Hague (photo Rob Van Der Meijden, Pixabay, 2016)

3. Erasmus University Medical Center (Erasmus MC), Rotterdam (photo Micheile Henderson, Unsplash 2019)

4. Den Haag city hall, The Hague (photo ellibi, Pixabay 2015)

5. Ministry of Finance, Korte Voorhout 7, The Hague (photo AdH)

6. Police station, Rotterdam (photo AdH)

7. Mauritshuis Museum, The Hague (photo Edward Lich, Pixabay)

8. Van Gogh Museum, Amsterdam (photo Frans Ruiter, Unsplash 2020)

9. Marnix Gymnasium, Rotterdam (photo AdH)

10. Theater De Veste, Delft (photo Ruben Vos 2024)

Icons made by Mark van Huystee (these are repeated across the book)

Text box for figure 1 – data was initially collected in 2019 and updated where possible, is subject to change and is only provided to give an indication of the (extra-large) size, amount or accommodation challenge of public real estate projects.

The photos of figure 1 show:

1. TU Delft's high-rise, Delft – Referred to as "EWI" or "Elektro," this 1960s building (68.000 m^2) served the former Electrical Engineering faculty (now EEMCS) and is listed as municipal heritage (TU Delft).

2. Het Binnenhof, Den Haag – Owned by the Rijksvastgoedbedrijf (RVB), this 13th-century complex includes Parliament, the Council of State, and the Ministry of General Affairs. It spans 90.000 m^2, has 4.000 spaces and is undergoing a renovation which is expected to exceed €2 billion. (Rijksvastgoedbedrijf 2020, Rijkoverheid 2024, binnenhofrenovatie.nl).

3. Erasmus Medical Centre, Rotterdam – One of the largest Dutch hospitals, covering about 460.000 m^2, with more than 17.000 employees and about 4.000 students. In 2021, it had over 650.000 outpatient visitors and about 30.000 patients admitted (Erasmus MC).

4. City Hall, Den Haag – Designed by Richard Meier (1990-1995), this 130.000 m^2 building features a large atrium, and hosts municipal offices, the central library and retail spaces (Meier Partners).

5. Ministry of Finance, Den Haag – Renovated in 2007-2008, this 66.000 m^2 building provides workspace for 1.750 employees (Rijksvastgoedbedrijf).

6. Police headquarters, Rotterdam – Part of the Netherlands Police's portfolio of more than 800 buildings which covers 1,9 million m^2 and supports 60.000+ employees (Annual Report 2024, Politie.nl).

7. Mauritshuis, Den Haag – A 17th-century museum housing Dutch and Flemish Golden Age works. It is government-owned and listed among the top 100 heritage sites. They host almost 500.000 visitors every year (Mauritshuis.nl).

8. Van Gogh Museum, Amsterdam – The largest collection of Van Gogh's works, this complex spans about 15.000 m^2. It has over 1,8 million visitors per year (Van Gogh Museum).

9. Marnix Gymnasium, Rotterdam – This early 20th-century secondary school housed about 600 students and 70 staff members. They have been in the same building since 1927 (Marnix Gymnasium).

10. Theater de Veste, Delft – A 1990s theatre with 83.500 visitors in 2018 (De Veste).

NanoLab, University of Twente
(photo AdH)

Chapter A1
Defining public real estate (PRE)

Hospitals, schools, museums, theatres, police stations, city halls and university buildings are examples of "public real estate" (PRE). The photos in figure 1 show some characteristic buildings in the Netherlands, which represent different categories of public real estate. I chose the selection in figure 1 to point out both the quality and quantity of public real estate, in order to demonstrate their characteristics – their diversity, identity, use, size and history – and to introduce the definition of "public real estate" by answering the following question: "what do these buildings have in common"?

The common characteristics of the buildings in figure 1 will be used to compose the definition of public real estate (PRE). The results from this inductive approach (from object features to defining general features) will be complemented with a deductive approach, using definitions from literature.

The PRE examples in figure 1 – including the Dutch parliament buildings ("het Binnenhof"), famous museums and hospital buildings – have some common characteristics, which are summarized below. Not all buildings tick all the boxes (for the total floor area), but all of them tick at least three of the following boxes:

- **they serve a public purpose:**
  for instance: education, healthcare, public safety, welfare and culture; this refers to the general purpose of a building, not necessarily all floor area, but usually the majority of the building, which justifies the building being called a school, hospital or theatre;
- **they accommodate a public function:**
  which does not mean that 100% of the function is public – in many buildings space is leased to retail, parking, restaurants or (coffee) cafes or related businesses;
- **they are funded with taxpayers' money:**
  public resources are used for operation, utilization and maintenance of the building; this does not mean that this public funding covers the total costs of ownership (TCO), which is one of the most important PRE challenges;
- **they are publicly accessible:**
  which indicates that a substantial part of the building is open to the public, either restricted by certain opening hours, paying a fee (museums, theatres) or by temporal privileges of certain user groups, like in many university libraries, which are popular beyond the university community.

Figure 2: definitions of "public real estate" tick at least two of these four boxes.

Even more iconic examples of public real estate are prisons (officially referred to as penitentiary buildings), embassy buildings in other countries and the palaces of the Dutch royal family. It is clear that these PRE examples have a public purpose and are funded with public money, but are not publicly accessible. I will specify more characteristics and explore more definitions to refine my own definition of Public Real Estate.

Definitions Public Real Estate

Source (see reference list for publication titles)	Definition of public real estate (PRE) and/or public real estate management (PREM)	Characteristics PRE
Dewulf, Den Heijer, De Puy & Van der Schaaf (1999)	PREM: The optimisation of the composition of the stock by matching supply and demand, taking into account general government policy, the user's primary process and the costs involved in the solution.	■ serving a public purpose □ accommodates a public function ■ funded with taxpayers' money □ publicly accessible ■ owned by a (semi) public authority
Van der Schaaf (2002)	"Public Real Estate Management is the management of a government's real estate portfolio by aligning the portfolio and services to (1) the needs of the users, (2) the financial policy set by the Treasury and (3) the political goals that government wants to achieve." Note: focus on government buildings.	■ serving a public purpose □ accommodates a public function ■ funded with taxpayers' money □ publicly accessible ■ owned by a (semi) public authority
Evers, Van der Schaaf & Dewulf (2002)	Public real estate (PRE) is a facility that supports the core business of the government. However, managers of public-building portfolios have to pay attention not only to the wishes and needs of users (...) but also to creating, by means of that public real estate, a high-quality built environment. (...) In striving to create sustainable, high-quality environments, the least that governments can do is to set a good example by guaranteeing the quality of their own property.	■ serving a public purpose □ accommodates a public function □ funded with taxpayers' money □ publicly accessible ■ owned by a (semi) public authority
Lind & Lindqvist (2005)	At this time the government owned almost all properties used by government authorities, both special-purpose buildings, such as prisons or universities, and general office buildings.	□ serving a public purpose ■ accommodates a public function □ funded with taxpayers' money □ publicly accessible ■ owned by a (semi) public authority
Teuben, Waldmann & Hordijk (2007)	(about public real estate:) "This type of real estate is not so much market-oriented but more based upon its use for society."	■ serving a public purpose ■ accommodates a public function □ funded with taxpayers' money □ publicly accessible □ owned by a (semi) public authority
BBN Adviseurs (2011) retrieved from "bouwstenen-voorsociaal.nl"	"For the purposes of this study, public real estate (or "communal real estate") is meant as the housing 1. of all services that are, in whole or in part, publicly financed. It concerns real estate for schools, child-care, culture, sports, care, welfare and other social services, including those of the police, fire brigade, municipality and province."	□ serving a public purpose ■ accommodates a public function ■ funded with taxpayers'W money □ publicly accessible □ owned by a (semi) public authority
Jager & Naus (2012)	Nationally, approximately two-thirds of the amount of communal (or public) real estate is not owned by governments but by private parties. The stock of public real estate in the Netherlands represents a value of 157 billion euros.	□ serving a public purpose □ accommodates a public function □ funded with taxpayers' money □ publicly accessible ■ owned by a (semi) public authority
Leent (2012)	Public real estate is first and foremost real estate with a public function. The public manifests itself as a visitor, student, client, volunteer, student, participant, entrepreneur, and so on. But the public is also a citizen. However, the term public-private partnership refers to the government.	□ serving a public purpose ■ accommodates a public function □ funded with taxpayers' money ■ publicly accessible □ owned by a (semi) public authority

Source (see reference list for publication titles)	Definition of public real estate (PRE) and/or public real estate management (PREM)	Characteristics PRE
Hermans (2014)	Characterisation of public works: When it comes to public works, we initially think of infrastructure: roads, viaducts, bridges, canals, sluices, dikes and railways. But it also includes 'communal real estate' – property used by the public sector itself. Consider, for example, offices for ministries, municipalities and county councils, but also hospitals, schools, palaces, prisons, universities, and so forth. And – certainly not of the least significance – houses in the social sector, public housing.	☐ serving a public purpose ■ accommodates a public function ☐ funded with taxpayers' money ■ publicly accessible ☐ owned by a (semi) public authority
de Moel (2014)	"Public real estate is a collective term for buildings with a function in the field of education, sport, culture, welfare, social care and/or (medical) care. Examples of public real estate include schools, community centres, refugee centres, sport facilities, churches, cultural centres, libraries and other facilities with social function. There are different definitions of public real estate. For some, PRE means a building with a public function, financed by public funds (tax money). For others, PRE is defined as a commercial real estate with an additional value for society."	■ serving a public purpose ■ accommodates a public function ■ funded with taxpayers' money ☐ publicly accessible ☐ owned by a (semi) public authority
Veuger (2014)	The specific characteristic of public real estate relates to (a) a building-related communal social activity and (b) meeting and facilitating the need of stakeholders from a recognised societal interest.	■ serving a public purpose ■ accommodates a public function ☐ funded with taxpayers' money ☐ publicly accessible ☐ owned by a (semi) public authority
Planbureau voor de Leefomgeving / PBL (2017)	"the term public real estate is intended to distinguish a certain collection of buildings from commercial real estate (offices, shops, business premises) and residential property. This study opted for a definition of public real estate based on the use, the service that takes place there."	☐ serving a public purpose ■ accommodates a public function ☐ funded with taxpayers' money ☐ publicly accessible ☐ owned by a (semi) public authority
Prins, Zuidema, Tillema (2017)	The basis is formed by four user functions from the Basic Buildings Administration (BAG). All buildings that have a community, education, care or sports function in the BAG are regarded as real estate with a public function.	☐ serving a public purpose ■ accommodates a public function ☐ funded with taxpayers' money ☐ publicly accessible ☐ owned by a (semi) public authority

Table 1: an overview of definitions and characteristics of public real estate (PRE) and/or public real estate management (PREM), translated into English when only available in Dutch.

Public ownership versus public use

The basis is formed by four user functions from the Basic Buildings Administration (BAG). All buildings that have a community, education, care or sports function in the BAG are regarded as real estate with a public function.

Some definitions of "public real estate" mention public ownership as the main criterion (see table 1 on previous pages). The buildings of figure 1 – and public buildings in general – are not necessarily owned by the national, regional or municipal government; they can also be owned by not-for-profit organisations such as universities, hospitals and museums or even by private organisations that lease them to public or not-for-profit organisations. According to some definitions, privately-owned buildings for public purposes are not "public real estate". Other sources consider "public use" the most important criterion (PBL 2017), which is also the position of my chair of Public Real Estate.

Concluding from table 1, public purpose and public function are by far the most important criteria to define "public real estate". Fewer definitions explicitly mention public ownership and public funding. Of all criteria, public accessibility is least mentioned. My own definition will follow later.

Broad versus narrow interpretations of public

According to broad definitions – in Dutch "maatschappelijk vastgoed", literally translated as societal or social real estate – social housing is also considered public real estate, which adds a considerable number of buildings to the portfolio. While social housing represents such a large portfolio, a different set of stakeholders and a different system of legislation and subsidies, my chair's definition of "Public Real Estate" does not include social housing. Various other chairs at TU Delft – even in the same department – focus on managing social housing or housing portfolios. My chair Public Real Estate focuses on non-residential, public buildings.

Due to their professional background or focus of their (PhD) studies, other authors of public real estate literature have focused their definitions on government buildings (Van der Schaaf 2002; Evers et al. 2002), even though they acknowledge that the public sector includes many more sectors. The term "public sector real estate" (White 2011) is also used for publicly owned, publicly managed and publicly leased real property assets; "public estate" for government-owned property. However, the broadest interpretation of "public" is "with an added value for society", which could also be applicable to commercial buildings that stimulate local employment or social cohesion. A very different definition for public real estate – referring to listed real estate – can be found on the website of the European Public Real Estate Association (EPRA 2021).

My chair focuses on (managing) portfolios of buildings for public purposes, with public functions and (partly) funded with public resources. Within this scope, I include land properties, but only in combination with a portfolio of buildings. I will not focus on "public space" as such and always assess a public building in the context of a larger portfolio.

Assessing buildings as part of portfolios

Every building is part of different portfolios from which it can be assessed. Portfolios can be defined by at least one common characteristic: location, owner, function type, construction period, heritage status, size etc. Each of these portfolios can be relevant to (public) real estate decisions. Often, they play a role in comparing both problems and solutions. This is illustrated for three types of portfolios (see figure 3): buildings on the same location, buildings with the same function and buildings from the same owner.

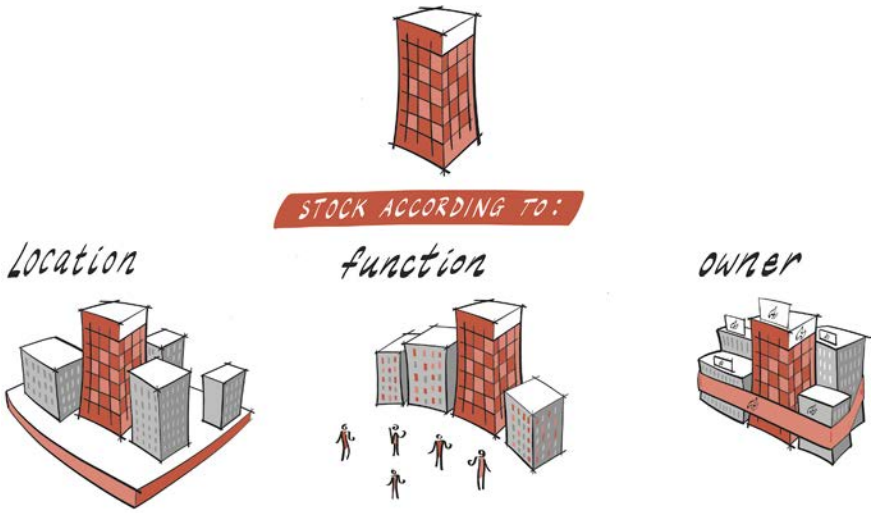


Figure 3: each (public) building is part of different types of portfolios – for instance: same location, same function and same owner – the latter is most important from the chair of Public Real Estate, while other types of portfolios are also considered in decisions. (Illustrations Mark van Huystee 2020)

For the chair of Public Real Estate, assessing a building as part of the portfolio of the same owner is most relevant. An example: when deciding about the future of a hospital building, it is necessary to include other buildings of that same hospital organisation in PRE decision-making. Can the shortage of space be solved in other buildings? All government buildings and all buildings of Leiden University are examples of portfolios of the same owner. Next to finding solutions for a single building, making a strategy for the whole portfolio is also an important task for public real estate managers: how do we match our portfolio of buildings with the changing organisation?

Figure 3a: for the chair of public real estate (PRE), assessing a public building as part of the portfolio of the same owner (and/or user) is most relevant. (Illustrations Mark van Huystee 2020)

Portfolios of buildings with the same function (all laboratories, schools or police stations) and at the same location (neighbourhood, city or region) are also relevant for PRE decision-making. For example: can a laboratory be combined with another one in the same area to have a higher budget for more quality of space? Studying both the local real estate market and trend reports about certain function types – for instance about future of offices, housing or retail – is an important task for public real estate managers.

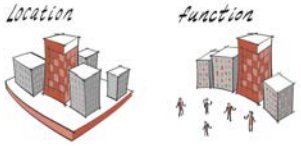


Figure 3b: in PRE decision making, (assessing portfolios with the same) function, location and other physical characteristics come next. (Illustrations Mark van Huystee 2020)

Taking the owners perspective in PRE often means taking the owner-occupier perspective: putting the portfolio that is both owned and used by a public organisation central in PRE decision-making. Assessing any public building from the owner-occupier perspective comes first, but in PRE analysis, assessing the same building's function, location and other physical characteristics is the next step, which connects the chair of PRE to other scientific disciplines at faculties of architecture.

The chair's PRE definition and perspective

In summary, my PRE definition is: "Public real estate encompasses building portfolios and land properties that serve a public purpose, that are (partly) funded with public resources – taxpayers' money – that accommodate a public function and/or are (partly) publicly accessible."

The chair of Public Real Estate takes the perspective of the owner-occupier of a PRE portfolio: the central government, the Netherlands police, universities and hospitals are examples. Often, PRE is owned by public organisations with substantial portfolios to manage. Both the large size of the portfolios and the complex management challenge are subjects of the next chapter.

TU Delft library
(photo AdH)

Aerial photo Faculty of Architecture and the Built Environment (photo Rob 't Hart for TU Delft 2009)

Chapter A2
Managing the impact of PRE

Looking again at the examples and the text box of figure 1, other characteristics of public real estate can be highlighted, which have to do with the impact they have on society, population, finance and environment. Since I was appointed in 2018 and was interviewed about my chair's focus, I have summarised these aspects in one short phrase "Public real estate is extra-large" or even shorter "PRE = XL".

Public real estate is extra-large (XL)

I will elaborate on this proposition, using the four icons again, which refer to (public) goals, euros, people and physical resources, including the environment.

"PRE has XL impact on cities"
PRE contains many iconic landmarks and heritage buildings; the buildings (a) are often located in densely-populated or densely-used areas and (b) are often listed buildings or considered by the public as buildings that characterise the city.

"PRE has XL impact on the identity of the organisations"
PRE reflects the organisations character and identity: many buildings are strongly associated with the organisations that have used them, either in the present or in the past – some buildings are still referred to with (nick)names of organisations that have already left/sold the buildings long ago (examples: "Former Post Office, Rotterdam", "American Embassy building, The Hague"). Consequently, public buildings with technical, environmental, functional or financial problems can also have a considerable negative effect on the identity and image of their users or the government in general. In analogy to the saying "don't judge the book by its cover", the public service can be judged by its building, with positive and negative consequences.

"PRE has XL impact on employees and regular users"
PRE is used by large numbers of people - many spend a considerable amount of time of their lives in them. That varies from millions of children in schools, hundred-thousands of students in buildings for higher education and tens of thousands of employees working at ministries or for the Netherlands Police.

"PRE has XL impact on the population"
Additionally, public buildings like libraries, hospitals, museums, city halls and theatres have XL numbers of visitors. Depending on their scale and regional or national function this ranges from ten-thousands to millions per year.

"PRE buildings are XL in size"
PRE buildings are among the largest buildings in each city – see also the top 10 buildings of Delft, Eindhoven and Groningen in the appendices – "PRE is extra-large in gross floor area", university faculty buildings are often fifty to hundred thousand m^2, ministries and hospitals exceed hundred thousand m^2. They match corporate headquarters in size, which are the only competitors for extra-large size for single-tenant buildings.

"PRE buildings are XL in environmental impact"
As a consequence of the extra-large size of both the individual buildings and the

the total portfolio, PRE buildings also have an XL impact on the environment. Consequently, implementing an energy-efficiency policy immediately affects a large portfolio and sets a good example for others.

"PRE buildings are XL in project and operating costs"
Also as a consequence of the extra-large size of public real estate in m^2, the land value of their locations, their intensive use and their impact on public identity, the financial impact of PRE buildings is also extra-large. The challenge to meet all public demands and at the same time to be resource-efficient with taxpayers' money, is the ultimate aim of public real estate managers, which they need support with.

"PRE buildings have an XL impact on the local/regional economy"
Related to the XL number of employees that public buildings accommodate, the location choices of public organisations affect the local employment. Additionally, the number of visitors museums, theatres and hospitals attract, also represent an economic value.

The impact of public real estate, as illustrated with some XL examples above, has multiple perspectives: (1) cultural/organisational, (2) social/functional, (3) economic/financial and (4) environmental/physical. These four perspectives align with the four icons that have been used in the PRE definition – and prior research – and will also be used in this publication. These perspectives can be identified on societal level (cultural, social, economic, environmental) and on institutional level (organisational, functional, financial and physical). They even align with individual needs: (1) identity & sense of belonging, (2) health & safety, (3) affordability and (4) sustainability and long-term security. These so-called "added values", which will be operationalised in chapter B3, when applied to the university campus . For each organisation, the potential "added values" can be expressed in (more or less) measurable indicators, which is illustrated in figure 4.

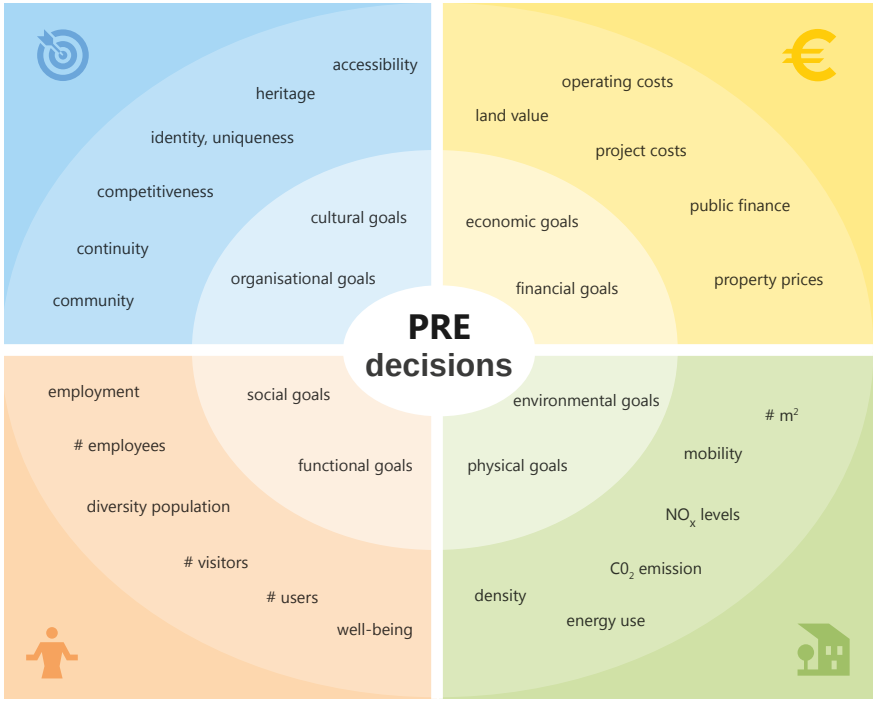


Figure 4: the multi-perspective impact of public real estate (PRE) decisions, on various goals, which can be expressed in (performance) indicators. (Den Heijer 2011, adapted from dissertation *Managing the university campus*)

Managing the university campus (Den Heijer 2011)

The impact of public real estate – as summarized in figure 4 – can be both negative and positive. For example, moving a hospital from the inner city to the outskirts of a city can have a negative impact on the accessibility of healthcare and on mobility for a large number of employees and patients, but a positive effect on the organisation's operating costs and its continuity for the future. The balance between these impacts should be carefully considered – and negotiated by a number of stakeholders – and is an important challenge for managers of public real estate. Consequently, this is the subject of (public) real estate management.

The multi-perspective impact of public real estate decisions

Managing public real estate aims at optimizing the added values from all four perspectives, contributing to goals on societal, (public) organisational and individual level. In the past 25 years this multi-stakeholder, multi-perspective and multivariable approach has become the scientific basis of our work, as public real estate researchers, including me. With that approach, we aimed to fill the scientific gap that was the result of relatively mono-disciplinary research until that point. To some extent, this was logical considering the complexity of this (real estate and facilities) management matter.

Figure 5: the cumulative levels of complexity in real estate management, in two variations: (on the left) from operational to strategic matters, (on the right) from supply-side to demand-side matters. (Den Heijer 2011, adapted from dissertation *Managing the university campus*)

Over time, as figure 5 demonstrates, complexity in real estate management increased, starting with considering only physical variables (the technical condition and quality of the floor area) and ending with taking into account a range of organisational goals (continuity, attracting talent, supporting identity etc.). Meanwhile, the functional goals (fitness for use, user satisfaction, well-being) and financial variables (budget, costs, property value) were added. Their order depended on the type of the organisation and its autonomy to decide about funding or user demands.

In general, many public organisations that were once fully dependent on the central government for funding, gradually moved their management scope from operational level to strategic level, while they became more financially and organisationally independent over the years. Figure 5 does not only apply to public real estate management (PREM), but also to other forms of real estate management (REM), like corporate real estate management (CREM). CREM is defined as "the management of a corporations' real estate portfolio by aligning the portfolio and services to the needs of the core business (processes), in order to obtain maximum added value for the business and to contribute optimally to the overall performance of the corporation (Dewulf et al. 2000, Krumm 2021).

Predominantly, private organisations with more financial incentives and pressure on scarce resources were initially more focused on the supply side, before gradually including the demand side to their set of key performance indicators (KPIs). Early corporate real estate management theory (Joroff et al. 1993) already demonstrated this in five cumulative development stages: "competency shifts" from taskmaster to controller, and ultimately to business strategist.

There are also similarities between the developments in both PREM and CREM and those in facilities management (FM): from operational to more strategic level, from technical or cost perspective to adding user, energy and organisational perspectives. In a comparison between CREM and FM, Van der Voordt (2017) describes "a change from the initial dominating focus on cost reduction in FM towards a stronger strategic focus on supporting the core business and to add value to the organisation".

FM is defined as the "Integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities." (EN15221-1: 2006 Facility Management, source: https://www. eurofm.org/about-fm/). Van der Voordt also emphases the growing complexity and mentions the increasing number of aspects that FM needs to take into account, including sustainability, Corporate Social Responsibility, user satisfaction, health and wellbeing and many other values (Van der Voordt 2017). Van der Voordt states that the common body of knowledge of FM and CREM may be used to improve both professions and disciplines and may result in a more integrated approach of Facilities and Real Estate Management (FREM).

In the next part of this book (part B), the cumulative levels of complexity are illustrated for decision-making about campuses, with more and more goals and conditions that matter. Our research for other public organisations (police, hospitals, ministries) has demonstrated that the four perspectives and levels of complexity are also recognised in decision-making processes for other public real estate portfolios.

The chair's four-perspective model and definition for real estate management

Over the years, as a basis for real estate management (REM), our research team has identified four main perspectives – organisational (blue), functional (orange), financial (yellow) and physical (green) with matching variables, stakeholders (see figure 6) and performance indicators (see table 2) – that need to be considered in every real estate decision. This is a result of observing decision-making in practice, interviewing public real estate managers (either campus managers or facilities managers at universities) and studying management theories (Den Heijer 2011). In figure 6 and 7 the four-perspective REM model is visualised. For more than ten years, the model can be recognised in our team's methods, databases and tools, in which we use the four colours and icons.

Figure 6: the four-perspective REM model connects demand and supply side (left-right) and strategic and operational level (top-bottom). (Den Heijer 2011, adapted from dissertation *Managing the university campus*)

Figure 7: the real estate management (REM) model with examples of performance criteria and values: "managing the built environment aims at balancing four perspectives in every decision", considering organisational, functional, financial and physical variables (Den Heijer 2011, adapted from dissertation *Managing the university campus*)

My chair's (P)REM definition: "(Public) Real Estate Management aims at adding value to performance by balancing organisational, financial, functional and physical perspectives, variables and performance criteria in every decision about building portfolios, matching supply and demand in time, connecting operational and strategic processes". Table 2 provides an overview of the elements of the four-perspective REM model.

icon	perspective	performance	variable	value	stakeholders
	organisational	continuity community identity, diversity	organisational goals	societal cultural	policy makers
	functional	functionality well-being productivity	users	user value	users
	financial	feasability accountability profitability	euros	property financial	controllers
	physical	sustainability quality circularity	footprint	environmental, architectural	engineers

Table 2: elements of the four-perspective REM model and examples of performance criteria (Den Heijer 2011, adapted from dissertation *Managing the university campus*).

The perspectives and their main variables are connected to a range of scientific disciplines (see part C1, figure 60). I did not specialise in any of them, but I became a specialist in connecting them, learning from decision makers and supporting them at the same time.

The chair's process framework for real estate management

The chair's definition for (public) real estate management not only contains the four-perspective approach - illustrated in the REM model - but also the phrase "matching supply and demand in time, connecting operational and strategic processes". The matching process between what the organisation and users need and what is available, sustainable and feasible is on-going: it happens both on a daily basis (in operational management) and for the long term (in strategic management). From employees searching for a meeting room to organisations designing a long-term portfolio strategy.

The process steps to match supply and demand, now and in the future, are illustrated in the REM process framework, also known as "DAS framework" (De Jonge et al. 2009), see figure 8. The abbreviation DAS stands for Designing an Accommodation Strategy, which highlights the process character of the framework and one of the purposes: strategy design. This framework distinguishes four process steps or management tasks: (1) assessing the current situation, (2) exploring changing demand, (3) generating future models and (4) defining projects to transform the current situation into the future. These steps often give structure to our research projects and were – for instance – the basis of both my dissertation (2011) and the Campus NL publication (2016).

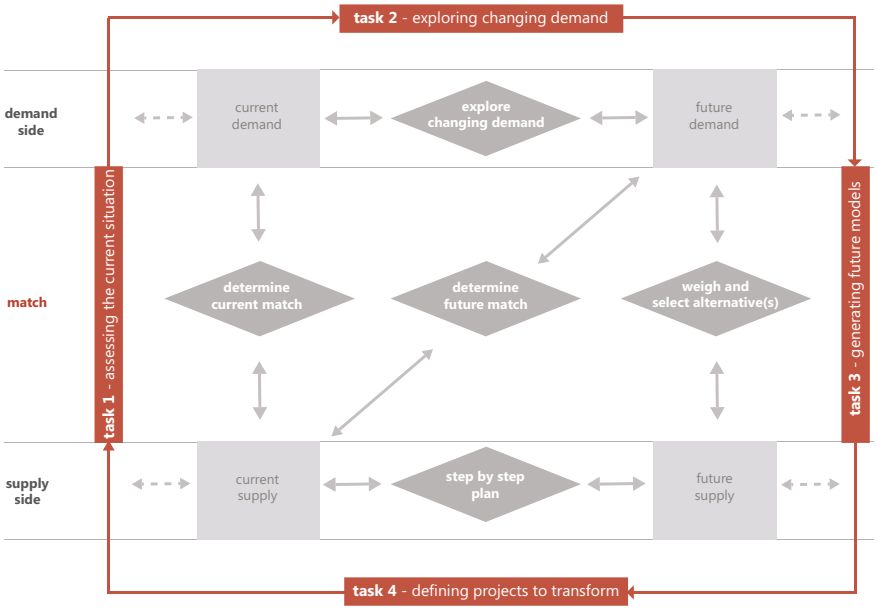


Figure 8: DAS framework, matching demand and supply, now and in the future (De Jonge et al. 2009, adapted:, a REM process framework with four management tasks.

Together, the first and second step determine the challenge, by (1) assessing the current situation and (2) exploring changing demand. What is the problem and will future demand ease or aggravate this? This can also be considered "the problem analysis". After that, the third and fourth step design the solution, by (3) generating future models and (4) defining project to transform the current situation into the future situation. This can also be considered the solution for the challenge or "the strategy to solve the problem". In this REM process framework, step 1 and step 2 determine the challenge and step 3 and step 4 design the solution, which is illustrated in figure 9.

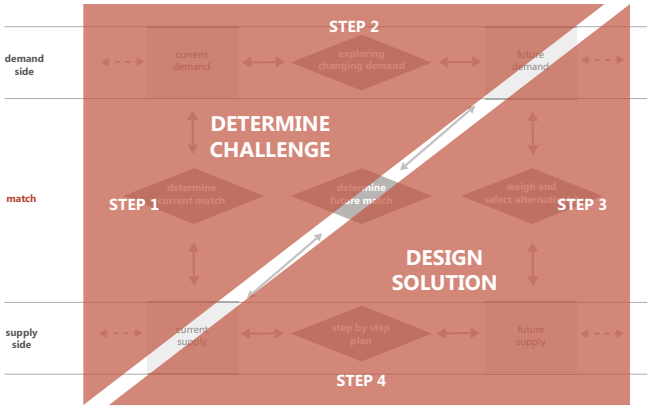
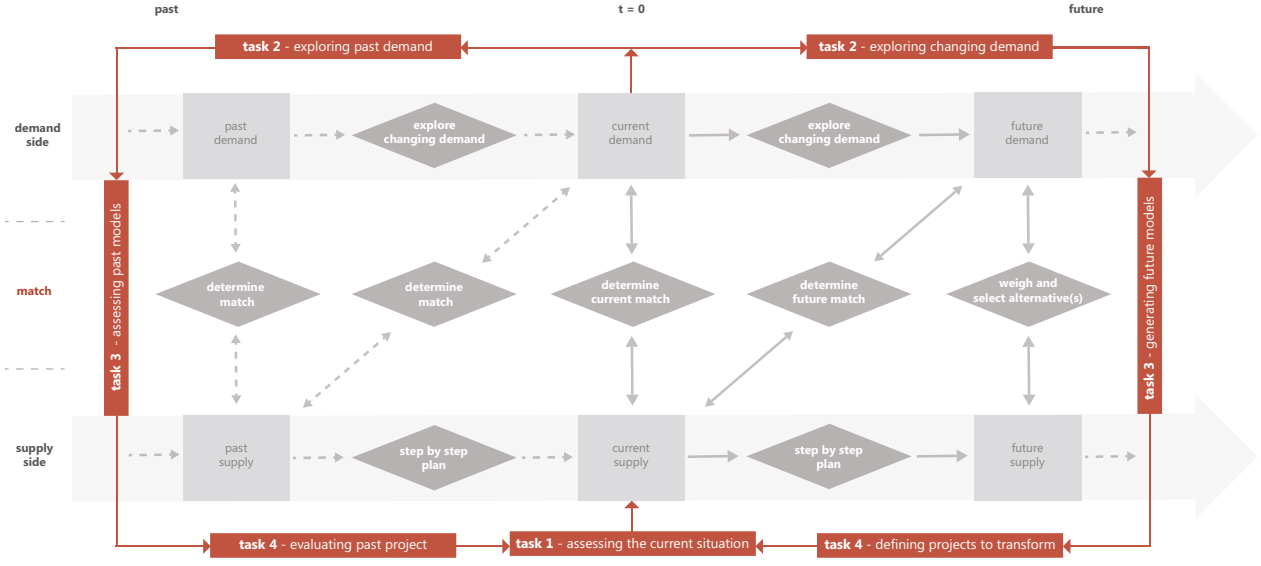


Figure 9: analyzing the REM process framework ("DAS framework"): together, step 1 and step 2 determine the challenge and step 3 and step 4 design the solution. (De Jonge et al. 2009, adapted).

The four-step REM process framework, which is aimed at the future in its default form, can also have a backward cycle that evaluates past decisions. In essence, the current match (step 1) is a result of changed demand (step 2, past to present) and the step-by-step plan of the past (step 4, past to present). This is illustrated in figure 10. This highlights the continuous process of matching supply and demand, which characterizes REM, since both demand and supply develop over time.

This expanded REM process framework not only looks ahead, but also looks back, adding four similar evaluation tasks to the four planning tasks: (step 1, past to present) compare current with past situation, (step 2, past to present) analyse past demand, (step 3, past to present) evaluate current models - that were once 'future' - and (step 4, past to present) evaluate past projects: lessons learned. In summary, planning for the future by (also) evaluating the past.

Figure 10: expanding the REM process framework (also known as "DAS framework") with a backward cycle, planning the future by learning from the past (Den Heijer 2011, adapted from dissertation *Managing the university campus*).



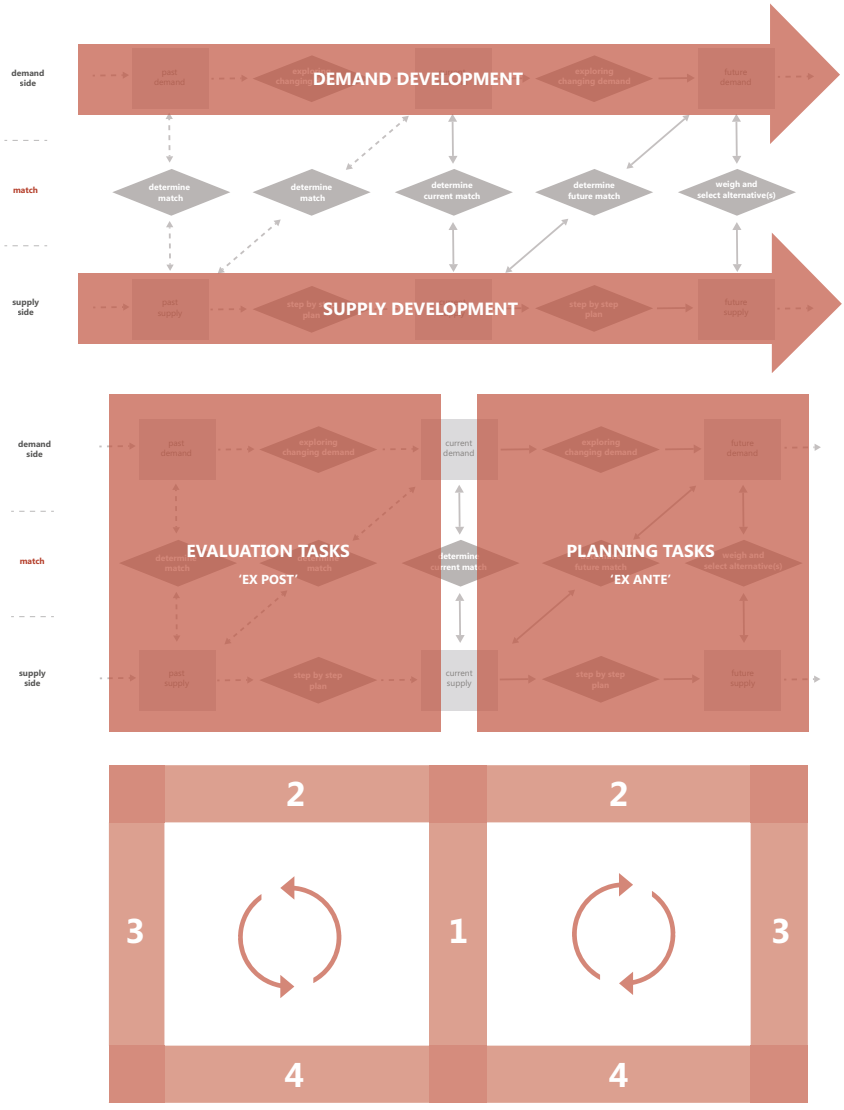


Figure 11 (a) contains the expanded REM process framework with demand and supply development from past to future. This highlights the continuous process of matching supply and demand that characterizes REM, since both demand and supply develop over time, also when supply is not actively changed by its owner, it ages over time and can have a different value which depends on the context.

Figure 11 (b) makes a division between an evaluation cycle ('ex post') and a planning cycle ('ex ante'). This adds four evaluation tasks to the four planning tasks, see table 3 for overview of tasks and a selection of their required methods and tools.

Figure 11 (c) shows the four evaluation steps and four planning steps in time. Two similar cycles are connected in the middle, the planning cycle turns clockwise, the evaluation cycle counter clockwise. Together, they evaluate the current situation as the result of the past (step 3, past to present) and assess it as the basis for the future (step 1, present to future). This approach corresponds to the content of part B of this book, in which I will

Figure 11: analyzing and expanding the REM process framework:
(a) expanding the framework: analysing demand and supply development, from past to future
(b) the evaluation cycle (looking back, learning from the past) and the planning cycle (looking ahead, planning for the future)
(c) the four evaluation steps and four planning steps in time: evaluating the current situation as the result of the past and assessing it as the basis for the future. The planning cycle turns clockwise, the evaluation cycle counter clockwise: (Den Heijer 2011, adapted from dissertation *Managing the university campus*).

describe campus developments of the past twenty-five years in order to design campus strategies for the future.

Over the years, our (campus) research team has developed methods and tools to support the four management steps, both forward (planning for the future) and backward (learning from the past), see table 3. Building portfolio databases with data about goals, users, euros and footprint (in line with the four-perspective REM model) to compare and benchmark the current situation (step 1), using scenario analysis to explore developments and trends in demand, including extrapolating from the past to future (step 2), applying serious gaming – changing roles for stakeholders in management games – to co-create future models (step 3) and filling project databases to learn lessons from the past and benchmark with innovative new projects (step 4). The project database can contain both new buildings, which experiment with new trends and refurbishments, which bring new life to old buildings. I refer to this type of database as "the sailboat", which can easily change course compared to "the containership", the metaphor I use for the portfolio database with data that shows more stable, long-term developments. Both databases are necessary to determine trends (see part C for examples of databases).

Table 3: four steps of the REM process framework (De Jonge et al. 2009, adapted), combined with the four-perspective REM model (Den Heijer 2011, adapted from dissertation *Managing the university campus*).

step #	step	evaluation tasks	planning tasks	methods and tools	required information
1	assessing the current situation	compare current with past situation	benchmark current with peers	portfolio database "the containership"	
2	exploring changing demand	analyse past demand	forecast future demand	scenario analysis	
3	generating future models	evaluate current models (which were once 'future')	compose future models based on strategic choices	serious gaming dashboard design co-creation	
4	defining projects to transform	evaluate past projects: lessons learned	benchmark with innovative projects	project database "the sailboat"	

Each of the four REM process framework steps requires information from each of the four perspectives of the REM model. Examples can be found in this book, in part B and C.

combined, the four-perspective REM model and four-step REM process framework provide structure for decision makers

Together, the REM process framework and the REM model not only provided structure for managers of public real estate, but also for researchers of public real estate. The number of variables in decision-making, increasing uncertainties in the context and extra-large impact on multiple stakeholders can easily be 'too complex to handle'. Like the managers of hospitals, university campuses and government buildings, who we supported in the past decades, I also needed this structure to write about (public) real estate management and campus management.

City library, Stuttgart
(photo AdH)

Chapter A3
TU Delft's legacy in PRE and campus research

Why not name your chair "public buildings"? Contrary to what my first photos may have indicated, I do not primarily focus on the buildings, but on the organisations that are deciding about these buildings. The term "real estate" refers to property and property relates to the owner of the building, which is often the leading decision maker.

Decision makers as our target group

PRE decision makers have been an important target group of our research from the start of TU Delft's department of Management in the Built Environment (MBE). The foundation of MBE in the early 1990s was supported by large public real estate owners, as well as corporate real estate management. The chair of Real Estate (in Dutch called "Vastgoedbeheer", and also named Real Estate Development & Management) was one of the founding chairs of MBE in 1991, next to Design & Construction Management ("Bouwmanagement") and Building Economics ("Bouweconomie"). In 1991, professor Hans de Jonge was appointed as the first Real Estate professor in Delft. From the start, this relatively new scientific discipline in the Faculty of Architecture has been user-centred, life-cycle focused and design-driven. This chair formed the basis of both Public Real Estate Management (PREM) and Corporate Real Estate Management (CREM), and later Urban Development Management (UDM, "Gebiedsontwikkeling"). The legacy of this chair was described in the book "Dear is durable" (edited by Arkesteijn et al. in 2016), which is also used as a reference throughout this book.

How can we support PRE decision makers, who are collectively responsible for an extra-large portfolio of buildings with extra-large impact on society, institutions and individuals, to make the best choices for a sustainable future and to spend taxpayers' money in a sensible way?

This question has been central and essential in PRE research over the years. As stated above, MBE has a legacy in PRE research - and real estate management (REM) research in general - and some prominent and note-worthy publications can be found in figure 12. They collectively explored theories, but applied them to different types of PRE.

Public real estate as a key research topic since the 1990s

After the foundation of MBE in the 1990s, the PRE publications from De Jonge, Dewulf, Evers and Van der Schaaf (first) focused on government buildings, because of our connections with the Government Real Estate Agency (in those days "Rijksgebouwendienst (Rgd)". I worked at Rijksgebouwendienst from 1996 to 1999. After that period, we wrote the book "Managing real estate, within a public organisation" (1999), which already distinguished the stakeholder, multi-perspective approach to PRE. Shortly after that, two prominent PRE books were published, with insights from science and practice (Van der Schaaf 2002, Evers et al. 2002). At the same time, De Vries and I focused on higher education (De Vries 2007, Den Heijer 2011), Van der Zwart on hospitals (2015) and Arkesteijn on museums (Arkesteijn et al. 2012) and municipal property, next to corporate real estate and higher education in a later stage (Arkesteijn 2019). Of course, this is just a selection of relevant publications, which formed the basis for this book.

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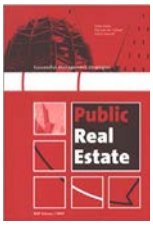

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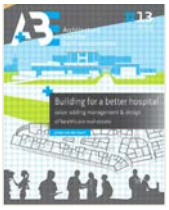

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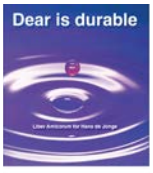


VII.

Figure 12: PRE publications of MBE researchers

I. Dewulf, G. P. R. M., Den Heijer, A. C., De Puy, L., & Van der Schaaf, P. (1999). Het managen van vastgoed binnen een publieke organisatie.

II. Evers, F. W. R., Van der Schaaf, P., & Dewulf, G. P. (2002). Public real estate: Successful management strategies.

III. Van der Schaaf, P. (2002). Public real estate management challenges for government: an international comparison of public real estate strategies.

IV. De Vries, J. (2007). Presteren door vastgoed, onderzoek naar de gevolgen van vastgoedingrepen voor de prestatie van hogescholen.

V. Van Der Zwart, J. (2015). Building for a better hospital: Value-adding management & design of healthcare real estate.

VI. Arkesteijn, M., De Jonge, H. (2012). Eigendom vastgoed rijksmusea; lessen voor een eventuele overdracht.

VII. Arkesteijn, M., van der Voordt, T., Remoy, H., & Chen, Y. (2016). Dear is Durable: Liber amicorum for Hans de Jonge.

Summarizing: public real estate is not (at all) a new field of study at the department of MBE, nor at TU Delft's Faculty of Architecture and the Built Environment. It has been there since the founding days of MBE, almost 30 years ago, in 1991.

And for those who think that I am now – after being appointed Professor of Public Real Estate – zooming out from specialisation "university campus" to public real estate, 1990s publications show that it is in fact the other way around. After starting my academic career in public real estate, I have gradually zoomed in on the university campus, which I will also do now.

From public real estate to campus matters

For more than twenty years I have been studying the university campus, even though the legacy of Public Real Estate even goes back further in time. At the beginning of the nineties, university buildings were still government-owned: every investment decision regarding university buildings needed to be assessed and approved by the government. In 1995, ownership of buildings and land was transferred to the universities, which gave them autonomy, but also made them responsible for managing millions of m^2 floor area – from libraries to laboratories, from lecture halls to offices. From that moment, universities frequently came to our (campus) research team for support and I was involved in generating management tools and information for all Dutch universities (see figure 13 for map).

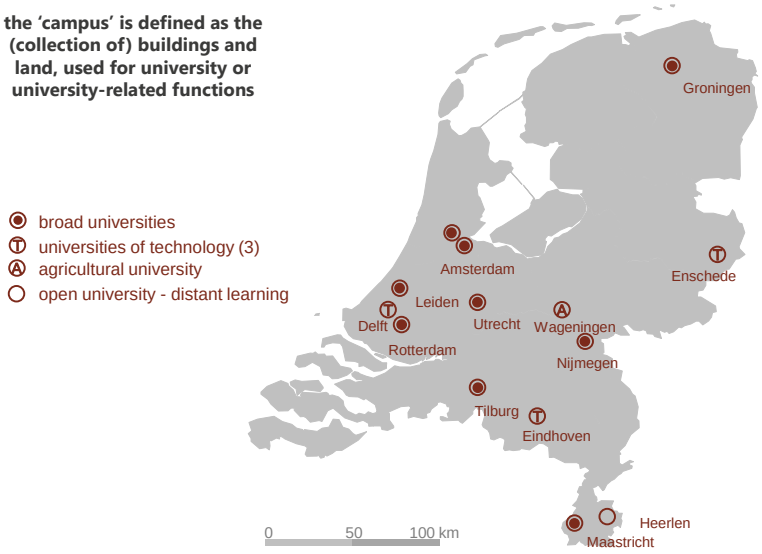
campus

noun (plural campuses)
the grounds and buildings of a university or college: the first year I had a room on campus.
North American the grounds of a school, hospital, or other institution.

origin
late 18th century (originally US): from Latin campus 'field' (see camp[1]).

source: Oxford Dictionary of English, Stevenson 2010

Figure 13: (including a textbox) focusing on the campus since 1999, building theory with Dutch universities (gradually, the focus shifted to campuses of European universities) (Den Heijer 2011, adapted from dissertation *Managing the university campus*)



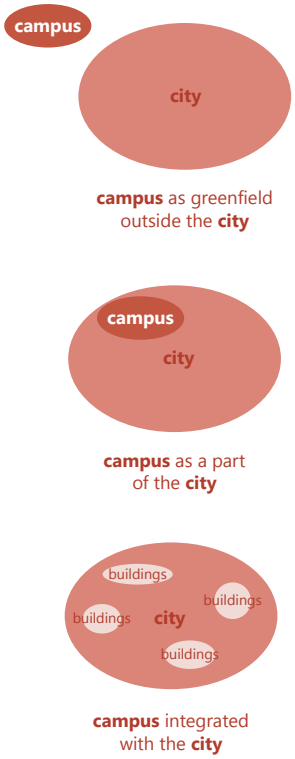


Figure 14: the definition of "campus" and three examples of spatial configurations of campuses. (Den Heijer 2011, adapted from dissertation *Managing the university campus*)

Since my dissertation (Den Heijer 2011) I have defined the campus as "the collection of buildings and land, used for university and university-related functions and not necessarily on one location". In figure 14, three spatial configurations of campuses are illustrated.

It is important to emphasize the following in this "campus" definition:

- the term "campus" is often associated with a collection of buildings on one location; my choice in 2011 to broaden this definition to "building and land on any location" was also context-related: many Dutch and other European universities are characterised by using buildings and land throughout the (inner) city and/or on various locations; they did not resemble the "greenfield outside the city" campus model, as illustrated as one of the three spatial configurations in figure 14, but were more like a combination of the other two models, in the city;

- defining the campus as more than (only) academic buildings was also the result of studying the development of "the campus as a city" – with housing, retail, cultural facilities and more - and "the city as a campus", welcoming students and employees to study, work and meet in buildings that are not owned by the university (see part B for more background information);

- in the definition, "use" and not "ownership" has been chosen as the main criterion; nonetheless, in the Dutch context, the majority of buildings that are predominantly used for university functions are also owned by the university (confirmed by recent studies like Campus NL, see figure 15); "managing the university campus" refers to the responsibility that universities have to manage the space that is used by students and employees for university purposes, regardless of its owner;

- in time, and certainly in times of corona, the broad "campus" definition could even include the homes of students and employees as "buildings used for university functions"; however, this could be confusing, while buildings that do not have

"university or university-related functions" as primary functions are often indicated as "off-campus" facilities that are "time-shared" for university functions for certain parts of the day, week, month or year; examples are churches that host diploma ceremonies and theatres that accommodate lectures

The term "campus" is also increasingly used for the areas of hospitals, schools and institutions. It is important to note that this usually does refer to "buildings on one location", so spatial configuration "greenfield outside the city" or "designated area, as part of the city". In the appendices, a map of the Netherlands is shown with many examples of "non-university campuses" such as medical campuses and business campuses.

In part B of this book, I will elaborate on the development of the "university campus" in the past 25 years and on current management challenges, which often also apply to other types of campuses and even (public) real estate portfolios in general. For those parts I lean on our findings from the past.

TU Delft's legacy in campus research

In the book "Dear is durable" (Arkesteijn et al. 2016), I look back on more than twenty years of campus research with the following statements, which I slightly edited for the purpose of this book (Den Heijer 2016):

- "Ever since (Public) Real Estate Management became a field of study in Delft, the campus has been an interesting object of study, with the TU Delft campus as the ultimate laboratory for TU Delft researchers."

- "Obviously, it was tempting to test early (public) real estate management theories in a built environment that the research team knew so well: the campus. At the same time, TU Delft board members and policy makers were more than happy that their own academic staff could support them in exploring strategies for their campus of the future."

- "Conveniently, the need for case studies to test public real estate management theory and Dutch universities needing advice and support in practice has led to the start of a successful collaboration between TU Delft's Campus Research Team and (public) real estate managers at universities since the mid-nineties, which is still active today."

- The main question was whether campus managers could learn from each other in the complicated process of managing their campuses. Between 2000 and 2007 a series of research projects was commissioned by the association of Dutch campus managers (HOI), leading to my PhD thesis and book "Managing the University Campus" (Den Heijer, 2011).

Figure 15 shows the covers of the books that were published since 2011, next to journal papers, book chapters and other publication types. In all projects of TU Delft's Campus Research Team, the objective has been to provide campus managers with information and tools to support decision-making on the campus. Conclusions from these publications will be used, either explicitly or implicitly, for the rest of this book.

The chair of Public Real Estate supports owner-occupiers in the built environment to achieve public goals. The research field connects both theories and practical references from other scientific disciplines in the built environment.

Figure 15: a selection of publications from TU Delft's Campus Research Team, which are sources for this book and which are open-source available on repository.tudelft.nl (TU Delft's repository), see part C and the appendices of this book for more info about these books.

I. Den Heijer, A. C. (2011). Managing the university campus. Information to support real estate decisions.

II. Den Heijer, A. C., & Tzovlas, G. E. (2014). The European campus - heritage and challenges. Delft: Delft University of Technology.

III. Den Heijer, A. C., Arkesteijn, M., de Jong, P., & de Bruyne, E. (2016). Campus NL: Investeren in de toekomst.

IV. Valks, B., Arkesteijn, M., den Heijer, A., & Vande Putte, H. (2016). Smart campus tools: Een verkenning bij Nederlandse universiteiten en lessen uit andere sectoren.

V. Valks, B., Arkesteijn, M., & den Heijer, A. (2018). Smart campus tools 2.0: An international comparison.

VI. Curvelo Magdaniel, F. T. J. (2017). Campuses, Cities and Innovation. 39 international cases accommodating tech-based research.

VII. Curvelo Magdaniel, F., den Heijer, A. C., & Arkesteijn, M. (2019). The European Campus: Management and Information.

VIII. Curvelo Magdaniel, F. (2016). Technology campuses and cities: A study on the relation between innovation and the built environment at the urban area level.

IX. Alghamdi, N. (2018). University Campuses in Saudi Arabia: Sustainability Challenges and Potential Solutions.

X. Arkesteijn, M. (2019). Corporate Real Estate alignment: a preference-based design and decision approach.

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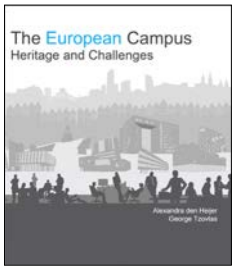

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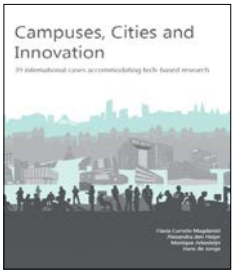

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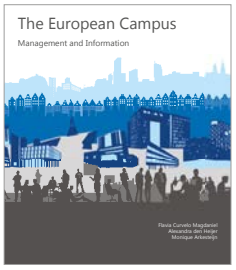

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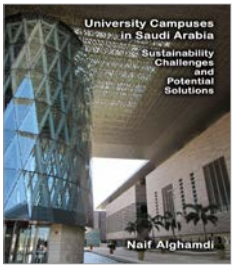

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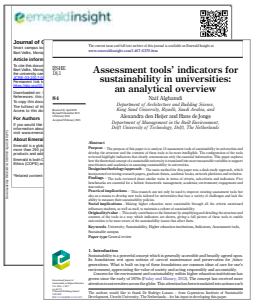


Staircase Architecture building
(photo Cheeseworks Fotografie/
Geert de Jong for TU Delft)

Part B

PAST, PRESENT & FUTURE CAMPUS

Part A – INTRODUCTION PUBLIC REAL ESTATE

A1 Defining PRE	A2 Managing the impact of PRE	A3 TU Delft's PRE legacy

Part B – PAST, PRESENT & FUTURE CAMPUS

B1 The campus matters	B2 Three physical states: solid, liquid & gas	B3 Management matters	B4 Strategies & themes

Part C – CAMPUS RESEARCH MATTERS

C1 Networks	C2 Theories & Methods	C3 Cases & Databases	C4 Tools & Dashboards

Part B – PAST, PRESENT & FUTURE of the CAMPUS

Even before the year 2020 was defined by the corona pandemic, "2020" marked 25 years of campus ownership for Dutch universities. This was a reason to (want to) describe what happened to the Dutch campus and campus management in the past twenty-five years, to observe patterns, identify trends, compare them with international findings and formulate common challenges for the future. This study is also based on TU Delft's campus research of the past 25 years. When I presented our (pre-corona) findings in my inaugural speech at the end of 2019, I named this new project "Campus 2020" in discussions with the association of Dutch universities, as a starting point for another round of data collection – document analysis, interviews and updates of campus data – that was planned in 2020.

Obviously, the year 2020 brought unprecedented challenges for universities all over the world and required emergency management, on campus and online. The corona crisis resulted in "campus lockdowns" all over the world. In the meantime, our Campus Research Team followed the online university media to observe trends. In the last months of 2020, when universities had more time to reflect on the long-term consequences of the pandemic, I scheduled interviews with campus managers of all thirteen Dutch universities, eventually talking to in total 30 campus managers about the present and the future campus. During these interviews, I asked universities to reflect and elaborate on the campus models and themes of 2015/2016, summarized in the book "Campus NL" (2016). The findings from these thirteen 2020/2021 interviews are added to this part of the book, building on the analysis that was presented in the inaugural speech. As a team, we will publish more result results, based on these interviews.

This part of the book contains the following parts:

B1 – The campus matters: a brief history

B2 – Three physical states of the changing university

B3 – Campus management matters

B4 – Campus strategies and themes

Aerial photo Wippolder 1919
(photo Nico Van der Kraaij)

Chapter B1
The campus matters: a brief history

"to matter"

verb [no object] 1 [usually with negative or in questions] be important or significant what did it matter to them? be influential or important

"The campus matters", it has meaning for various user groups that call it their academic home or visit it, it has added value for the organisation.

source: Oxford Dictionary of English, Stevenson 2010

"The campus matters": it has added value for the organisation and meaning for various user groups that call it their academic home or visit it. This phrase also is a proposition for campus management and campus management research: "if the campus did not matter, why would we invest in it or spend energy on it" or "what happens if we do not invest in it?". In my 2011 dissertation, I elaborate on this proposition in the preface: what happens if you ignore the campus, which university goals and user groups are affected and how? It was - and still is – one of my drivers to prove that the campus matters. That it justifies the invested financial resources and scarce energy resources, apart from the human resources that are spent on managing the campus. In the past 25 years, we discovered that the campus' added value is easier to prove 'negatively', when the physical campus is no longer available or accessible, after a fire that destroys a faculty building or during a world-wide corona crisis that has left the campus vacant and has moved the university online.

Looking back on more than three decades at the TU Delft campus

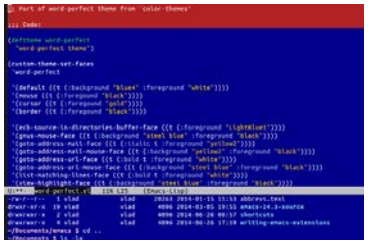
The moment I started studying the university campus aligns with the transfer of campus ownership to Dutch universities in 1995. So, when I started to prepare my inaugural speech in 2019, looking back 25 years seemed logical for a combination of reasons: I could summarize 25 years of campus trends, campus management and campus research.

And while twenty-five years is quite a long time in an academic career, it is "a brief history" in the long history of universities. This also counts for Dutch universities: the majority of them is more than hundred years old (see Den Heijer 2011, p64). At the end of 2019, the Dutch universities had been owners of their campus buildings and land for 25 years. Ownership had been transferred from the Dutch government to the universities from 1995 (Den Heijer 2011, p71). At that time, they cheered the autonomy of decision-making, but feared the lack of resources to finance backlog maintenance and investments in campus renewal. Back then, about two-thirds of the Dutch campus portfolio dated from the 1970s or earlier decades (Den Heijer 2011, p135). This meant that reinvestment was the main theme of campus strategies, which required amounts of financial resources that equalled new investments (Den Heijer 2002a, 2011).

In my inaugural speech, I illustrated the period of the past twenty-five years with the campus of TU Delft, my academic home since I arrived as a student in 1988. While every campus has a different story, similar trends can be identified. Since I have easy access to both data series and photos, as an employee of TU Delft, I have selected Delft's campus history as an example to illustrate Dutch and international trends, as described in Campus NL (2016) and European Campus (2014 and 2019) research.

Before looking at land property and the buildings of TU Delft in the mid-nineties, I like to remember working on a university campus in that period. The Internet was new, we just got TU Delft e-mail addresses, we wrote research reports using WordPerfect 5.1 or Word 6.0 and used transparencies when giving a presentation. For my graduation presentation in 1994, I used an innovative 'frame' to place on an overhead projector and show the audience the screen of my desktop computer. There was only one 'frame' available for the whole faculty. I had floppy disks as a back-up for my presentation and report, some the older and flexible 5,25-inch versions and most the 3,5-inch innovations that could contain 264 kB. All the sources of my research - books, reports and data - were physical

and needed physical storage space. The conclusion is that twenty-five years is a long time, if you observe the technological changes in education and research.



1.

2.

3.

4.

5.

6.

Figure 16:

1. Wordperfect 5.1 (photo Thomas Gehrlein / Syohei YOSHIDA)
2. photo of author (photo Sam Rentmeester for Delta 1996)
3. slide projector (photo Steve Morgan 2016)
4. desktop computer (photo Unsplash)
5. overhead projector (photo freebie. photography)
6. floppy disks (photo George Chernilevsky)

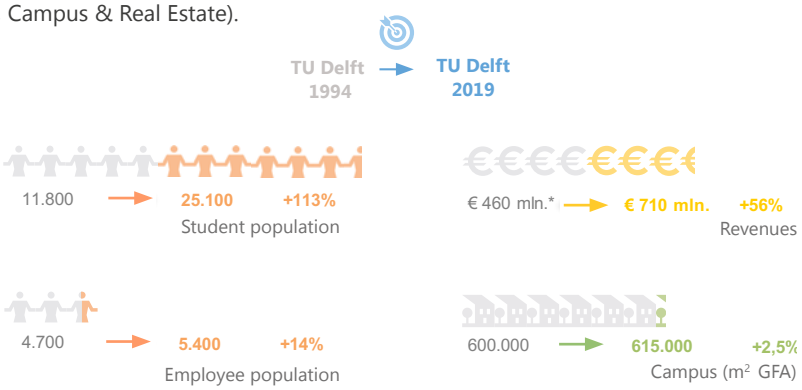
When I started working as a researcher, the TU Delft provided a desktop computer, a wired phone and a (flexible) name tag on the door. I shared my room with a professor and an associate professor. In the first decade, I have moved many times (in the same faculty building), because the department grew rapidly and everybody had to fit in. For facility managers this was a constant puzzle. In 2007, our research group was relocated to a large, flexible office, as an experiment in the faculty. However, we still had allocated desks, but we got laptop computers, which allowed us to be more flexible and work at home more often. That was the last office we had, until a fire destroyed the whole building in 2008. After the fire, we moved to a heritage building, designed in the 1910s, closer to Delft's city centre, in the north part of the campus. My workplace became flexible, with a mobile phone, laptop and Wi-Fi network around campus and at home, I could finish my dissertation at work and at home. Back then, in 2011, with the lessons of the fire, we already had a sneak preview of what was to come. Looking back now, most lessons are still relevant today. I will present them with the development of TU Delft's campus as an example.

TU Delft campus in the early 1990s, before the central library was added 'behind' the Aula and with the former Architecture building in the forefront (photo TU Delft).

The campus both changed and stayed the same

Looking at an aerial view of TU Delft's campus in the early 1990s, it can be perceived in two ways: it changed and stayed the same. With the exception of the Architecture building in the forefront, which went up in flames in 2008, the largest buildings are still there in 2021 and seem unaffected from an aerial view. Nonetheless, many of these buildings have been under construction or still are. Also, the landmark high-rise building, which reveals the location from TU Delft's campus from a long distance and is often used as an image for TU Delft in the media, plays an important role in the perception that the campus is predominantly the same as twenty-five years ago. However, another TU Delft landmark – the central library – is still missing in this photo. Since its construction in 1995, it has become an attraction on campus, both for campus users and visitors.

The analysis of campus data shows that the campus only increased 2,5% in size (net growth) in the period 1994-2019, comparing the gross floor area of buildings. Nonetheless, it is estimated that at least one-third of the total floor area (about 600.000 m2 in 1994) has been subject of substantial campus investments. About 160.000 m2 has been added to the campus – obtained or built new – and about the same volume has been disposed - sold or demolished – resulting in more or less the same campus size as twenty-five years ago. This is striking, considering the fact that the university more than doubled in terms of student population: +113% comparing 2019 to 1994. Additionally, the university enrols millions of students in online courses (source data: TU Delft, Campus & Real Estate).



Figue 17: TU Delft in 1994 and 2019: a comparison of student, employee, finance and campus data (source: TU Annual Annual report 1994, TU Delft Annual report 2018, TU Delft facts and figures, students October 2019).

The comparison of 2019 with 1994 data in figure 17 shows that even though the student population more than doubled in size (+113%), and the employee population increased as well (+14%), the finance situation also substantially changed, not just in budget (+56%, corrected for inflation), but also in types of funding flows and sources. Again, the floor area stays remarkably constant (+2,5%), which is an indication for increased campus efficiency and a compliment for campus management.

Is this situation exceptional for Delft? It is not, which was illustrated by our Campus NL (2016) data for all thirteen Dutch universities. That sector study looked back ten years and observed a 58% growth in student numbers with a relative constant employee population and campus size. Older research shows (Den Heijer 2002b, 2016 etc.) that the Dutch university campus has had roughly the same size since the 1990s: 4,4 million m^2 gross floor area.

Again, the perception could be "not much has changed", but the campus considerably changed. What did change then? The short answer is: the use of space. In fact, the utilization of all resources – human, energy, land and buildings – to support the university's goals has substantially changed.

The functional change of the campus: from only academic space to city functions

The year-by-year development of the TU Delft campus (see figure 18 with two maps of 1994 and 2019) illustrates that universities started with predominantly academic space in the mid-nineties, when they became campus owners. Gradually over the years, more functions were added, not only for a larger community, but also because the city developed and enclosed the campus. This put pressure on campus land and infrastructure. Following the changes in research funding and the Bachelor-Master system, increasingly more research institutes and universities of applied sciences ('hogescholen') were accommodated on or near university campuses. In Delft, the number of start-ups increased rapidly, facilitating many entrepreneurial students, alumni and other small businesses on campus (YES!Delft). Our European research shows that especially the campuses of universities of technology show similar trends (Curvelo Magdaniel et al. 2017). The world-wide rise of science parks, technology parks and innovation districts in the past decades confirms this.

Mekelpark TU Delft Campus (photo Food&More TU Delft 2019)

campus development in 25 years

1994

600.000 m² campus
Academic
Related Business
TNO, RWS, Radex
Residential
528 student housing units

2019 (compared to 1994)

615.000 m² campus (+2.5%)
Academic
investment in **62% (368.000 m²)**
disposal of **27% (164.000 m²)**
Related Business
TNO, Deltares, Radex (same in 1994) + YES!Delft, Haagse Hogeschool, Inholland, TDG, 3M, Exact, Applikon, Holland PTC and more
Residential
3.228 student housing (**+511%**)
Retail and leisure: many more (and more diverse) restaurants, sports and cultural facilities
Infrastructure: many more public transport connections

Figure 18: two TU Delft campus maps, from 1994 and 2019, which illustrate the functional change of the campus in 25 years: from predominantly academic to multifunctional (more housing, retail & leisure, businesses, infra).(Maps made by TU Delft students October 2019, data retrieved from TU Delft Annual report 2018, TU Delft facts and figures)

At the same time, the internationalisation of education (in English) and the resulting international student mobility, also encouraged by the Bachelor-Master system, had a large effect on student numbers. Some countries and universities attracted many, others observed a 'brain drain'. World-wide rankings of universities played an important role in the global competition for talent. For all, certainties in predicting student numbers by following local demographics disappeared and campus flexibility became a theme in many university strategies. On many campuses, the number of student housing units has risen steeply in the past twenty-five years: at least +500% in Delft. Of course, many universities also heavily leaned on their university cities in search of suitable housing options, in close collaboration with student housing associations and private investors. Short-stay options for university guests also became more and more in demand, while an increasing amount of the university population has temporary contracts or visits for one semester or less.

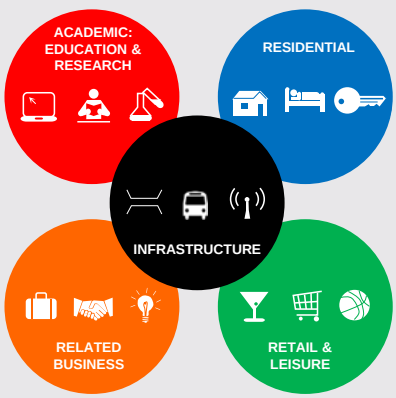
With a substantial amount of housing units on campus, the campus was increasingly used beyond working hours and required more leisure and retail functions. Gradually, facilities were added, ranging from more sports facilities to cultural functions and from espresso bars to different types of restaurants and food trucks to serve a multinational community. The supply has become more demand-driven and flexible: it follows the users and use patterns. Also, a diversity in opening hours allowed the campus community to work very early or late, to avoid rush hours on the road or in public transport, to support the flexible workforce and student population. New supermarket formulas and campus-specific shops were added to support the campus inhabitants, living in the 3200 student housing units (TU Delft data, 2019) on campus grounds.

Following the rising demand for other campus functions, infrastructure also became more important, certainly due to the rapidly growing student population and the pressure on public transport, campus accessibility, parking and cycle paths. In Delft, the removal of many parking spaces to create Mekelpark (open from 2009) moved the car mobility from the centre of the campus and added to the quality of campus life. Public space, "the in-between", became more important: circulation space between buildings and within buildings became more functional for informal activities (see BK city project findings in Den Heijer, 2017). While university land and buildings are publicly accessible, the use is predominantly university-related. Even related businesses and institutions experience a threshold to enter each other's buildings. Many have introduced public zones, sometimes as co-working space, but incentives lack for many user groups to actually use them.

The change of campus-city relations

Figure 19 summarizes thethe five main campus functions - see appendix for an overview of functions and how they can be divided over campus and city, as confirmed in interviews with Dutch universities in 2006, 2016 and 2020. The division of campus functions between campus, city, region and even countries is one of the strategic campus decisions (see Den Heijer and Curvelo Magdaniel 2018).

five main campus functions



academic
classrooms, library, offices, laboratories, lecture halls, ...

residential
student housing, hotels, ...

related business
start-ups, incubators, industry, ...

retail & leisure
sports, restaurants, cafes, ...

infrastructure

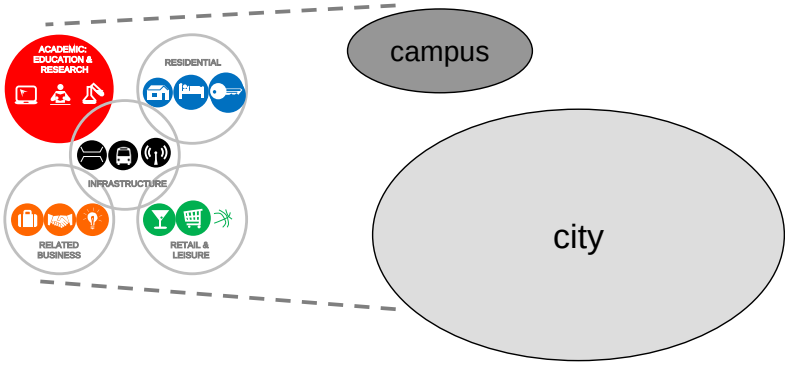
Figure 19: the functional definition of the campus: five main space functions (source: Chapman (2006), adapted by Den Heijer 2011)

In the past twenty-five years the relationship between the city and university campus has developed into a mutual-beneficial partnership – demographically, socio-economically, culturally and environmentally – even though their dependency and collective agenda is also reason for conflicts (Den Heijer et al. 2012). Locations of student housing, related businesses and accessibility are among the issues that need aligned spatial strategies. Figure 20 shows four contrasting future models that the university campus can strive for.

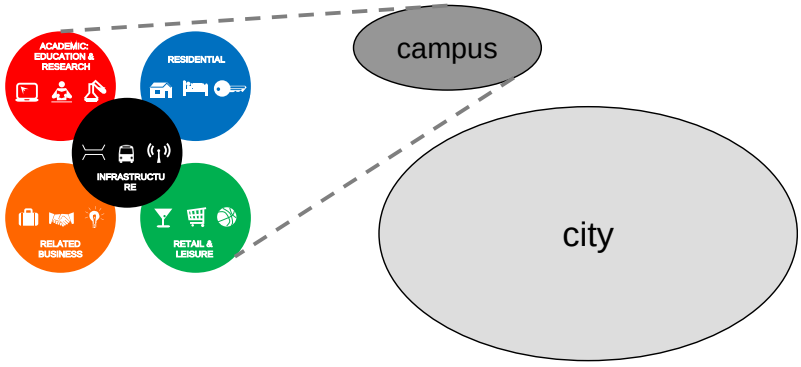
Figure 20: one past model and three future models for campus-city relations and the area that accommodates an increasingly multifunctional mix of campus functions. (source: Chapman (2006), adapted by Den Heijer 2011)

campus-city models

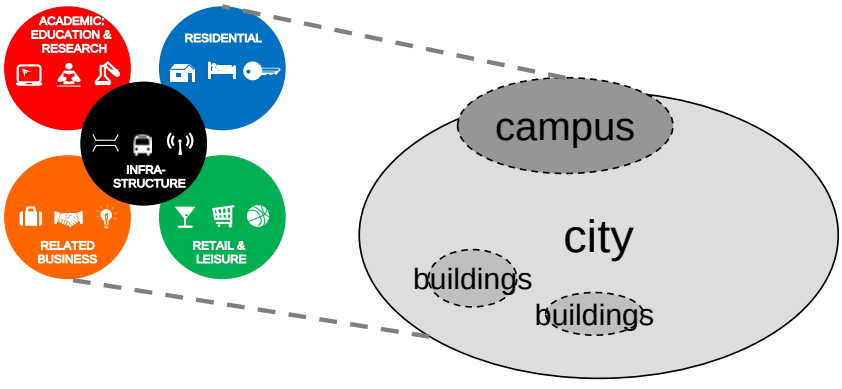
past campus-city model
the campus is predominantly academic space, other function smaller and mostly in city



future campus-city model A
"campus as city";
the campus competes with the city ("new town development")

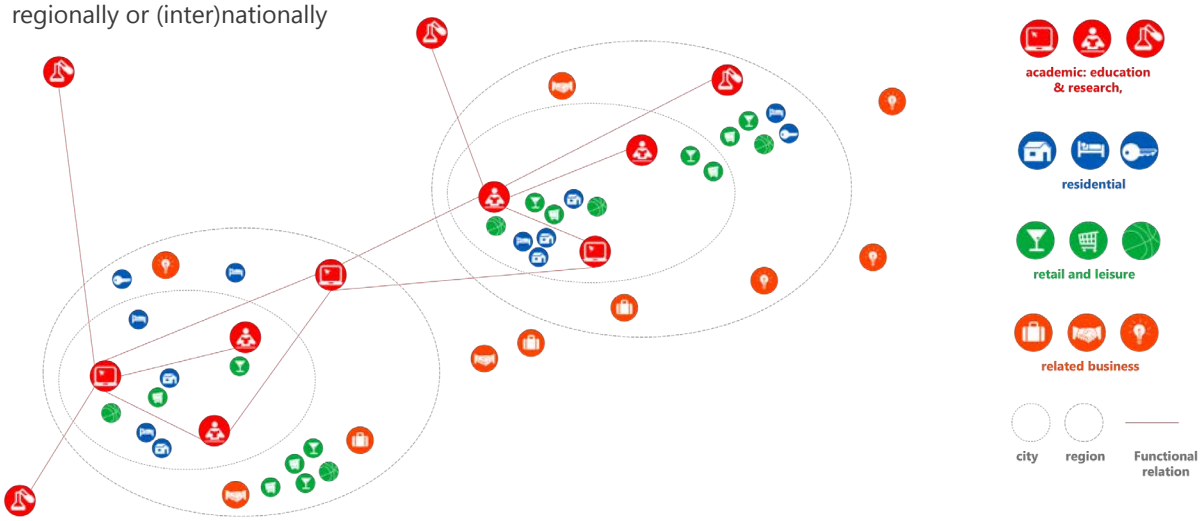


future campus-city model B
"city as campus";
shared functions on campus and in city ("univer-city")



future campus-city model C

"distributed campus";
regionally or (inter)nationally



The past model represents the campus of the past, predominantly academic functions on campus and a relative small amount (compared to the current situation) of supportive and related functions in the city. Model A represents a campus-city model that strives for a campus location for (almost) all its functions - student housing, retail and leisure, related businesses and all infrastructure that connects and supports them - creating "a campus as a city". Model B represents a campus-city model that considers the campus part of the city and the collective spatial area a "univer-city". Model C zooms out to the region or even a larger area, considering transnational laboratories and off-campus options for many campus functions: home workplaces, co-working space at other businesses, theatres as lecture halls, city libraries as study space, urban coffee bars for meetings.

The considerations to choose (a combination of) models A, B and C will be subject of the next sections. In section B2, these three models are defined and characterized as "traditional" (A), "network" (B) and "virtual" (C). These models describe the three physical states of the university and are compared with three states of matter: solid (A), liquid (B) and gas (C).

On the next two pages - as an intermezzo between two sections of this chapter - the terms "solid, liquid and gas" are introduced. Definitions from physics for these three main states of matter, their properties and transition processes (change of state) are seen as an analogy for "three physical states of the university", as also demonstrated in the subtitle of this book.

states of matter - defining “solid, liquid and gas”

the three main states of matter

Almost all substances can be categorised as solid, liquid, or gas – the three states of matter. Each state is represented by a specific symbol: (s) for solids, (l) for liquids, and (g) for gases. The kinetic theory of matter suggests that all substances are composed of very small particles (atoms, molecules, ions and electrons). These particles are arranged differently in each state, with distinct movements and energy levels. In many instances, matter transitions between states with relative ease. Common terms such as melting and condensation describe these processes and are part of everyday language. Simple models illustrating how particles are arranged and behave in solids, liquids, and gases can be useful for understanding what happens during a change of state.

Plasma can be considered as the fourth state of matter.

scientific explanation for “three states of matter” and “state of matter properties” (re-interpretation from secondary educational textbooks)

state of matter properties

solid

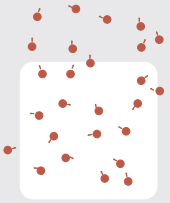
Solids retain their shape and have a fixed volume.

solid particles:
- Are in contact with each other, making solids incompressible.
- Are typically arranged in a regular, repeating pattern.
- Cannot move past one another but can only vibrate in place.

liquid

Liquids adapt to the shape of the container they are in.

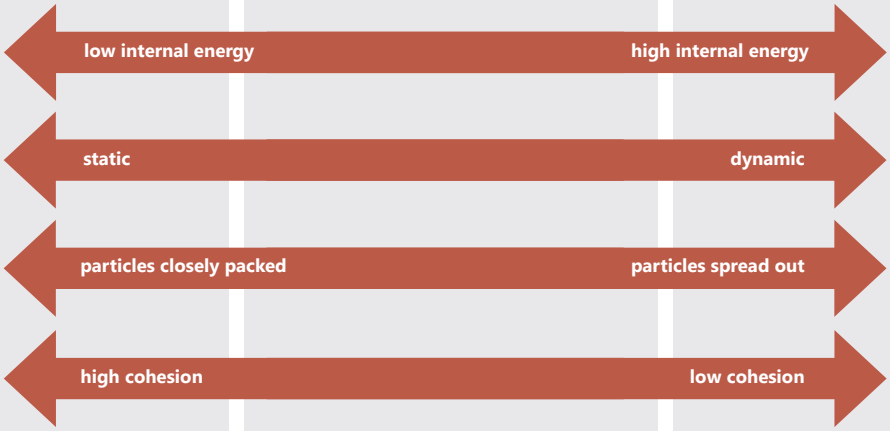
liquid particles:
- Are packed closely together, so liquids have a fixed volume and can only be compressed a little.
- Are arranged in a somewhat random pattern.
- Have restricted movement, shifting in all directions but within a limited range.



gas

Gases do not have a fixed shape or volume.

gas particles:
- Are spaced far apart, which allows gases to be compressed.
- Are arranged randomly.
- Can move freely in all directions, from one place to another.



changes in states of matter: phase transitions

The state of matter can change depending on pressure and temperature conditions. These changes are called phase transitions.

When heated, many solid substances undergo a change in state. They usually first transform into a liquid and then into a gas. However, some materials skip the liquid phase entirely and shift straight from solid to gas.

To understand what happens during melting, consider a solid being heated. Its atoms absorb energy, which enables them to break some of the bonds holding them tightly together. The structure becomes less orderly, and the atoms generally move further apart. They gain more freedom to move around within the material, and the solid transitions into a liquid.

As heating continues, the atoms in the liquid become increasingly disordered, move faster, and spread further apart. At the boiling point, they have sufficient energy to escape completely from their neighbours. Now widely separated and moving rapidly, the atoms form a gas.

Cooling reverses these changes. As a gas cools, its particles lose energy and slow down. With less energy, they can no longer separate after colliding, so they remain close together, forming a liquid. If the cooling persists, the liquid eventually solidifies.

scientific explanation for "changes in states of matter" (re-interpretation from secondary educational textbooks)

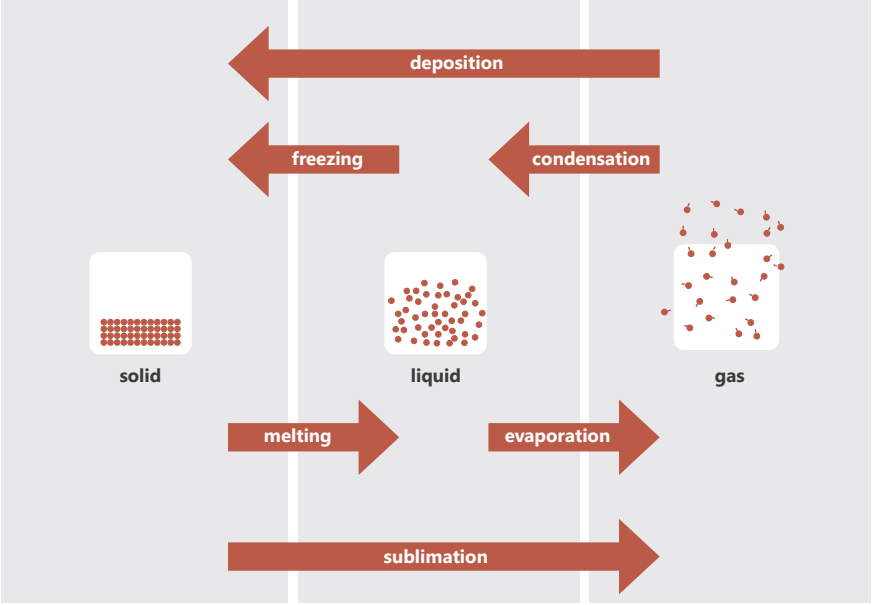


illustration for "changes in states of matter" (re-interpretation from secondary educational textbooks) by Ruben Vos 2020

three states of H_2O: ice (solid state), water (liquid state) and water vapor (gas state), illustrated by Mark van Huystee in 2020

KU Leuven (photo AdH)

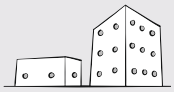
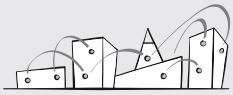
Chapter B2
Three physical states of the changing university

The changing campus reflects the changing university. Some of the developments in the past twenty-five years have already been mentioned briefly, like the rapidly increasing student numbers, internationalisation and funding changes. Many more developments we (members of the campus research team) described in publications about the Dutch and European campuses (Campus NL 2016; European Campus, 2014 and 2019), analysing literature, university documents and trend reports and identifying patterns, sketching scenarios and designing future models.

Over the years, I have summarized the transition of the university with three models, based on university and campus literature. In my 2011 dissertation, I referred to these models as (A) "traditional", (B) "network" and (C) "virtual". In my description, which has evolved in the past ten years, I have emphasised differences that have an effect on the physical setting and spatial characteristics. I will describe these models one-by-one, also referring to the physical states that I started to associate with each of these models from 2016: (A) "solid", (B) "liquid" and (C) "gas". How I got to this analogy, I will explain later. The definitions from physics can be found on the previous two pages. Below I will briefly introduce the three models, followed by more extensive descriptions.

Table 4: summary of three campus models; (A) "traditional", (B) "network" and (C) "virtual". (Den Heijer 2019, illustrations Mark van Huystee 2019)

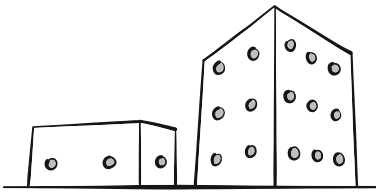
photos (L-R): King's College Chapel, Cambridge (Kirsten Drew / Unsplash 2020), TU Delft library (Blommaert 2010) and outdoor workspace (Bram Naus / Unsplash 2020)

model (A) - "solid"	model (B) - "liquid"	model (C) - "gas"
		
the traditional university and campus - represents fixed structures, hierarchy, exclusiveness and the need for territory	the network university and campus – represents flexible structures, multidisciplinary, open and interconnected, with shared space on campus	the virtual university and campus – represents individual autonomy, mobility, freedom and the possibility to work and study anytime and anywhere, online and off-campus
		

While there are examples of universities that resemble only one of these models, most universities nowadays are a composition of these three models: some more solid (traditional), some more liquid (network) and some more gas (virtual). Each of these three models have positive and negative aspects and influence university goals, finances, users and energy resources in different ways. These models have been used in a series of interviews with Dutch universities – in 2006, 2016 and 2020/2021 – to discuss strategic campus choices and their consequences for the future of the university, the well-being and productivity of users, the financial sustainability and the environmental impact and footprint. Findings from these interviews will be used in the following three sections about each of the three models.

King's College , Cambridge, UK (photo Kirsten Drew / Unsplash 2020)

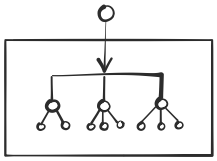
Model A – the traditional university and campus – SOLID matter

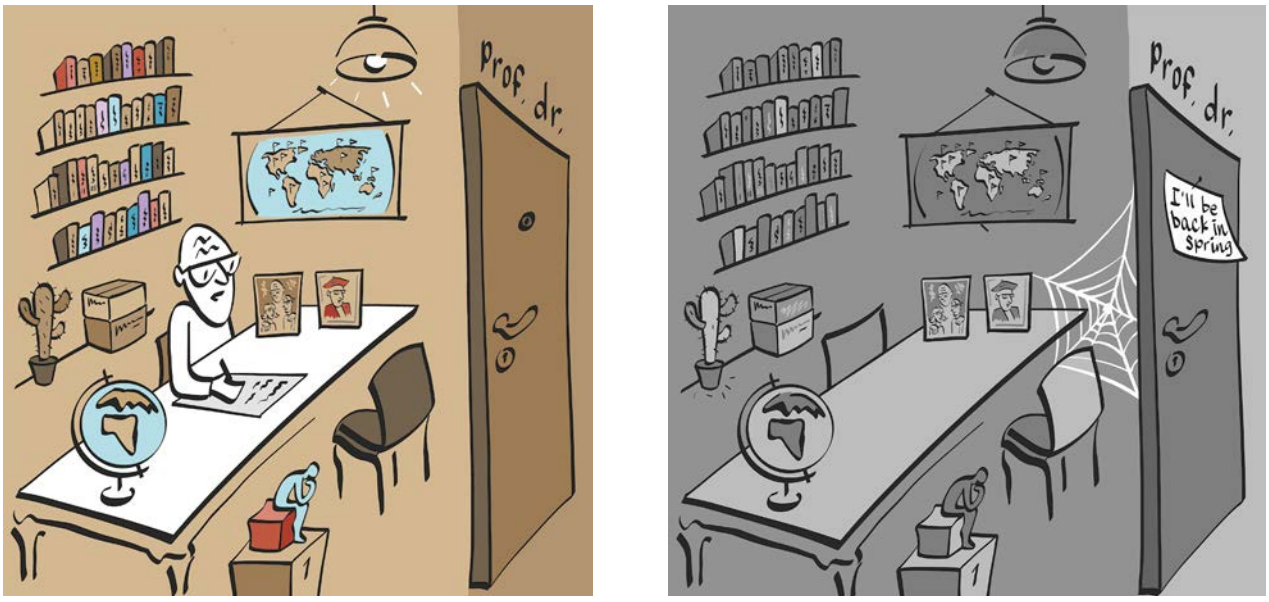


(Illustration Mark van Huystee 2019)

This traditional model represents the qualities of the university of the past, with top-down funding, mainly from the national government, and education and research in the national language. In the idealized version of this model, academic communities are relatively small and their members all know each other. Faculties, schools, colleges all have their own unique characteristics and separate buildings. They have their own libraries, restaurants and lecture halls, which they do not share with others. Employees and students have 9-to-5 schedules and daytime working hours on campus. Individual workplaces are located in cellular offices, classes have designated classrooms.

This model is associated with the "solid" state of matter, because it represents fixed structures, hierarchy, exclusiveness and the need for territory. In solid matter, mobility of molecules is low, they are positioned in regular patterns and their mutual relations are strong (strong cohesion). These molecules can refer to organisational units - such as faculties, colleges, schools – and also to individuals. More associations and characteristics can be found in table 5, summarized and assigned to organisational (goals), functional (use/users), physical/environmental (m2, energy) and financial (euros) aspects of the university. These associations have (potential) positive and negative impact – added value – for the university and are based on interviews with Dutch universities, workshops with other European universities and campus literature.

	positive associations campus model A	neutral associations campus model A	negative associations campus model A
goals	+ classical university, as it was in past centuries + celebrating traditions, legacy, past performance, 'wall of fame', professors' robes + preserve academic heritage, which contributes to the identity, reputation, status and ranking + uniqueness, strong brand + loyalty of employees, life-long commitment of alumni	• top-down organisation 	- gated, closed community, exclusion, elite, ivory tower - limited connectedness and knowledge exchange between communities (schools, faculties, colleges) - missed opportunities for interdisciplinary education, research, innovation - old-school, old-fashioned
user(s)	+ "my own office, meeting room, lab..." + home, territory , privacy + sense of belonging + pride, status, reputation: 'part of exclusive club' + 'members only' + small scale, academic family, "everybody knows you", strong relations + strong community sense, feeling at home on campus + supported individually, privileged	• one workplace	- "you cannot use my office, meeting room, lab..." - territoriality - different privileges - limited accessibility - inflexible for change - piles of paper on personal desks: no incentive to clean desk and threshold to share - low utilization rates - vacant facilities - less flexible for growth or changing demand
m^2, energy	+ more ownership and emotional attachment to place + higher tolerance for functional/technical defects	• faculty building	- large footprint per user (compared to other models) - resource-inefficient: vacant rooms heated, cooled, cleaned, maintained
euros	+ academic heritage is irreplaceable or has high replacement value: alternatives are not available or very expensive	• top-down funding	- higher total costs of ownership, caused by higher footprint, energy use and inflexibility for mutations



Figures A+/A-: "solid" model A illustrated, on the left with positive associations (exclusive, unique, personal, home, pride, private storage, status and privacy), on the right with negative associations (vacant, claimed but underutilized, books inaccessible, waste of resources) (Illustration Mark van Huystee 2020)

Table 5: associations with the traditional, solid model, based on interviews and workshops with European universities, and potential positive and negative added value for the university (Illustration Mark van Huystee 2020)

In figures A+/A- the "solid" model A is illustrated with an individual academic office, which is considered symbolic for the traditional university and campus by campus managers. On the left, the image highlights the positive associations with this academic working environment: exclusive, unique, personal, home, pride, private storage, status and privacy. On the right, the negative associations are emphasized: vacant, claimed but underutilized, books inaccessible, waste of resources. Private territory reflects the wish of many and the logistic, financial and sustainable challenge of campus managers.

The traditional model in a university context is positively associated with the academic history and foundations of the current universities: the classical university. Academic ceremonies, professors' robes and images of past rectors and deans emphasize the history of the university. This includes the visible pride of past performances on a "wall of fame", highlighting award-winning performances and academic achievements. Ideally, this pride is shown in areas that are most public – which receive most visitors – even though this traditional model has more private than public space by definition.

Many buildings are accessible for 'members only' or designated user groups. This could mean that keys have access to restricted zones, but also that some printers, coffee machines or meeting rooms are only are assigned to certain groups. An iconic old-school example is the faculty club, where only professors are welcome. By invitation only: hierarchy and status are important in this model. This is also expressed in the workplace: the higher your function, the larger your office.

In this model, time stood still in a positive and negative sense. Campus managers comment that the traditional model has high sentimental value, even for generations that have already left the university, provides a home for an academic community, is highly appreciated for its privacy, uniqueness and exclusiveness. This does not only apply to century-old heritage buildings, which are often also considered irreplaceable by the general public, but also to buildings from the 1960s and 1970s, which have proven their value by their solidness over the years, standing the test of time. Their robustness and reliability provided private workplaces for many, since buildings from these decades

The traditional model is associated with the academic history, professors' robes and ceremonies (photo from Dies Natalis, TU Delft 2009)

are abundant on university campuses, often forming the majority of floor area (data European Campus 2014, Campus NL 2016).

Ironically, the strong appreciation for these buildings has been a blessing for campus management over the years, in times of backlog maintenance and tight campus budgets. Users seem to be much more forgiving about technical and functional defects, when they fear the alternative of leaving their home base and being accommodated elsewhere. And the other way around: the expectations of new buildings are often so high that user satisfaction is lower after moving to new buildings. Of course, this is also influenced by new buildings often being more resource-efficient and flexible, designed for the network university of model B.

Campus managers also agree upon the fact that the tradition model has a high footprint and low utilization rates (high vacancy rate) and is energy-consuming. The territoriality, often cherished by the campus community, with cellular offices and user-specific facilities, has a high value and high price at the same time. Its inflexibility of change, which was inevitable when universities started growing and became more international, created a continuous logistic challenge. The rather static supply of space of the traditional model A became very difficult to match with the dynamics of network model B.

Small-scale university colleges, as new parts of existing universities, reinvented the traditional model A in the beginning of the twenty-first century. While the whole university was already gradually changing to model B, Dutch campus managers explicitly mentioned the revival of model A, encouraged by international guests that were drawn to Dutch universities because of their educational programmes in English and high ranks in world-wide rankings. They strongly reminded the Dutch universities of the value of the academic history, university ranking and brand.

Summarizing, the traditional, solid model is cherished for its community sense, 'own facilities' – from individual workplaces and faculty libraries – privacy, relatively small scale and academic heritage. But it is a challenge to find a balance between the advantages for the identity, productivity and well-being of users and the disadvantages for the university's budget and energy resources. Many (European and Dutch) universities claim that even if this would be their preferred university and campus model, they would

not be able to afford it or justify the resource-consuming effect on the environment. Nonetheless, they are searching for ways to keep the added value and save the (environmental) costs. More about these strategies can be found in the strategic campus choices.

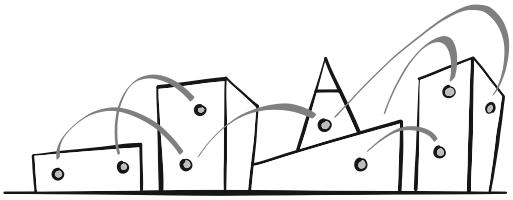
"the oldest student cafe of the Netherlands" in Franeker, Friesland (photo AdH)


just returned
just returned

TU Delft library (photo Blommaert for TU Delft 2010)

(Illustration Mark van Huystee 2019)

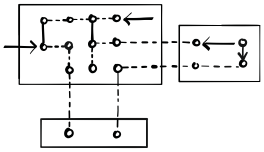
Model B – the network university and campus – LIQUID matter

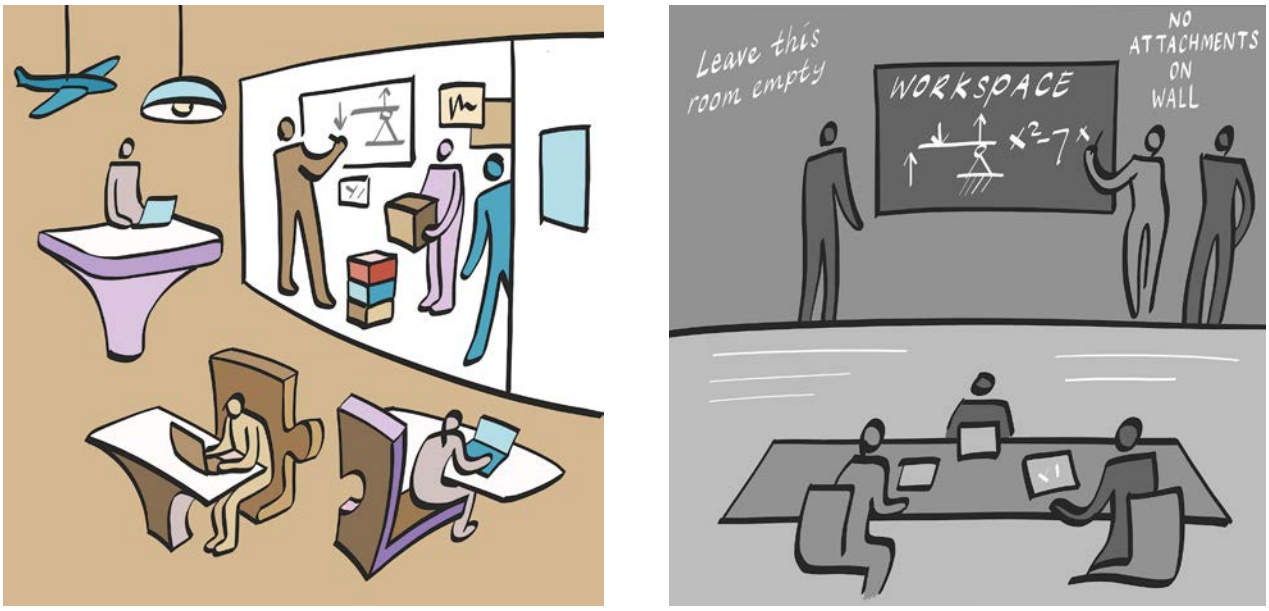


This network model represents the increased dynamics of the university community, more international, more interdisciplinary, more flexible, more mobile and more temporary. Gradually in the past twenty-five years, this applied to the student body, educational curricula, employee population, research programmes, research funding, university guests and university partnerships. Both figuratively and literally 'tearing down the walls' between faculties and schools also meant more shared facilities: central lecture halls, central libraries, shared restaurants and – by experiment – also shared workplaces, which is still sensitive matter at many universities nowadays.

The opportunities and openness of the network university also made many universities – and all Dutch universities - grow in size. Often, sharing was not a choice, but a necessity. Construction simply could not keep up with rapidly rising demand. This caused a culture change, which became common. So, the trend of sharing resources was not just caused by effectiveness (the need for interdisciplinary education & research) and efficiency (the ambition to become more sustainable), but also by urgency (limited budgets, no time to build new). This aligns with the saying "under pressure, everything becomes fluid". According to the physics definition "fluid (or liquid) is a substance that has no fixed shape and yields easily to external pressure' (see text boxes on pages 46-47 for more physics definitions). This analogy applies to the organisation and its units. This 'fluidity' also encouraged people to use 'the in-between' as functional space: circulation space like corridors and outdoor space between buildings is more and more used as an informal place to meet.

This model is associated with the "liquid" state of matter, because it represents flexible, fluid structures, multidisciplinary, open and interconnected, with shared space on campus. In liquid matter, molecules can freely move in a defined volume: the university or campus in this case. Compared to solid matter, their mutual relations have weakened, but they can mix with more different molecules (weaker cohesion than solid). These molecules can refer to organisational units - faculties, colleges, schools – and also to individuals. Liquidity as a term also refers to more easily available financial resources than when invested in solid assets. More associations and characteristics can be found in table 6, summarized and assigned to organisational (goals), functional (use/users), physical/environmental (m2, energy) and financial (euros) aspects of the university. These associations have (potential) positive and negative impact – added value – for the university and are based on interviews with Dutch universities, workshops with other European universities and campus literature.

	positive associations campus model B	neutral associations campus model B	negative associations campus model B
goals	+ multinational organisation with multidisciplinary potential + world player, also considering its size and network connections + university that can respond to societal challenges and changing demand + adaptable, flexible workforce + more shared space encourages interaction, collaboration and innovation	• horizontal organisation 	- a large organisation can make individuals feel anonymous, less connected and less loyal to the institution - many different identities and cultures of faculties and schools can be overshadowed by a large institution - an open campus can be a risk for safety and security - less (social) control - weaker (social) cohesion
user(s)	+ more user groups mix, which enriches campus life and adds to diversity goals + more public space and interaction can make people feel part of a vibrant community + being part of different teams can encourage talent development, rotation and provide career opportunities + higher utilization rates (lower vacancy rates) + users can find their preferred place for each activity and move around campus, also outside + best facilities on campus accessible for all users	• multiple workplaces	- less territory can make people feel less at home and less visible and traceable for others - more interaction on campus can be distracting and affect mental well-being - less privacy and silence can affect productivity - shared space often requires reservations or keeping other user's demands into account, which limits the freedom to use space for individuals and forces them to plan ahead - more shared space means more time spent to move between locations, which affects productivity
m^2, energy	+ reduced footprint (m2) and energy-consumption per user + more resource-efficient than model A + flexible for change in demand + more sustainable: better use of energy-consuming and costly resources	• shared facilities	- more shared space means more mobility on campus, which takes energy - suitable for all can also lead to greyscales (instead of colourful – see images) - more mobility demands higher quality of public space and circulation space
euros	+ costs for university lower (than solid model A) + more resilient for change, less costs need to be made when demand changes + total costs of campus shared with more partners + 'to share or not to be': some facilities are only feasible when they are shared, other funding streams are crucial for the academic 'business case'	• multiple funding sources	- more intensively used facilities need more cleaning, maintenance, which raises the costs per m2 - meeting more diverse space demands (including health, safety and security) of more user groups raises the cost per m2 - university management spends more human, financial and energy resources on dynamics, required flexibility and increased mobility



Figures B+/B-: "liquid" model B illustrated, on the left with positive associations (working together, inspired by others, meeting place, open, multicolour, flexible, visible), on the right with negative associations (crowded, anonymous, could be anywhere, greyscales, clean-desk). (Illustration Mark van Huystee 2020)

Table 6: associations with the network, liquid model, based on interviews and workshops with European universities, and potential positive and negative added value for the university. (Illustration Mark van Huystee 2020)

In figures B+/B- the "liquid" model B is illustrated with an open working environment, which provides a variety of workplaces for a diversity of users. This is considered symbolic for the network university and campus. On the left, the image highlights the positive associations: working together, inspired by others, meeting place, open, multicolour, flexible, visible. On the right, the negative associations are emphasized: crowded, anonymous, could-be-anywhere, greyscales, clean-desk. Often, shared spaces lose their 'couleur locale' and turn into one-size-fits-all spaces. Ironically, the ambition to mix all colours can fade to grey. Everybody's working environment could easily feel turn into nobody's home.

The network campus welcomed many new user groups and partners: universities of applied sciences, research institutes, start-ups and more mature related businesses. Also, universities started working together and formed more networks, between similar types of universities – like universities of technology – regionally clustered and with complimentary scientific disciplines (mixing alpha, beta and gamma in education and research). Next to those horizontal connection in higher education – between research universities – more vertical connections were made with regional and local educational institutions, from day-care facilities for parents on campus and international primary schools to practical colleges with manufacturing facilities. The 'liquid' campus became increasingly open, mixed and urban.

Funding became more private, space more shared. This transition took place around the change of the century, also caused by the urgency to find more funding sources and to lower the costs of the campus. Nevertheless, the incentives to broaden the scope of education and research and open the university for more user groups, came from society and higher education policy.

The network model welcomed many new user groups and is associaties with more crowded places (photo Communicatie Bouwkunde/TU Delft 2018).

Sharing space was encouraged for reasons of effectiveness and efficiency: the campus increasingly became a marketplace for knowledge exchange and innovation. Sharing was considered both a positive and negative choice. When research contracts got shorter and shorter, investments in expensive facilities such as laboratories were no longer feasible. Additionally, universities started to rent out space to partner institutions or even commercially. Sharing use could also mean sharing costs, so for many facilities it was "to share or not to be" (which also was a proposition for my dissertation, see appendices).

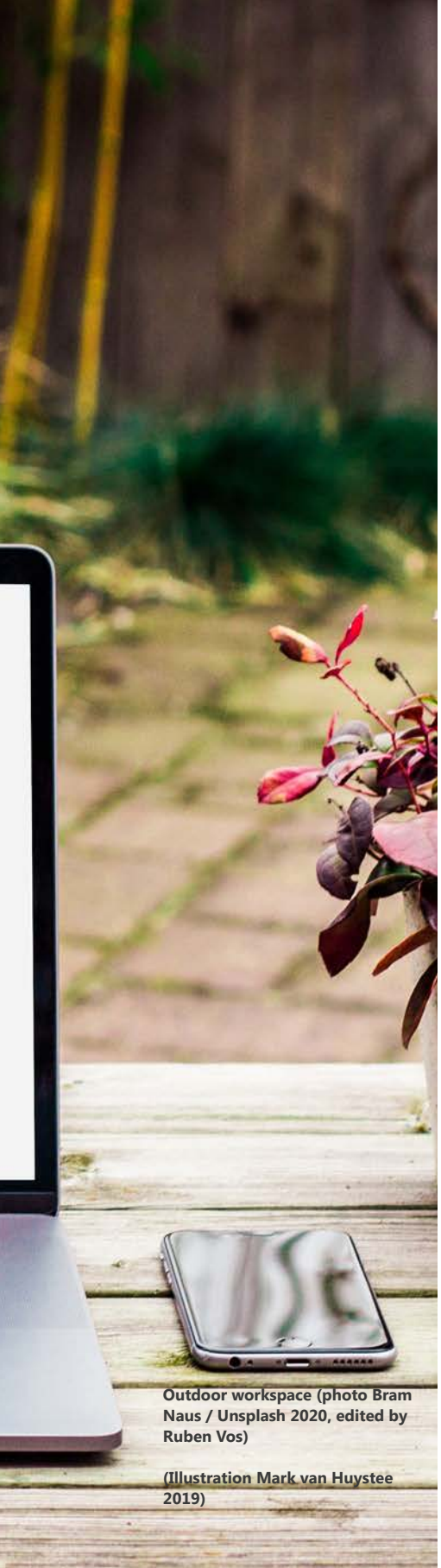
Lecture halls were among the first facilities that were shared and centrally scheduled by universities. More and more, students moved between faculty buildings for classes. Enrolment numbers increased, groups became larger and most universities had only a few 500+ lecture halls. When facilities are scarce, there is a greater understanding for sharing space. Some scarcity is only limited to certain times of the year. At the beginning of each semester large lecture halls are scarce, at the end of each semester quiet workplaces for exams are much harder to find. Consequently, universities started to schedule and allocate space in a smarter way, also temporarily changing the function and use of space. Dynamic use patterns required dynamic functionality of space. The solid space use model made room – also literally – for more liquid space use.

Multidisciplinary education and research accelerated the growth of central libraries, usually replacing faculty libraries, but not necessarily. At Dutch universities, some faculty libraries still exist, even though central libraries have become more prominent on campus. In many cases, libraries define the centre of the campus. In the past twenty-five years, libraries were increasingly used for studying in silence, not only for exploring collections. Digitalization of sources fuelled this trend . Opening hours were expanded to evenings and – in some cases – weekends, but not yet for all facilities. Schedules became more dynamic and followed demand. During exam times, libraries and workshops could also be open past midnight.

Summarised, this liquid network model was – and still is – an answer to (rapid) changes in size, more (interdisciplinary) challenges, more competition, more collaboration and more uncertainties in higher education and research. Size and focus are only predictable in the short term. More flexibility is required in every way: in education, in research, among students, in the employee population and on campus. Since model B, campus management has become a logic challenge. This requires more flexible buildings, more flexible space, but most importantly: more flexible people.

Zuidserre at Faculty of Architecture and the Built Environment TU Delft (photo AdH)

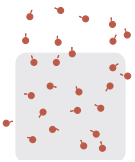

Introduction to Wind Turbines: Physics and Technology
Dealing with Power and Dynamics
Design in Healthcare: Using Patient Journey Mapping
Sustainable packaging in a circular economy
Forensic Engineering: Learning from Failures
Solar Energy: Photovoltaic (PV) Energy Conversion
Helicopter Performance, Stability and Control
Communicating Effectively: How to Inspire and Convince
Multi-stakeholder Strategies
Hello (Real) World with ROS – Robot Operating System
Taming Big Data Streams
Aeroacoustics: Measurement Techniques
Hyperloop: Changing the Future of Transportation
Aeroelasticity
Advanced Dynamics
Modeling, Simulation and Application of Propulsion Systems
Rotor and Wake Aerodynamics
Railway Engineering
Offshore Wind Farm Technology
Smart Grids: Modeling
Non-linear Modeling
Aerobic Granular Sludge Technology for Wastewater Treatment
Project Management: Mastering Complexity
Business Model Innovation
Leadership Essentials for Engineers
Electric Cars
Water management
Design your Next Career Move
Product Design & Health
Design Practice in Business
Healthy Ageing in 6 Steps
Product Design: The Delft Design Approach
Sustainable Urban Freight Transport: A Global Perspective
Advanced Transport Phenomena
Nanofiltration and Reverse Osmosis in Water Treatment
The Hardware of a Quantum Computer
Integration of Photovoltaic Systems in Microgrids
Solar Energy Engineering: Comprehensive Exams
Solar Energy: Photovoltaic (PV) Systems
Project Finance: Funding Projects Successfully
Smart Grids: The Basics
Adaptive Planning for Infrastructure and Water Management

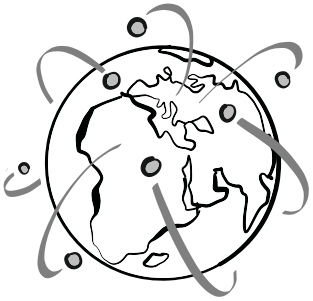


Outdoor workspace (photo Bram Naus / Unsplash 2020, edited by Ruben Vos)

(Illustration Mark van Huystee 2019)

Model C – the virtual university and campus – GAS matter



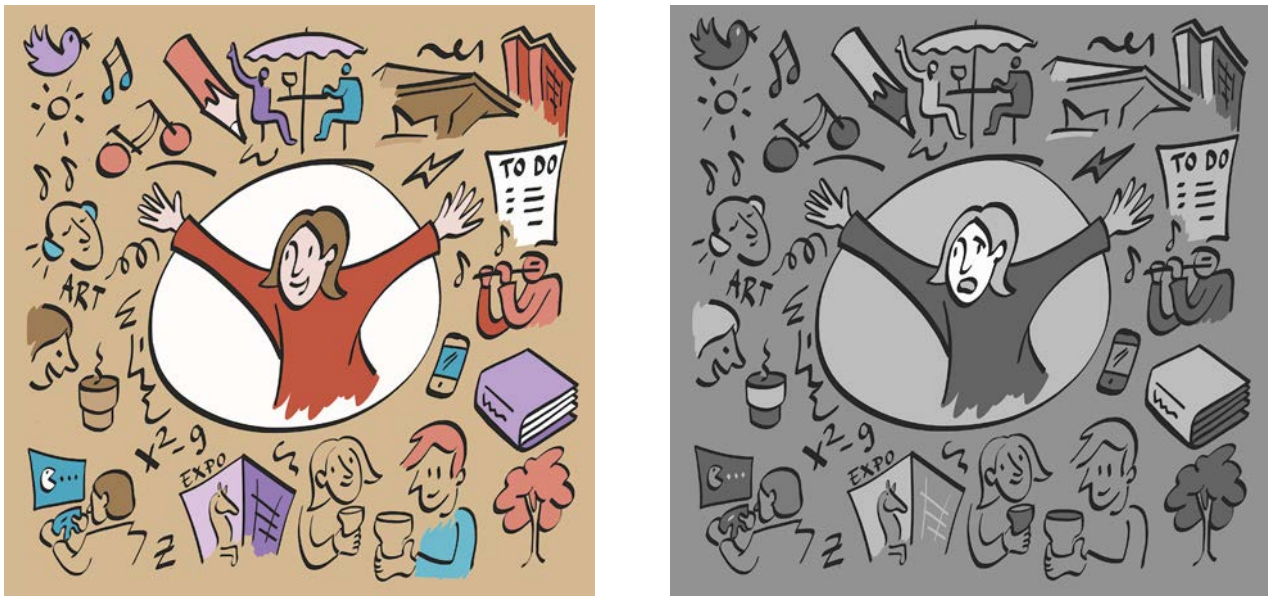


This virtual model represents individual autonomy, mobility, freedom and the possibility to work and study anytime and anywhere, online and off-campus. Technological developments played a profound role in the development of the university and campus in the past twenty-five years. Digitalisation, faster networks, wireless technology, laptop computers and smartphones changed the way of working and open-source policies in both education and research supported the world-wide exchange of knowledge. Place and time independency of many educational and research activities made the university population more flexible and mobile than ever before. In theory, on an open campus, they could take the space and time that was available – like gas molecules - which was the world and '24/7'. Weekends and night shifts were no longer excluded from the agendas of students and researchers. Both physical and time barriers for work, study and private life disappeared.

In this gas state the term 'virtual' does not only mean online, as following online courses or answering your e-mail still requires a place, just not on campus or on a traditional workplace of model A. Therefore, it also refers to off-campus: in non-university buildings, at home or 'on route'. Having a workplace at home was not a new phenomenon for academic staff and students in the past twenty-five years, but the functionality of the home workplace has improved rapidly for all kinds of activities. These activities range from exploring (online) libraries to communicating with colleagues through e-mail, audio and video applications. Improved Wi-Fi connections and access to campus networks enabled many to (plan) work as flexible as they wanted. Increased communication and group work in both education and research did no longer require campus users to be on campus. Progressively during the past decades, universities started to facilitate distant learning and working. They did that not only to enable world-wide talent to follow online courses or collaborate in research teams, but also for 'regular' students and employees with (work) space on campus.

This model is associated with the "gas" state of matter, because it represents maximum mobility of individuals and the absence of a fixed volume that keeps them together (which could also lead to the atomization of the organisation). In gas matter, molecules can freely move beyond the traditionally defined volume for the substance, respectively the campus and university in this case. Compared with liquid matter, mutual relations have (almost) disappeared (cohesion very weak). These molecules can refer to individuals, but also to organisational units like faculties, colleges and schools that started branches

	positive associations campus model C	neutral associations campus model C	negative associations campus model C
goals	+ more inclusive: education and research more accessible for different, more diverse target groups + allowing employees/students to find their own match between work/study and private life + facilitating distant learning and working from home, creating a flexible workforce	• bottom-up organisation 	- less or no presence on campus (can) make individuals feel lonely, disconnected and less loyal to the institution - lack of (social) cohesion affects the identity of the organisation - lack of (informal) interaction affects serendipity, interdisciplinary encounters and (possibly) innovation opportunities - lack of personal contact and social control affect motivation and/or completion rates - exclusively online and digital activities (can) increase the cybersecurity risks
user(s)	+ more, world-wide possibilities for talent + maximum freedom for students and employees to find their own balance between work/study and private life	• "work where you want"	- less interaction can make people loose contact with the university community - employees and students need to spend energy (time, money) on finding or creating a suitable workplace off-campus, at home or elsewhere
m^2, energy	+ less m2 and energy needed on campus, so very resource-efficient for university, if universities can find alternative uses for existing buildings	• anywhere off-campus	- the absence of a vibrant campus makes the university 'invisible' - energy use elsewhere increases, for instance: at home of students and staff - space use elsewhere increases, for instance: more pressure on floor area homes
euros	+ this model radically reduces space and energy demand (per user) on campus and could save substantial financial campus resources, if universities can find alternative uses for existing buildings + able to reach larger groups, to make more online courses (more) feasible + able to find more (online) research partners to co-fund research projects + resilient for changes in demand, lower transition costs + total costs of campus potentially much lower	• funding bottom-up	- many more resources needed for online campus: content, training, storage, networks, licences, security, backups, ... - more resources needed to accommodate home workplace: ICT facilities and furniture - not easy to reduce m2 and costs, if universities cannot find alternative uses (or owners) for buildings



Figures C+/C-: "gas" model C illustrated, on the left with positive associations (endless possibilities, flexible life-work balance in time and place, accessible for many), on the right with negative associations (multiple distractions, no structure, silence and rest, the fear of missing out, loneliness). (Illustration Mark van Huystee 2020)

Table 7: associations with the virtual, gas model, based on interviews and workshops with European universities, and potential positive and negative added value for the university. (Illustration Mark van Huystee 2020)

all over the world and virtual 'extension schools' with online content. More associations and characteristics can be found in table 7 summarized and assigned to organisational (goals), functional (use/users), physical/environmental (m^2, energy) and financial (euros) aspects of the university. These associations have (potential) positive and negative impact – added value – for the university and are based on interviews with Dutch universities, workshops with other European universities and campus literature (sources).

Financially, this virtual model also reflects a radical transition in funding structures: from top-down funding in the traditional model and project funding in the network model, to individual bottom-up funding responsibility in the gas model, making professors "academic entrepreneurs". Funding flows also changed from relatively long-term (predictable) to short-term (temporary, uncertain). At the same time, a positive development was that the funding opportunities changed from national to European to global over the years. Consequently, the competition for funding also became global.

In figures C+/C- the "gas" model C is illustrated with an overview of on-campus, off-campus and online associations with academic life, which symbolizes the '24-7' life experience of studying and working in a hybrid environment with attractive cultural, sports and leisure facilities. On the left, the attractions are considered positive: endless possibilities, flexible life-work balance in time and place, accessible for many. On the right, the same possibilities are considered negative: as multiple distractions and an abundance of options, which leads to indecisiveness, resulting in lack of structure, silence and rest, the fear of missing out and loneliness. The 'fear of missing out' is a social anxiety, which is also aggravated in times of social media. An abundance of options of online courses, study paths and extracurricular activities is both a blessing and a threat to mental health and study success.

The world-wide university network "Eduroam" also encouraged working on other national and international campuses, as laptops and other devices of students and staff automatically recognised this 'familiar' network near university buildings. Technically, this connected a huge number of universities and created a world-wide campus that

The virtual model is associated with endless opportunities and online accessibility. (photo Chris Montgomery / Unsplash 2020)

welcomes academics and students worldwide online. As a result, working on any campus – theoretically - was an option. In addition, many universities also made sure that Eduroam was available outside and even at the most heavily used locations in the inner city. This optimally supported flexible working and learning.

Nonetheless, the possibility to work place and time independent did not mean that students and staff were allowed or willing to embrace this model fulltime. The downside of this model gradually became clear. Completion rates of online courses turned out to be much lower than of on-campus courses (see text box), which was also demonstrated by the Open University NL when they started to organise physical encounters on campuses of other Dutch universities: the study success rates were higher. Motivation also appeared to be encouraged by peer pressure, not just for students but also for staff. Other negative side-effects of the virtual model were loneliness among students and community loss among the employee population. In a way, the virtual model also justified the traditional model. This also became very clear after the fire of our Architecture building in 2008 and more recently during the corona crisis in 2020, when universities world-wide involuntarily changed into (almost) 100% virtual organisations and campuses (see text box).

Summarized, this gas, virtual model is cherished for its time and place independency of learning and working, making use of the advanced technological developments and crossing the boundaries of the physical campus. The freedom and autonomy of individuals enables them to work and learn when and where they want, so also at most inspiring or most convenient places – including home. Energy and space use on campus can radically change, but so does the function of the campus as a place to meet, co-work and inspire each other. The psychological and organisational downside - also see De Boer (2021) about the effects of COVID-19 on Dutch higher education - was experienced world-wide during the corona crisis. Lessons from that period will be used for strategic campus choices.

Managing the virtual campus
by Alexandra den Heijer 2020

While academic communities involuntarily test the virtual campus model on a world-wide scale in the coronavirus crisis, our urgent tasks are alternated with lingering thoughts about the future of practically everything. This brings back memories of our own Architecture building went up in flames in 2008. What we did in 2008 after the fire, was focusing on emergency management and at the same time on making notes about what we observed, which eventually led to publications and presentations about lessons learned (see case BK city). Health and safety first, but social needs are next in Maslov's hierarchy of needs. Creating a place to meet was essential for a sense of belonging to a group after the fire. This needs to be a virtual place to meet now.

In the past days, our Campus Research Team also discussed our responsibility to study "what currently happens on campus" – or rather "off-campus" – and to report about this. As a team of researchers, we will also keep track of the creative, inspiring, moving and unusual (or even unbelievable) examples we find of managing the virtual university and the 100% virtual campus in these surreal times, including how universities are using the physical campus (empty student residences, laboratories and research equipment) for emergency matters. How flexible and adaptable we are to change.

But even though we cherish both the improvisation and creativity in our own academic communities, we share the strong feelings of uncertainty about the future, ranging from our individual worries and fears about health and our loved ones… to the stress about the long-term effects on all of our lives. We know there is a system change ahead, also in higher education, and there is time for contemplation now… with the hope that also this crisis brings opportunities.

[blog post: https://managingtheuniversitycampus.nl/2020/03/20/managing-the-virtual-campus/ March 20, 2020, edited]

Online students can't help being sociable
by BBC 2014

It was a revolution moving higher education from bricks to clicks… and now it's started to go back to bricks again.

"The typical completion rate for a MOOC is about 5% to 10%. For MOOC students ("MOOCers") attending learning hubs, the completion rates are between 30% and 100%." Source: Coursera (7 million students)

Online university providers, which offered people the chance to study from home, are turning full circle by creating a network of learning centres where students can meet and study together. Instead of demolishing the dusty old classrooms of academia, the online university revolution is responsible for opening some new ones.

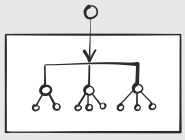
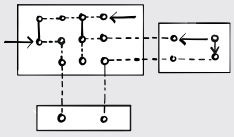
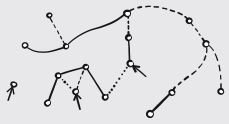
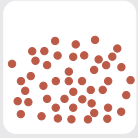
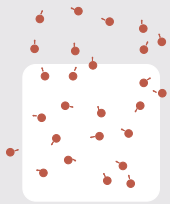
Coursera, a major California-based provider of online courses, is creating an international network of "learning hubs", where students can follow these virtual courses in real-life, bricks and mortar settings. They're scheduled and arranged online, with the only vital ingredients being a laptop, wi-fi and somewhere to talk.

source: http://www.bbc.com/news/business-26925463 (April 9, 2014)

Solid, liquid and gas at a glance

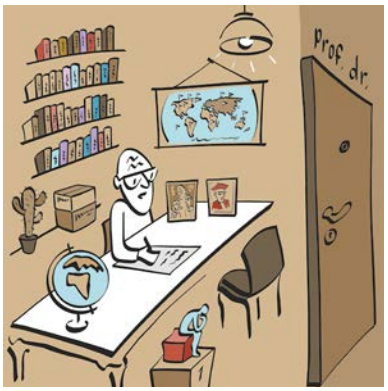
While there are examples of universities that resemble only one of these models, most universities are a composition of these three models: some more solid, some more liquid and some more gas. Based on our studies over the past decades, there are some obvious patterns. Centuries-old universities often seem to be more traditional - almost by definition - because of their history, rich legacy and rituals. Universities of technology (including agricultural universities) seem to be more networked, also because of the required interdisciplinarity to deal with societal challenges and their (link to) applied research, in collaboration with many stakeholders in society. Open universities already embraced the individual study paths before digitalisation and are almost exclusively virtual now.

Table 8: comparing the basic characteristics of the solid (traditional), network (liquid) and (virtual) gas model. (Den Heijer 2019, illustrations Mark van Huystee 2019)

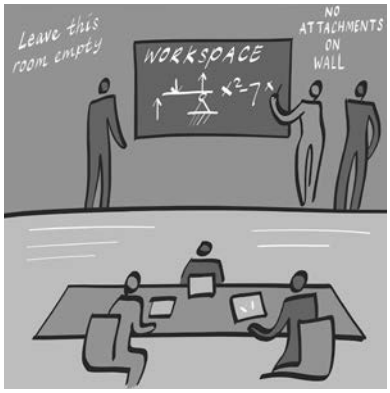
	model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
	top-down organisation 	horizontal organisation 	bottom-up organisation 
	one workplace	multiple workplaces	"work where you want"
	faculty building	shared facilities	anywhere off-campus
	top-down funding	multiple funding sources	funding bottom-up
	"9-to-5"	dynamic	"24/7"
			
	high	**cohesion between users**	low
	high	**required financial resources for campus**	low
	high	**required energy resources for campus**	low
	high	**footprint user**	low

summary positive and negative associations

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
+ traditions, rituals	+ interdisciplinary, innovative	+ accessible for many
+ loyalty, belonging	+ > 1 boss	+ autonomy of individuals
+ "members only"	+ serendipity, place to meet	+ paperless
+ exclusive, unique	+ open, more visible	+ very flexible
+ home, territory	+ campus costs lower than A	+ campus costs < 5% total



- territoriality, vacancy	- anonymous	- lonely
- closed doors	- everyone's workplace is nobody's workplace	- social isolation
- island culture	- crowded	- less connected to colleagues
- campus costs > 20%	- more mobility on campus	- less loyal to university
- high footprint user		- lower course completion rates



Transitions of the university and campus models in time

The models A, B and C were described in that order to illustrate the most dominant transition in the past twenty-five years, from mainly traditional to partly network to partly virtual. In practice, (almost) no university is exclusively one model. Nonetheless, in the past decades, trends could be observed. These trends and an indication of their emergence are described below.

trend around 2000 - from solid to liquid to gas - "bricks will be replaced by clicks"

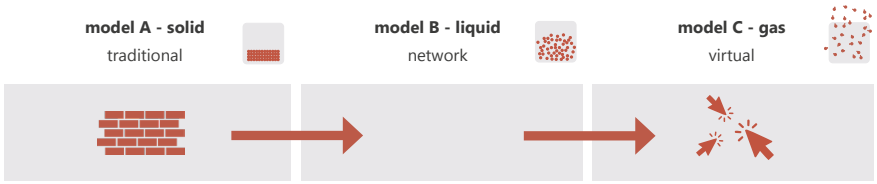


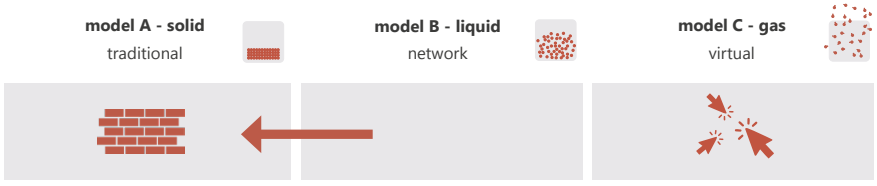
Figure 21: transitions between three university and campus models (repeated on p. 70-75)

Around the change of the millennium, many (university and campus publications) stated that the virtual university was the future, also referred to as "clicks and mortar" (Chapman 2006). With the world as a playing field, the opportunities seemed endless, bounded by available resources: time, energy and budget. Some stated that the world became the campus, the world-wide campus, others claimed that the physical campus would disappear, because it was no longer in need. But ever since the digitalisation and the virtual university have emerged, Dutch campus managers have claimed in interviews (in 2002 and 2006, but also in 2016 and 2020) that new demand did not necessarily replace old demand: it was extra and added to the logistic challenge of universities to meet the traditional, network and virtual demands with decreasing available resources. This still defines the main campus management challenge for many universities world-wide.

Interviews for my dissertation in 2006 indicated that many Dutch universities had made the shift to more networked, with the four universities of technology (Delft, Eindhoven, Twente and Wageningen) heading the game, also by forming a (4TU) network together and by sharing expensive laboratories and scarce resources (including human resources), even on a European scale.

In the same decade, the working and learning environment had already become more off-campus, by increasingly facilitating the home workplace, but also more and more considering the city as a campus. This was expressed by the presence of students in the city library, faculty meetings in restaurants and lectures in cinemas and city theatres. The 'campus' expanded to non-university property and the digitalisation expanded working hours to '24/7'. The campus was a mix of solid, liquid and gas.

trend from the 2000s - 'university colleges' reinvent the small and traditional - from liquid to solid

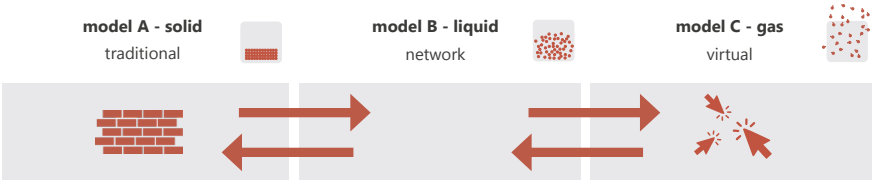


An early sign of universities 'reinventing' the traditional model was the development of small and selective 'university colleges' and accommodating them in heritage buildings. This was a response to the rapidly growing highly-ranked universities that functioned as a magnet for world-wide talent. For some of that talent, universities started to offer

honours programmes to satisfy the increasing demand for exclusiveness and small-scale education. University colleges provided broad, international liberal arts and sciences programme, leading to Bachelor (Honours) degrees, often for a higher tuition fee than regular Bachelor programmes, which were not in English in the 2000s (which is still often the case in the early 2020s). At that time, Master programmes gradually switched to English and became more specialized.

In terms of campus models, 'university colleges' are examples of the trend from liquid to solid, on a small scale. They cherish the accommodation model of the past: exclusive, territorial and with unique architectural qualities, often located in heritage or iconic buildings (examples in the Netherlands: Maastricht, Utrecht/Middelburg, Amsterdam and Rotterdam). The higher tuition fees of university colleges allowed higher accommodation costs.

2008: lessons from emergencies – forced relocations – for the campus models



Emergencies force organisations into accommodation solutions that they would not choose for under normal circumstances. They involuntarily test new – or more extreme – models that could also turn out to have more advantages than expected. At the same time, it can make the users miss (and revalue) the former housing situation that they might have taken for granted. These are the opportunities of a crisis.

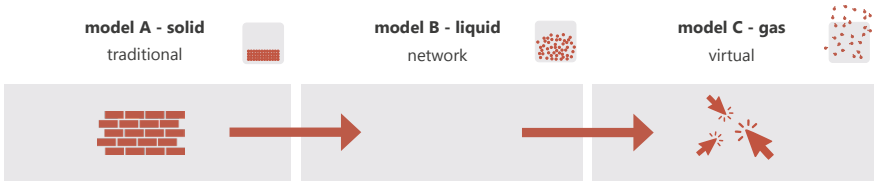
For my dissertation in 2011, I formulated a proposition about this subject: "It takes a crisis – for instance a fire – to change the academic workplace". With this proposition I also wanted to emphasize that (culture) changes in the working environment are often resisted and that they need urgency. With the example of our own fire in 2008, I had evidence of both situations: the community was more flexible to work in other buildings and off-campus than they imagined and they were more aware than ever of what they missed about the building that went up in flames.

In 2008, a fire destroyed the building of TU Delft's Faculty of Architecture and the Built Environment. The faculty was moved to a heritage building. Lessons from that project "BK city" can be found in publications (Den Heijer 2009, 2017). (source photos (L-R): Bryan Tong Minh 2008 and Rob 't Hart 2009)

Weeks after the fire, our 'BK city' project team already discovered that the community that was forced into a "100% network and virtual model" could not wait to get back to campus. At that time, using mobile phones and laptops was not as common as it is now. And while we expected many in an Architecture faculty to prefer new and innovative, we were happily surprised that they embraced our choice to bring life to an old heritage building from the 1910s. Back then, we already concluded that re-use would be more in line with TU Delft's sustainability strategy than building new. The challenge was to fit a faculty that was a mix of traditional, networked and virtual (mobile) in a building that was created for a 100% traditional university.

Concluding from this case, we discovered that there are limits to the virtual model and that emergencies often give a rebound effect: users value traditions more than before. Nonetheless, this case also demonstrated that in case of an emergency everything becomes fluid. After the relocation, many activities were accommodated as liquid matter: shared, more flexible and more often in other university buildings. Also, a faculty community equipped with laptops and smart phones was more able to work anywhere, as gas matter. Opportunities of any crisis should be used to reassess the mix between solid, liquid and gas, which the corona crisis also demonstrates on a world-wide scale.

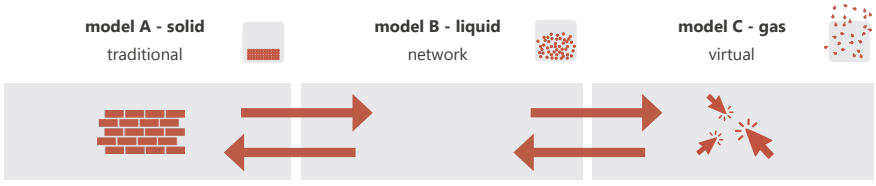
trend from 2010s – rapidly growing institutions started extension schools: more liquid and gas



With rankings becoming increasingly important and digitalisation even more prominent – with smart phones, laptops, file-sharing, open-source publishing as a few trends – the 2010s were characterised by student and staff mobility, not only physical but also virtual. Massive Open Online Courses (MOOCs) became more and more popular. Universities invested more heavily in increasingly critical ICT resources, sometimes from the same budget as campus management, which made the budgets per square meter tighter and tighter. In essence, it was not 'from liquid to gas', but 'more liquid and more gas'.

Managing the university campus (Den Heijer 2011)

trend around 2015 – blended learning and hybrid environments: solid, liquid and gas

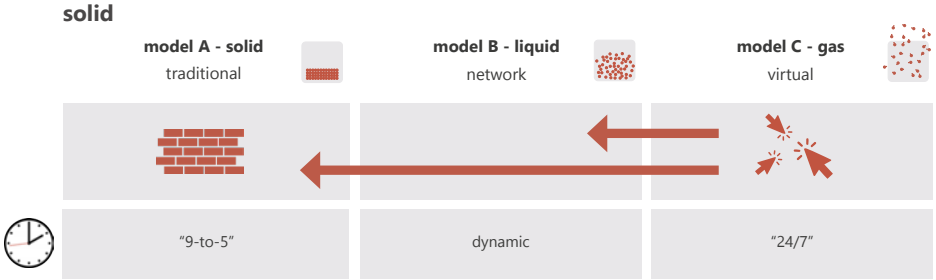


The early predictions of Dutch campus managers in 2002 and 2006 became reality, when it was clear that universities needed to facilitate the traditional, network and virtual campus at the same time: clicks did not replace bricks, they were added to bricks. This was also demonstrated by the terms 'blended learning' and 'hybrid environments' that were used in education and research. Hybrid environments are defined as an approach to merge physical and virtual spaces - and integrate formal and informal spaces - in order to overcome disciplinary and organizational boundaries. Space matters, but not just physical space (source: Ninneman et al. 2020). These concepts aim at smartly combining the best of all models, which is a challenge for many universities. This challenge not

Campus NL: Investeren in de toekomst / Investing in the future (Den Heijer et al 2016)

only refers to combining the qualities and functionalities, but also smartly allocating the human, financial and physical (energy) resources that are often scarce.

trend from 2015 – the trend to go back to campus – from virtual to liquid and solid



pull factors

quality of campus:
- better facilities
- better network, ICT applications
- silence

other users:
- group work, in multiple teams
- group pressure to study and work
- sense of community
- friendship and love (!)

healthy work-life balance:
- isolate work from home
- safe and healthy working environment

push factors

distractions at home:
- roommates, family members
- hobbies, social life
- on-demand TV, gaming

more pressure:
- higher tiution fees students
- more tasks employees
- more pressure on performance
- risk of burn-out

housing market:
- home workplace to small, not private
- home office to expensive

The first signs of the downside of the virtual campus and the trend to (want to) return to campus were illustrated by the low completion rates of online courses. Online students missed peer pressure, physical contact with tutors and regular working hours to be disciplined and motivated. On campus, the libraries and other (quiet) places to study became more and more popular. In 2016, interviews with Dutch campus managers confirmed this trend: they could hardly satisfy the need for study places.

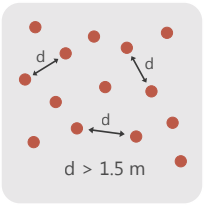
The reasons for returning to campus can be divided in push and pull factors. Push factors encompass the negative aspects of the off-campus working environment, especially the home workplace, that drive students and staff to campus. Pull factors summarize the positive campus aspects that attracts them the university buildings and grounds.

Push factors are distractions at home: roommates and family members, but also hobbies, social life, on-demand TV, gaming etc. Also, more pressure on the university community is a push factor: higher tuition fees for students, more tasks for employees, stricter performance criteria and higher risk of burn-outs. Additionally, the housing market (home workplace too small, not private and too expensive) with rising housing prices drives users to campus, especially employees. More and more staff members simply cannot afford functional workplaces for (all) family members. (However, this could also have a reverse effect: housing prices are often relatively high in university cities, which

drives employees to move to distant locations, which could encourage them to work from home more often.)

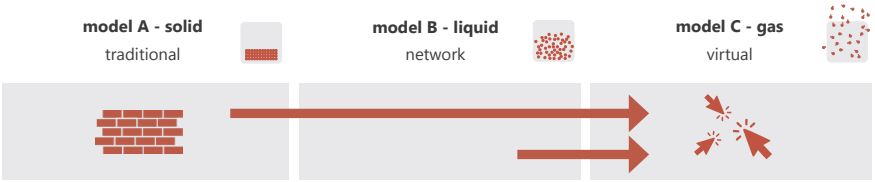
Pull factors are the qualities of the campus, compared to off-campus workplaces - better furniture, facilities, ICT applications and networks - and silence is mentioned explicitly. Other pull factors are the presence of other users and user groups, for content reasons (more teamwork in education and research), but certainly also for social reasons (peer pressure, sense of community and relations on campus). Last but not least, a healthy work-life balance encourages more and more people to readapt to regular working hours ('back to 9-to-5'), to minimize working hours at home and to spend more hours offline and on campus. This campus trend I presented during my inaugural speech in November 2019. The corona pandemic in 2020 reversed that predominant campus trend: it pushed both students and staff members back to their workplaces at home and the online, digital, virtual campus.

University building VU Amsterdam (photo AdH)



Social distancing in model C gas (Illustration Ruben Vos 2020)

2020/2021 - the world-wide corona crisis - the (almost) 100% virtual model



No-one could have predicted that in 2020, the virtual university and campus model would involuntarily become the main model for universities all over the world, during the corona pandemic. In the strictest lockdown periods, students and academics worked 100% from home (also see De Boer (2021) for a COVID-19 timeline in Dutch higher education). Universities that were ahead of the game with blended learning and hybrid environments had a huge advantage: they could practically switch from physical to virtual over the weekend in March 2020. But many also struggled with lack of digital content, slow networks and university populations that were not yet equipped with laptops and smart phones for work.

The pull and push factors, formulated in 2019, were more valid than ever. Distractions at home were augmented for parents whose children needed to be home-schooled. Attention spans were challenged with all-day video meetings or fulltime online education. Safeguarding the work-life balance is harder, when the place is the same. And the campus and its community were missed more than ever before: "You don't know what you've got 'till it's gone". When months passed, the cohesion in the organisation – like in a gas – became weaker, also caused by the lack of unplanned, informal meetings in the campus corridors, negatively affecting serendipity.

On the bright side, many who resisted online teaching and working at home before 2020 were also forced into the virtual model and gradually became more convinced of the benefits. Many who never attended webinars were now organising them. Some meetings just work better online. Indeed, also this COVID-19 crisis had opportunities. More post-pandemic trends are studied in project Campus NL (Den Heijer et al. 2024).

A virtual graduation ceremony during COVID-19 pandemic (photo Mohammad Shahhosseini / Unsplash 2020)

Summary: the campus of the future is a combination of solid, liquid and gas

After these different periods with a series of trends, the challenge for the campus of the future remains the same: how do we accommodate the traditional, network and virtual campus – solid, liquid and gas – and in which combination? This question should be answered for all function types on campus, ranging from educational space and research space to office space and support functions like restaurants, student housing, sports facilities etc.

In general, the solid-liquid-gas distribution can be made for the following space types on campus (see table 9):

- **the (hybrid) learning environment**: which percentages of the lecture halls, classrooms, studio spaces and study places will be accommodated in (solid) faculty-specific educational facilities, only assigned to students of that specific faculty, in (liquid) shared educational facilities, centrally organised and often also centrally located and in (gas) off-campus facilities, like theatres, cinemas and city libraries, and often replaced by online education, to follow anywhere, anytime and possibly at home?

- **the academic workplace:** which percentage of the working environment of academic and support staff will be accommodated in (solid) individual, personal desks, user-specific meeting rooms and support offices close to the workplaces, in (liquid) shared workplaces, shared meeting rooms and centrally-located support offices and in (gas) off-campus facilities, at other universities, in the city and at home?

- **libraries:** which percentage of library facilities – books, magazines and other sources of information - will be located in (solid) faculty libraries, (liquid) central libraries and (gas) off-campus city libraries and online repositories?

- **restaurants and cafes:** which percentage of bars and restaurants will be located in (solid) faculty buildings, (liquid) university restaurants and food trucks that offer a range of food types and (gas) off-campus city facilities, also available for delivery anywhere?

- **storage space:** which percentage of storage space – for dynamic (work-in-progress) and static archives of education, research and valorisation - will be located in (solid) personal or user-specific facilities, on private bookshelves and in private rooms, in (liquid) central facilities, shared with colleagues on different organisational levels and in (gas) off-campus facilities and online file-sharing facilities?

Chapter B4 elaborates on examples (and themes) for different functions and space types on campus, collected from prior research and provided by Dutch campus managers in interviews during academic year 2020/2021. Which trends do universities identify (also influenced by the experience of the corona crisis), how do they plan to change their campus strategy and which projects already demonstrate the changed strategy and trends?

	model A - solid at the faculty	**model B - liquid** shared on campus	**model C - gas** off-campus
			
labs	traditional laboratories	shared laboratories	lab hotels off-campus labs
libraries	faculty library	central library	city library
offices	traditional workplaces	flexible office concepts	home workplace third places
storage space	personal	shared	digital
lecture halls	faculty-specific	university-shared	off-campus or online
classrooms	faculty-specific	university-shared	off-campus or online
study places	at the faculty	on campus, shared or in learning centres	off-campus, in the city or at home
meeting rooms	close to workplace	shared meeting rooms	off-campus or online, in restaurants and conference centres
exam space	in the faculty building	centrally on campus	in off-campus sport facilities or churches
ceremonial space	in the faculty buildings	centrally on campus	in off-campus city halls, churches or (other) heritage, city icons
cafes & restaurants	faculty coffee corner, faculty restaurant	university restaurant, campus food trucks	cafes and restaurants in the city

Table 9: space types on campus categorized by solid-liquid-gas ratio. (Illustration Mark van Huystee 2020)

One important conclusion from campus research can already be drawn: the combination of campus models always contains a minimum of each model. The reasons why neither model A nor model B or C will disappear, according to university and campus managers:

- **Why "solid" model A will not disappear:** "If we lose model A, we lose the foundation of the university": the traditions, sense of belonging for a community, the loyalty to the institution. Model A has been and will be important for the long-term identity and continuity of the university.

- **Why "liquid" model B will not disappear**: The required connectedness, collaborations in research and social engagement with the community has justified and will justify model B in the future. Working together is essential for many societal challenges, which model B supports.

- **Why "gas" model C will not disappear:** The digitalisation and responsibility to reach out beyond the on-campus student population and educate world-wide, also to satisfy the life-long-learning needs, keeps model C relevant. During and after the corona pandemic the value of online alternatives became obvious, which convinced the university community that hybrid learning and working environments are the future; the question is in which composition.

The arguments above to keep the best of model A, B and C mainly focus on the added value for the primary process: the missions of the organisation - education, research and valorisation - and the needs of users. The decisions about the optimal combination of ABC are also very dependent on the budgetary context and the effect on sustainability goals.

- **Why "solid" model A is threatened:** With sustainability goals and budget cuts moving higher and higher on the university's strategic agenda, the space-consuming character of model A is under surveillance. The dynamic use patterns of today's university and the relatively high vacancy rates of academic offices and other facilities urge universities to reconsider private, and certainly individual, territory and start time-sharing* facilities.

- **Why "liquid" model B is threatened:** The number of potential connections and the number of networks can lead to larger and larger organisations, with individuals that feel more and more anonymous. Additionally, the ambition to make everybody feel at home and avoid 'couleur locale' in shared facilities, can also lead to impersonal spaces in greyscales. The clean-desk policies for shared workplaces can make users feel like guests on their own campus.

- **Why "gas" model C is threatened:** The abundance of online courses, lectures and meetings and the lack of physical contact between campus users – which was experienced at all universities in the corona crisis – can have a 'rebound effect': it can make the university community prefer physical over virtual. Also, mental health issues urge students and staff back to office hours, silent zones (and timeslots) on campus and more activities (and spaces) that ban smart phones and laptops. Safety of networks and (un)reliability of online sources can also push organisations back to analogue and on-campus.

***Sharing should often be interpreted as 'time-sharing'**
(Den Heijer 2019)

sharing

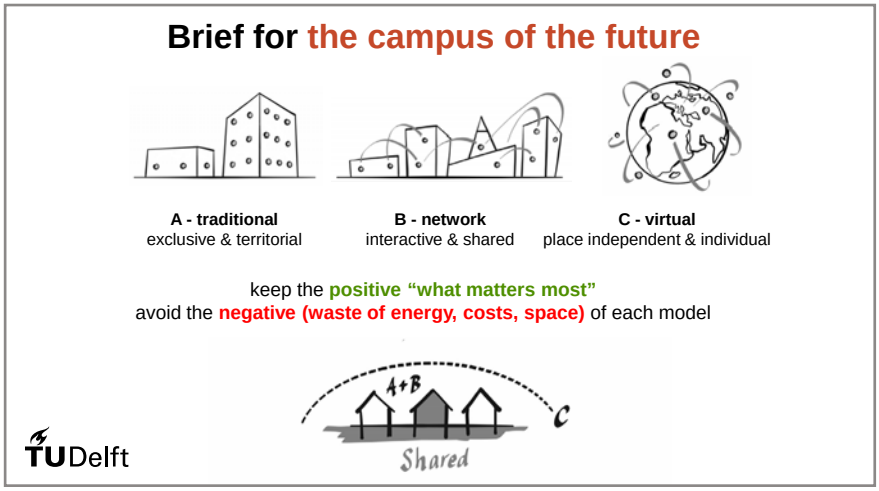
using the same facilities at the same time; the advantage is that facilities can be used at any time, without reservations; the risk is that facilities are (too) full at some moments and vacant at other moments

time-sharing

using the same facilities at different times; often organised with a reservation or booking system

source: own definition

The brief for the campus of the future is a combination of solid, liquid and gas. The challenge is to keep the positive characteristics – "what matters most" – while avoiding the negative characteristics, the "waste of energy, financial resources and space".



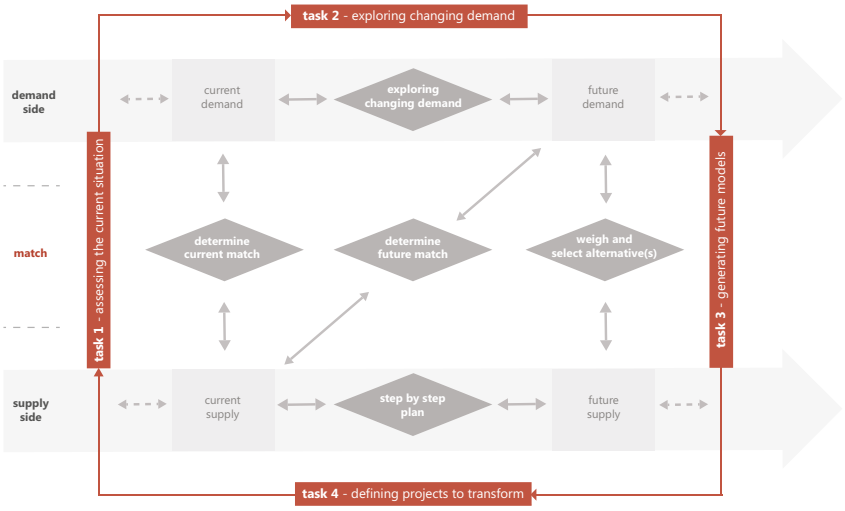
In nature, H_2O is present in three states of matter at the same time, under different circumstances and in different places: as solid matter (ice), liquid matter (water) and gas (water damp / steam / vapour) – as a metaphor, this also applies to the presence of all states of matter on the campus, under different circumstances, for different activities and in different places. In the next section B3, the management context is added to the challenge of finding the best match between solid, liquid and gas on campus.

Figure 22: Brief for the campus of the future and three states of H_2O at the same time – caption: in nature, H_2O is present in three states of matter at the same time, under different circumstances and in different places: as solid matter (ice), liquid matter (water) and gas (water damp / steam / vapour) – as a metaphor, this also applies to the presence of all states of matter on the campus, under different circumstances, for different activities and in different places. (Illustration Mark van Huystee 2020)

(photo Nathalia Segato, Unsplash 2021)

Chapter B3
Management matters

The title of this chapter "management matters" can be read in two ways. With "matters" as a verb, this title states that campus managers are important in the process of finding the best match between solid, liquid and gas on campus. With "matters" as a noun, this points at the issues that campus managers have to deal with. Figure 23 shows that these interpretations are connected to the REM (strategy design) process framework and the REM (information) model as introduced in part A of this book (A2).



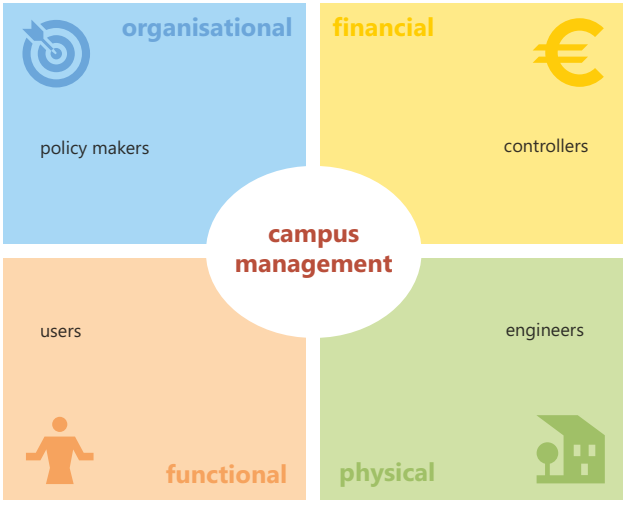


Figure 23a and 23b: management matters in two different ways: (above) in the REM strategy design process framework, matching supply and demand in time (De Jonge et al. 2009, adapted) and (below) in the REM (information) model, integrating management matters from four perspectives in campus decisions.

matter

noun
a subject or situation under consideration: a great deal of work was done on this matter | financial matters.

verb [no object]
[usually with negative or in questions] be important or significant: it doesn't matter what the guests wear | what did it matter to them?

source: Oxford Dictionary of English, Stevenson 2010

This chapter focuses on both interpretations of "management matters" and will focus on the stakeholders – also mentioned in figure 23 – that represent the four different perspectives: policy makers (organisational), users (functional), controllers (financial) and engineers (physical), with the campus manager in the middle to take their goals, needs and conditions into account.

An illustration of the campus management negotiation table

For more than ten years, I have written that "managing the campus aims at adding value to the university's performance by balancing four perspectives – connecting organisational, functional, financial and physical variables – in every decision". For my inaugural speech, I decided to ask illustrator Mark van Huystee to help me visualise how campus managers experience this. I based my storyline for him on the many interviews I had with campus managers over the years.

This illustration – shortly referred to as "the table" – resembles the campus management (and REM) model in colours, icons and positions of the stakeholders. This image was first presented during my inaugural speech in November 2019, for which occasion it was created. From that moment and during the presentations that followed, it was embraced by many campus managers as "the story of their lives".

With this illustration, I wanted to make the following statements:

- Campus management is complex matter, since increasingly more issues are brought to the negotiation table, illustrated by the piles of paper that every stakeholder brings;

- Every stakeholder brings relevant goals, needs and conditions to the table, but they are often conflicting (expressed with different colours) and the person in the middle needs to solve the multi-coloured puzzle.

- It is much easier to plead for and from only one perspective (one-dimensional) – and lobby for the maximum – than to be the campus manager in the middle who needs to optimize and (by definition) needs to disappoint some stakeholders around the table.

- The most common "threat" in management processes is that every stakeholder can bring their maximum request to the table and "expectations are not managed" that either the solutions require stakeholders to compromise or solutions are not possible (and processes are delayed). How stakeholders can be encouraged to co-create optimal solutions with "the person in the middle" is one of our research missions.

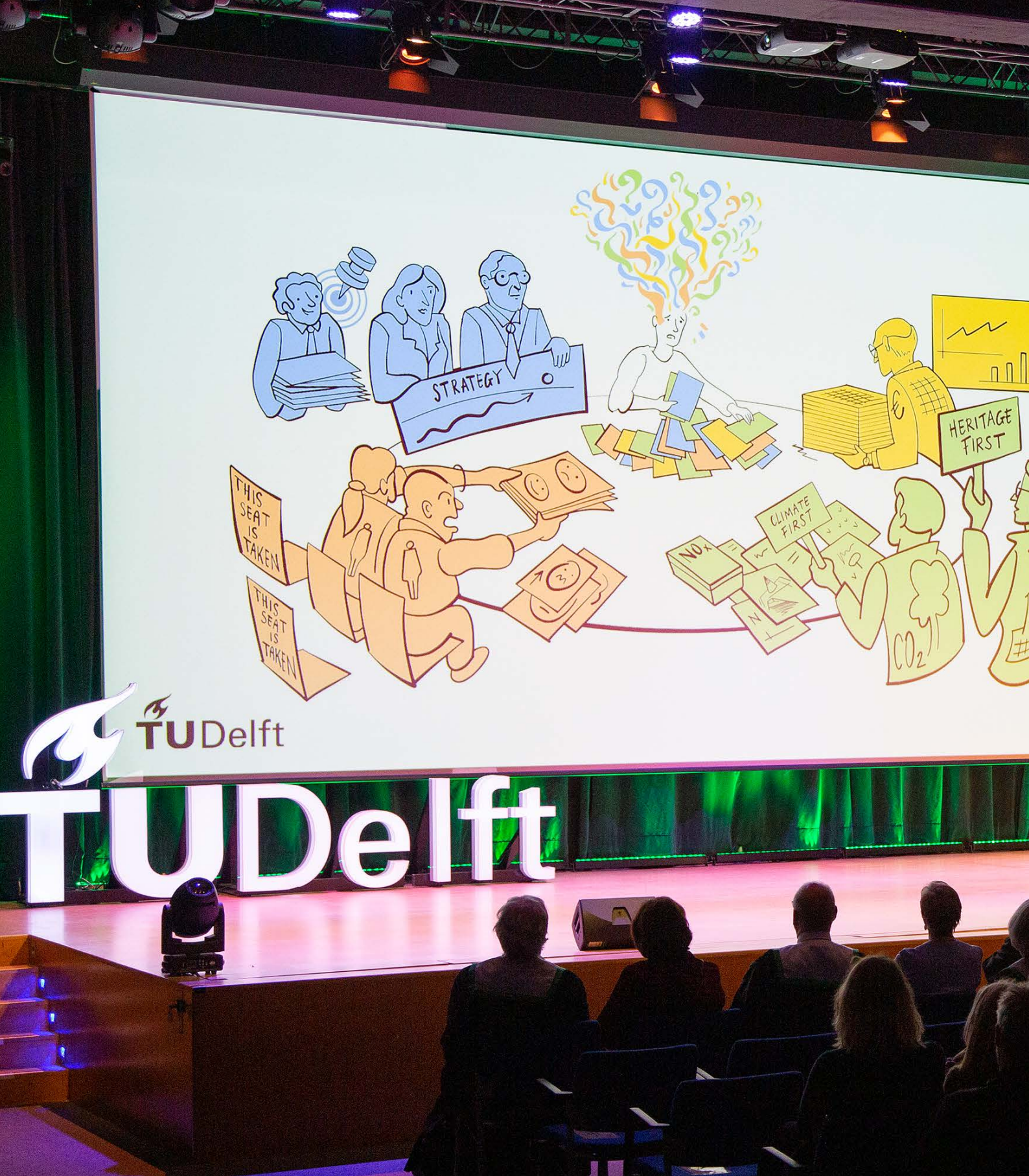
- Universities and other organisations should ask themselves the question: who is taking the role of the person in the middle?

- I plead for more respect for the person in the middle, both at universities and in other organisations that own and/or manage public real estate and – more general – in society and politics.

In the next subsection, I will zoom in on all sides of the table, ending in the middle, and ending with the agenda of our Campus Research Team, to support the person in the middle - the public real estate manager - with networks, methods, databases and tools.

Figure 24: managing the campus aims at adding value to performance by balancing four perspectives, connecting organisational, functional, financial and physical variables in every decision. (Den Heijer 2019)

Illustration by Mark van Huystee for inaugural speech Den Heijer in 2019.


STRATEGY
THIS SEAT IS TAKEN
THIS SEAT IS TAKEN
HERITAGE FIRST
CLIMATE FIRST
NOx
CO2
TUDelft
TUDelft

Inaugural speech AdH November 13, 2019 (photo Hans Krüse 2019)

selection/size

identity

ranking

reputation, image

internationalisation

diversity, inclusion

educational policy: contact hours, hybrid learning

research policy: (inter)national networks, shared labs

social engagement

Figure 25a: the organisational perspective at the "management table": the policy makers. (Illustration Mark van Huystee 2020)

Figure 25b: organisational keywords in random order from interviews Campus NL 2016 and 2020/2021 (Campus NL 2016, 2020)

Representing "policy makers" in blue, the organisational perspective brings many strategic choices for the continuity of the university to the table. Policy documents for the long term, visions on the future of the university, but also choices for next academic year. How large, how diverse, how specialised, how international and how selective do we want or need to be? How do we attract and retain talent and how do we support excellence? How do we secure and improve our reputation, image and ranking? These are some of the themes that can be recognised in strategic plans, visions and missions which are brought to the table in large piles in the illustration, see figure 25 (a+b).

organisation matters

For making a campus decision, any organisational mission, goal, purpose and performance needs to be translated to quality and quantity requirements for the campus. Ideally, the campus supports all organisational goals – the blue, organisational perspective will aim at maximizing this support. The following issues and notions from prior research are relevant for this perspective:

- "Every university goal can be frustrated by the physical campus"; with this first proposition for my PhD defence (in 2011), I wanted to emphasize that the campus has a defining role in achieving organisational goals. However, it is often easier to prove the negative impact than to determine the positive impact (Compare "the quality of our buildings will attract more talent" and "aging buildings with technical defects will affect the attractiveness for talent").

- "You don't know what you've got 'till it's gone"; our faculty of architecture – ironically - discovered after the destructive fire in 2008 "that the value of a building for an organisation is best assessed when it is taken away". The (replacement) value of what is missing seems to be easier assessed that the value of what is there. In 2020, the value of the campus for universities was best assessed, when universities could not use the physical campus in (lockdown) times of the corona crisis.

- "The all-inclusive campus"; university goals can be categorised according to their three missions - education, research and valorisation - but are also more often formulated in terms of talent recruitment, innovation power, social engagement and added value to society. Terms as selection, inclusion, smart growth, identity, diversity, internationalisation, specialisation are found in mission reports. How do universities translate them into campus requirements? Over the years, our research team has gathered solutions, but also marked them with the consequences for other perspectives around the negotiation table: the environmental impact, the financial impact and the impact on the well-being of people (see part C for examples).

- "Organisational goals about resource-efficiency: sustainable university development"; often, the organisation goals – in strategy documents - do not only state the ambitions for primary processes like education, research and valorisation (or innovation), but also requirements or conditions for the secondary processes and the resources those ambitions take. Sustainability ambitions and mental health issues of the university community are higher on the strategic agenda than ever (according to Dutch universities in interviews conducted in 2020/2021). The UN's Sustainable Development Goals (SDGs) are very often mentioned as a foundation for organisational goals (see Ninnemann et al. 2020). In this sense, the stakeholder of the blue perspective already compromises towards (the person in) the middle of "the table", considering the financial, human/functional and environmental/ physical consequences of organisational demands. Nonetheless, their require specialists on each of these themes to provide them with knowledge. They often require examples of similar organisations – benchmarks of other universities – to substantiate their ambitions.

- "The network university adds more policy makers to the negotiation table"; the organisational perspective in broader sense does not only bring university goals to the table, but also goals of stakeholders outside the university that influence the primary goals education, research and valorisation. This could be ministries of education and (inter)national science boards. Also, networks that the university is part of – European networks, partner universities, regional/local research partners – could add conditions to the campus negotiation table.

- "Think global, act local": in many European countries, the university has become part of an "innovation ecosystem" with quadruple-helix partners from industry, governments and civil society. The added value for the local, regional and national (knowledge) economy, demography and social-cultural circumstances is more and more acknowledged (and studied, see our "university-city" and European campus research themes). Additionally, social engagement of universities, also towards their neighbouring communities, also opens the campus for more user groups and changes the agenda of what happens on campus.

What is considered a threat to "the table" is that organisational ambitions, criteria and conditions pile up and campus decision making process stops, because it is "too complex to handle". To avoid this impasse, the organisational perspective could be encouraged to judge to which extent a building or "space" meets the organisational criteria. Additionally, the policy makers and other stakeholders from the blue perspective could be encouraged to take the positions of other stakeholders at the table in serious gaming sessions (see part C for examples).

organisational assessment criteria

In essence, the organisational choices have a huge influence on the solid-liquid-gas ratio on campus: how traditional, networked and virtual do we want to be as a university? (see figure 26) This division aligns with the three university and campus models as introduced earlier. Strategic choices determine how much space is assigned to designated groups, how much is 'to share' and how much takes place off-campus: at home or elsewhere. For instance, the corona crisis made every university reconsider how many days employees are allowed – or encouraged – to work from home. This (potentially) has a substantial effect on the demand for space on campus, community sense, utilization rates of existing facilities and energy use (among other aspects).

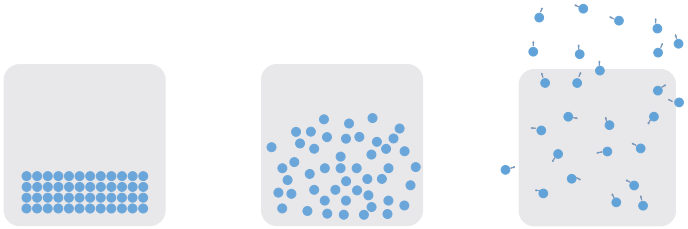


Figure 26: solid-liquid-gas ratio for organisational perspective.

One method to make organisational goals tangible is assessing the current campus on organisational criteria that matter, which is illustrated in figure 28 with a "blue stakeholder" next to a campus map and a spreadsheet. The question is which criteria could be used to determine which spaces or buildings add value – either positively or negatively – to the organisational goals? See figure 27 (list) for organisational ways of "adding value" with campus decisions. Which buildings contribute to organisational goals and which buildings hinder goals (and why)? Exemplary queries could be:

- which spaces are most public (for all), shared (multiple campus groups) and most private (designated users only)?
- which spaces support innovations in education – for instance: hybrid learning – that the university aims for?
- which spaces – for instance: laboratories – are most suitable for collaboration with university partners?
- which spaces demonstrate the university's legacy (alumni, production, inventions, impact) or what the university is proud of?
- which spaces are used as living lab or showcase work-in-progress and what the university is planning to achieve, in education, research and valorisation?
- which spaces most / least express the university's culture, identity and values? (which buildings are most used in media and corporate communication, which spaces are most used for ceremonial photos?)

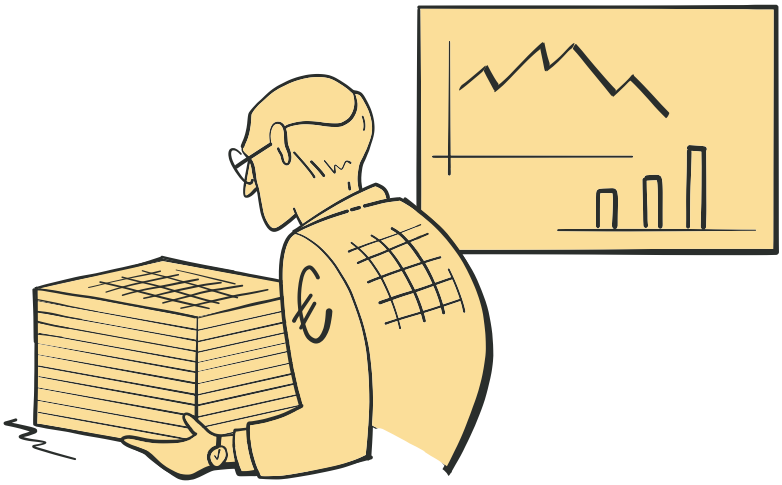
The questions above can be linked to added values (see figure 27) and can be answered for both the current situation as the campus of the future: what would, could or should be the most suitable spaces for traditional, network and (zooming out to city/region) virtual campus activities in education, research and valorisation? These preferences then

Figure 27: organisational added values

should be matched with the preferences and conditions that come from the other sides of the table.

Figure 28: assessing the campus from an organisational perspective: which spaces are most suitable to support our organisational goals? (Illustration Mark van Huystee 2020)

The financial perspective on managing the campus



financial sustainability

property value

private versus public funding

costs per m2

feasibility

benefits

total costs of ownership

business model
cost and benefits

alternative
investments

% campus costs of
total costs

Figure 29a the financial perspective at the "management table": the controllers. (Illustration Mark van Huystee 2020)

Figure 29b: financial keywords in random order from interviews Campus NL 2016 and 2020/2021. (Campus NL 2016, 2020)

Representing "controllers" in yellow, the financial perspective brings a reality check for many strategic choices to the table. For instance, "how large, how specialised and how selective can we afford to be?", which links the organisational to the financial perspective. The budgetary situation of many European universities has already demonstrated for years or even decades that the financial context often determines strategic choices. The term "business model" has entered the university board room long ago, since public funding has been under pressure. As campus property owners, many universities not only calculate the costs per m^2, but the total costs of ownership. Controllers perform feasibility studies, assess financial sustainability and weigh investments in the campus against direct investments in education and research. These are some of the themes that can be recognised in financial guidelines and conditions, which are brought to the table in spreadsheets, charts and stacked piles in the illustration, see figure 29 (a+b).

financial matters

For making a campus decision, the budgetary context needs to be translated to financial requirements for the campus. For controllers, it is a challenge to allocate (increasingly) scarce financial resources to education, research, salaries of personnel and facilities. The following issues and notions from prior research are relevant for this perspective:

- "If you think the campus is expensive, try ignoring it". With this sentence in my dissertation's introduction (in 2011) I loosely referred to "If you think education is expensive, try ignorance" (JFK/Harvard president Derek Bok). From the beginning, I wanted to emphasize that the campus is an essential resource in achieving goals, which is indeed capital-intensive. At the same time, that is all the more reason to carefully assess if every m2 is really necessary for the goals and activities of the organisation.

- "Sustainable universities, also financially". More and more often, European universities are assessing their financial sustainability, while some discover that they are not "too big to fail" and actually go bankrupt. Increasingly, universities

in Europe are considered autonomous institutions that are responsible for their own management, including the financial risks. The aging campus - with backlog maintenance in need of substantial reinvestments - adds to those risks.

- "Short-term funding conditions increase risks". At the same time, funding flows have become more unpredictable with shorter research contracts and more mobility among students world-wide. Today's student community and research portfolio are very dynamic: while once quite stable, they can now change rapidly in size and in specialisation. Consequently, space demand also rapidly changes and investments which require long-term payback are hardly ever feasible and very risky.

- "To share or not to be, that is the question". Consequently, universities join forces with network partners, for strategic purposes, but also for financial reasons. "To share of not to be" is a phrase that I used in my presentations (as a variation of Shakespeare's "To be or not to be"): a shared laboratory or no laboratory. In this sense, sharing becomes a positive choice instead of a negative choice, which it is still for many who are used to having exclusive access to specific university facilities.

- "From cost control to total costs of ownership (TCO)". Financial campus management has professionalised from focusing on (only) "cost control" to calculating the total costs of ownership and comparing them with the benefits and values. Opportunity costs – "the loss of other alternatives when one alternative is chosen" – are also considered. As a teacher, I often illustrate this by asking architecture students about campus decisions. At first, they are always in favour of investing in the campus. Until I illustrate which amount of money is involved and which direct investments in education or student ICT facilities could be alternative choices. Then, they reconsider and often change their minds. This also demonstrates that students can switch sides of the table: from the physical (green) side to the functional (orange) side. As taxpayers, they could even move to the financial (yellow) side and as political representatives of their community, to the (blue) organisational side.

- "Accountability and political attention". The financial perspective in broader sense does not only bring university controllers to the table, but also accountants at ministries of education and science and certainly also the taxpayers, since public resources are involved. Accountability for the allocation of resources, political attention and public criticism in the media are increasingly important.

- "Spending taxpayers' money on campus". Spending public resources – and taxpayers' money – responsibly could be considered the most important added value from the financial perspective. Within the university, controlling risk and assuring financial sustainability are important by monitoring the total costs of ownership and the utilization of capital-intensive floor area, which relates this perspective to the functional (orange) perspective.

What is considered a threat to "the table" is that financial criteria and conditions pile up and the campus decision making process stops, because it is "not feasible". To avoid this impasse, the financial perspective could be encouraged to judge to which extent a building or "space" meets the financial criteria. Additionally, the controllers and other stakeholders from the yellow perspective could be encouraged to take the positions of other stakeholders at the table in serious gaming sessions (see part C for examples).

financial assessment criteria

In essence, the financial context substantially affects the solid-liquid-gas ratio on campus: how traditional, networked and virtual can we afford to be as a university? (see figure 30) Financial criteria determine how much space we can afford to reserve for designated groups, how much 'shared space' can we co-finance with partners and how much takes place off-campus: at home or elsewhere (and who pays the bill for that). For instance, the corona crisis made every university reconsider how many days employees are allowed – or encouraged – to work from home. At the same time, employees are struggling with space at home, also due to the housing prices. To what extent will the university cover the home workplace costs? Probably not the "total costs of ownership".

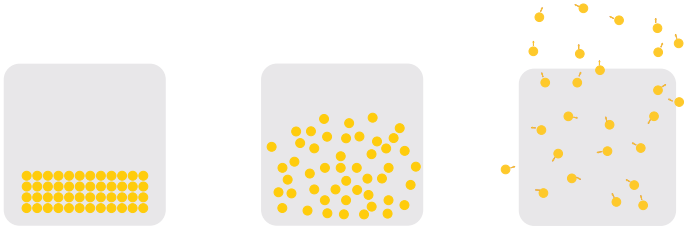


Figure 30: solid-liquid-gas ratio for financial perspective.

One method to make financial goals tangible is assessing the current campus on financial criteria that matter, which is illustrated in figure 32 with a "yellow stakeholder" next to a campus map and a spreadsheet. The question is which criteria could be used to determine which spaces or buildings add value – either positively or negatively – to the financial goals? See figure 31 (list) for financial ways of "adding value" with campus decisions. Which buildings contribute to financial goals and which buildings hinder goals (and why)? Exemplary queries could be:

- which spaces have the highest and the lowest costs? (from maintenance costs to total costs of ownership)
- which spaces have high costs and low utilization rates? (this relates to the orange, functional perspective)
- which spaces have the highest value (benefits for alternative users), for university functions, university-related functions and for other functions (market value*)
- *market value is often theoretical, considering the specific function, location and size of university buildings: they are usually extra-large (see chapter A2 for other XL public real estate): too large for most organisations that need accommodation; instead, the value is determined by the interest of co-funding partners in educational and research, including industry, governments and civil society (quadruple-helix partners).

The questions above can be linked to added values (see figure 31) and can be answered for both the current situation as the campus of the future: what would, could or should be the most suitable spaces for traditional, network and (zooming out to city/region) virtual campus activities in education, research and valorisation? These preferences then should be matched with the preferences and conditions that come from the other sides of the table.

financial added values

spending
public resources responsibly

safeguarding
financial sustainability

reducing
financial risks

enhancing
co-funding potential

reducing
total costs of ownership

supporting
resource-efficiency

increasing
financial flexibility

Figure 31: financial added values

Figure 32: assessing the campus from a financial perspective: which spaces are most suitable to support our financial goals? (Illustration Mark van Huystee 2020)

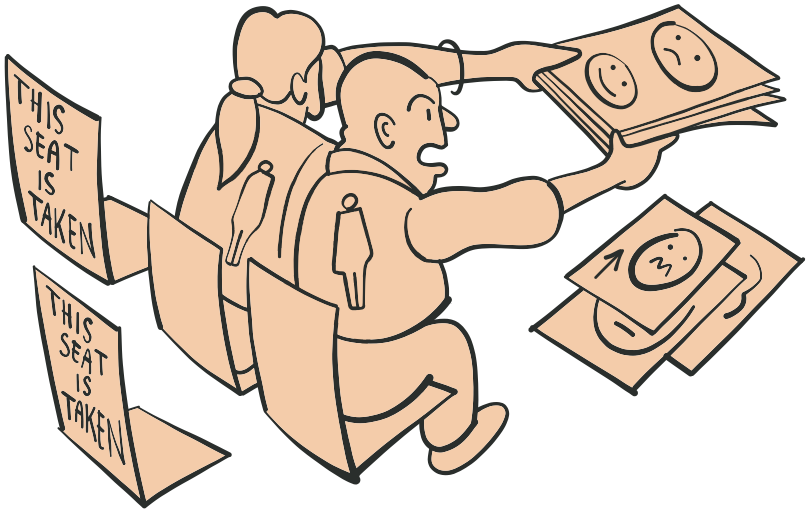


Figure 33a: the functional perspective at the "management table": the users. (Illustration Mark van Huystee 2020)

Figure 33b: functional keywords in random order from interviews Campus NL 2016 and 2020/2021 (Campus NL 2016, 2020)

Representing "users" in orange, the functional perspective brings the individual needs to the table. This differs from the blue, organisational perspective, which focuses on institutional goals and the collective needs of the community. However, these perspectives are also connected, since they both focus on the demand side of the campus decision: on respectively strategic and operational level. The main question is: "What do users demand from the campus, now and in the future?" Keywords like community, silence, territory and well-being are often mentioned in interviews. Users can be categorised in different groups – students, academics, support staff, visitors – but the individual needs in the same group can still differ. These are some of the themes that can be recognised in user requirements and satisfaction surveys, which are brought to the table on sheets of paper with smileys and other emoticons in the illustration, see figure 33 (a+b).

functional matters

For making a campus decision, user demands need to be translated to quality and quantity requirements for the campus. Ideally, the campus supports demands of all user groups – the orange, functional perspective will aim at maximizing this support. The following issues and notions from prior research are relevant for this perspective:

- "The campus as a place for many". User activities (in education, research and valorisation at universities) are the basis of user demand. Figure 53 (page 120) shows the division of functional space types on campus, which demonstrates that office space is the most predominant function on campus, while many (internal and external stakeholders) expect it to be classrooms and lecture halls. However, sharing office space for educational purposes (meeting rooms for student presentations etc.) is a resource-efficient development. At the same time, this has made it harder to categorize function types and to measure the types of use (education, research) by the types of spaces (office, lecture halls, libraries etc.). Lecture halls are also used for research, study places at libraries are also used by staff and guests. Figure 53 also illustrates which space functions can accommodate which activities with an example from Campus NL.

- "Dynamics in demand". User demand has become much more dynamic in the past decades, because the size of user groups has become more unpredictable (more student mobility, shorter contracts for employees) and user groups have become more heterogenous, also in terms of needs. Also, the increasing number of visitors, short-stay guests and representatives of university partners has made user demand more diverse. In this context, the term "neurodiversity" is mention more often, to take into account when designing study places and workspaces. It has become more complex to satisfy all user needs, since they are sometimes contradictory.

- As a basis for user needs, Maslov's "hierarchy of needs" (1954) is often referenced, for instance by Blyth and Worthington in 2001, translated to built environment demands. For our campus research, we also use this pyramid (adapted from Maslov 1954, Blyth and Worthington 2001, applied to the campus for benchmark research from 2004) to express the cumulative human needs: a healthy, safe, social, attractive and inspiring workplace. These were used for quality assessments of both buildings and portfolios, also divided in three quality levels: from plain & efficient (meeting health and safety demands), to meeting place (adding social & attractive), to representative icon (adding inspiring). From 2006, we applied those labels to buildings and percentages of floor area in our databases (see my 2011 dissertation and part C of this book for examples). While subjective, we distinguished basic quality that meets the minimal technical conditions (plain & efficient) from quality levels that serve the social needs of the university community (meeting place) and the reputation of the university or its impact on society (representative icon).

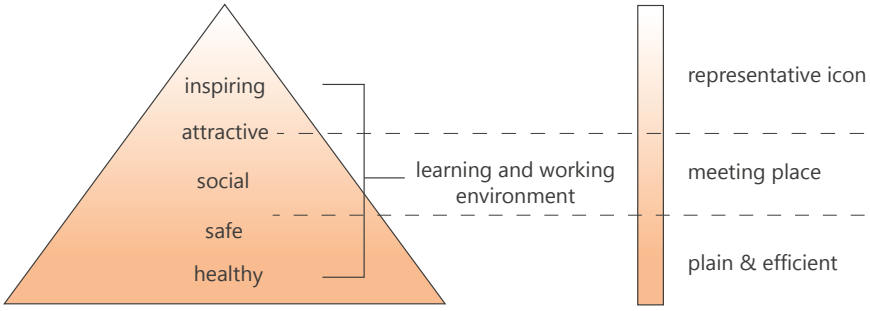


Figure 34: pyramid with Maslov's "hierachy of needs" (adapted from Maslov 1954, Blyth and Worthington 2001, as used in dissertation 2011 *Managing the university campus* and more recent research for quality assessments).

- "The campus of the future has bipolar demands": accommodate offline and online, silence and buzz, analogue (no-tech) and digital (high-tech). I have used phrase – also with the word "binary" instead of bipolar – in many presentations and based this on our assessment of functional requirements of recent campus projects. The seemingly contradictory demands that can even come from a single user, who comes to the campus to learn or work in silence, but also needs the "buzz" of a community and vibrant campus in the breaks. The same goes for offline time and online time: we need it both to be productive. And after at least one (corona) year of digital solutions for practically every activity, we also cherish "analogue" again: making written notes, physical meetings without laptops and lectures without slides.

- "Mental well-being" has become one of the most important themes for both human resource management (for employees) and student affairs. Even before the corona crisis, the pressure on students and staff was already very high. The value of a healthy, safe and social workplace is acknowledged as crucial in universities' health programmes.

***Sharing should often be interpreted as 'time-sharing'**

sharing

using the same facilities at the same time; the advantage is that facilities can be used at any time, without reservations; the risk is that facilities are (too) full at some moments and vacant at other moments

time-sharing

using the same facilities at different times; often organised with a reservation or booking system

source: own definition

- "Silence is the new scarcity" is another statement that I posed after our Campus NL research (2017), when quiet study places appeared to be the "most-wanted" space type on Dutch campuses. For employees, that is still the territorial office, while utilization rates have become lower and lower over the years, because of the transition from the traditional university to the network and virtual university, as described in chapter B1. The combination of these two user demands could also provide solutions for both, when user groups are willing to time-share: using the same facilities at different times. Figure 55 (page 132) shows a map with the use of the TU Delft campus in time, also as feedback for managers and users about utilization).

What is considered a threat to "the table" is that a diversity of (contradicting) user demands and (dis)satisfaction reports pile up and the campus decision making process stops, because it is "not satisfactory" for all. To avoid this impasse, the functional perspective could be encouraged to judge to which extent a building or "space" meets the functional criteria. Additionally, the users and other stakeholders from the orange perspective could be encouraged to take the positions of other stakeholders at the table in serious gaming sessions (see part C for examples).

functional assessment criteria

In essence, the patterns of user behaviour determine the solid-liquid-gas ratio on campus: how traditional, networked and virtual do employees work and students learn? (see figure 35) Top-down, the policy makers can set boundaries for this ratio. Nonetheless, they also have to take user needs and preferences into account.

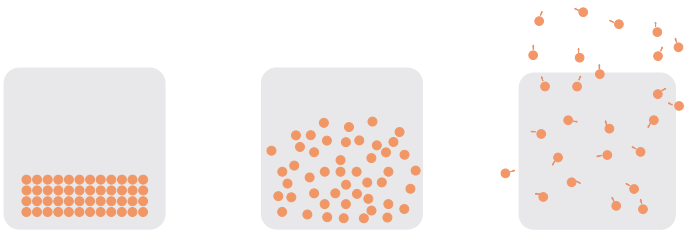


Figure 35: solid-liquid-gas ratio for functional perspective

One method to make functional goals tangible is assessing the current campus on functional criteria that matter, which is illustrated in figure 37 with an "orange stakeholder" next to a campus map and a spreadsheet. The question is which criteria could be used to determine which spaces or buildings add value – either positively or negatively – to the functional goals? See figure 36 (list) for functional ways of "adding value" with campus decisions. Which buildings contribute to functional goals and which buildings hinder goals (and why)? Exemplary queries could be:

- which spaces best support (specific) user activities, like hybrid learning, quiet studying, state-of-the art labs? and which have functional problems?

- which spaces are most and least valued by user groups (for silence, community, pride, ...), and why?

functional added values

supporting
user activities

enabling
productivity

safeguarding
health and well-being

silence, privacy

sense of belonging, homebase

identity, pride

increasing
user satisfaction

encouraging
user engagement

Figure 36: functional added values

- which spaces meet the cumulative human needs: healthy, safe, social, attractive and inspiring? alternatively: applying the quality levels "plain & efficient", "meeting place" and "representative icon" (as in our campus databases)

- which spaces have highest and lowest utilization rates*? which timeslots are most and least used?

  * Generating reliable utilization rates, based on real-time use instead of scheduled use, is an important management (and research) theme; this is part of research project "smart campus tools" that I will elaborate at the end of part B3 and in part C4; additionally, project "Campus NL 2023-2027" for utilization data for office space (Den Heijer et al. 2024) and educational space.

The questions above can be linked to added values (see figure 37) and can be answered for both the current situation as the campus of the future: what would, could or should be the most suitable spaces for traditional, network and (zooming out to city/region) virtual campus activities in education, research and valorisation? These preferences then should be matched with the preferences and conditions that come from the other sides of the table.

Figure 37: assessing the campus from a functional perspective: which spaces are most suitable to support our functional goals? (Illustration Mark van Huystee 2020)

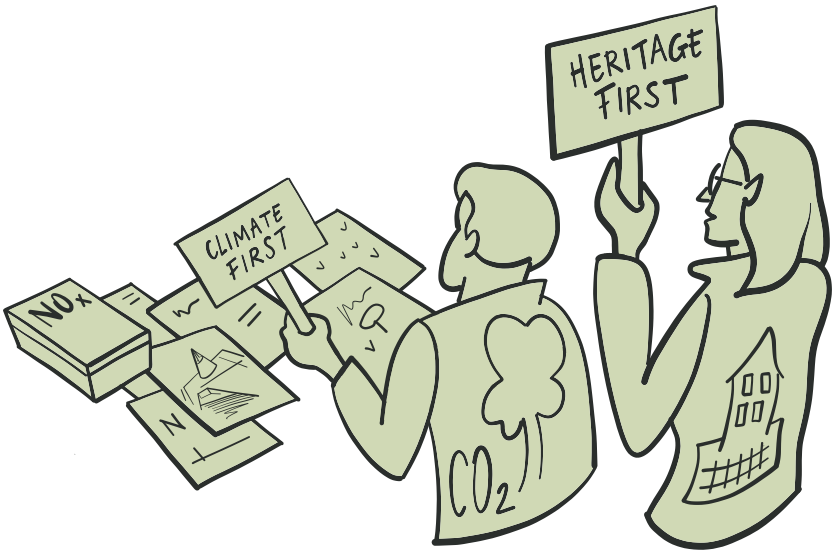


Figure 38a: the physical perspective at the "management table": the engineers. (Illustration Mark van Huystee 2020)

Figure 38b: physical keywords in random order from interviews Campus NL 2016 and 2020/2021. (Campus NL 2016, 2020)

Representing "the engineers" in green, the physical perspective brings a range of environmental issues to the table. From energy-efficiency to circularity, from heritage value to technical conditions. How do we preserve the university's heritage and provide the community the quality of indoor and outdoor space to support their activities and to meet their expectations? What is the environmental footprint of our university and campus? How do we practise what we preach in sustainability (education and research) on our own campus and set an example for society? How do we reduce waste and contribute to circularity? How do we contribute to the UN's sustainable development goals (SDGs)? These are some of the themes that can be recognised in campus design guidelines, technical rules and regulations, sustainability plans and targets, which are brought to the table with activist urgency in the illustration, see figure 38 (a+b).

physical / environmental matters

For making a campus decision, environmental conditions, regulations and ambitions need to be translated to quality and quantity requirements for the campus. Ideally, the campus supports all these goals, legal space standards and restrictions – the green, physical perspective will aim at maximizing this support. The following issues and notions from prior research are relevant for this perspective:

- "The most effective way to reduce energy is to reduce the campus". With this first statement in our sustainable campus research in 2008 – commissioned by the Dutch government, for all Dutch universities – I wanted to challenge some "penny-wise pound-foolish solutions" that were suggested: strategies to reduce energy use, while I questioned the need for certain floor area in general. Given the low utilization rates of some floor area, it would be most sustainable to reconsider "if we really needed to build more".

- "Trade quantity for quality of space". There are many quality requirements: for heritage, urban setting, landscape, interior design and minimal technical conditions

condition structure

Excellent	21 %
	917,000 m2
Good	28 %
	1,230,000 m2
moderate	21 %
	911,000 m2
below average	15 %
	667,000 m2
bad	12 %
	538,000 m2
very bad	3 %
	152,000 m2

age structure 2015

< 1910	7 %
10's	2 %
20's	1 %
30's	0 %
40's	1 %
50's	3 %
60's	17 %
70's	26 %
80's	13 %
90's	10 %
00's	14 %
> 2010	8 %

Figure 39: Condition and age structure (Campus NL 2016)

for health & safety. Considering the scarce resources, both in terms of energy and finance, quality is often only affordable or acceptable, if the footprint for the organisation is reduced. Preserving quality (for instance: heritage) by saving resources on the required quantity of space.

- "The virtual campus is less sustainable than the reduction of m^2 on campus might suggest." with this proposition for my PhD defence (in 2011), I wanted to emphasize that the transition towards a more virtual campus - with more activities accommodated off-campus and at home – might lower the energy use of universities, but moves it to the households of employees and students and other organisations. What is more sustainable: accommodating 300 students in one lecture hall on campus or 300 students at home, following an online lecture? Providing academic offices on campus or supporting the home office? The transition towards the virtual university demonstrated that the off-campus facilities did not make the on-campus facilities disappear, which even increases the use of resources. In 2021, when universities rethink the ratio between on-campus and off-campus activities and environmental issues are even more pressing, this sustainability challenge is higher on the agenda than ever.

- "The university's heritage is cherished by many". European universities manage a substantial amount of heritage buildings. Their relatively old age and long legacy can also be observed from the characteristics of their portfolio of buildings: the inner-city locations, industrial setting and/or landmark function in cities. Their large size or century-old history contribute to their presence and impact on the population, visitors and tourists. Many of them are also prominently present on home pages of universities, used to underpin the institution's image. Consequently, decisions about campus heritage do not only affect the university community, but also the population. Emotional responses of the public to (planned) interventions in university heritage are quite common. For those campus decisions, the green perspective at the negotiation table also includes the general public in the background.

photos (L-R): Academische Club UvA (AdH), Bibliotheek KU Leuven (AdH) and Lu Xùn statue at Sun Yat-Sen University Guangzhou Campus (Takeshi Morisato / Unsplash 2019)

- "Backlog maintenance is still an issue on the aging campus". While sustainability issues dominate the physical campus agenda, one issue has been on the agenda of campus property owners from the start: the aging campus and the managerial challenge to keep the condition on an acceptable level. Figure 39 illustrates both the age distribution and the condition scores of Campus NL in 2016. Budget and planning limitations make it hard for universities to follow the dynamics in demand with the relatively static supply and to keep up with the speed of replacement cycles of building components. Avoiding waste is an ambition, but the performance of education and research cannot be jeopardised either. Product-service systems that guarantee the performance (and not only provide the product) could be a solution, which have been studied and tested on our campus (Azcarate Aguerre 2023).

- "Practise what you preach". On many campuses – especially of universities of technology – engineers and designers are not only studying the smart and sustainable future of the built environment, but are also testing them in a living lab setting. Even at our own faculty of architecture and the built environment, this already applies to many research themes like heritage, landscape design, urbanism, circularity, climate design and sustainability (see figure 40), energy systems, facade engineering and – as our campus research team demonstrates – management in the built environment. As a research theme, we also explore the drivers and barriers of testbeds and living labs (see part C).

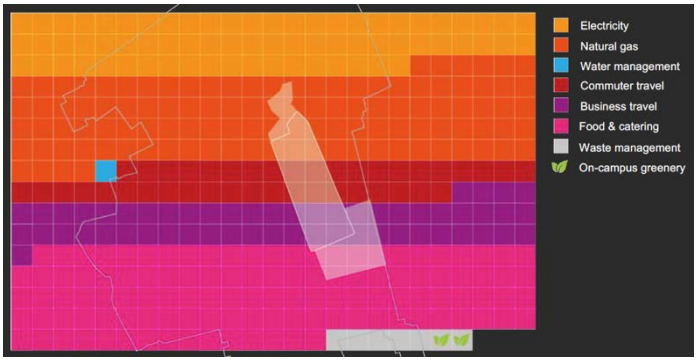


Figure 40: "TU Delft's Carbon Roadmap" (professor Andy van den Dobbelsteen & Tess Blom 2019), comparing the carbon footprint of the university with the real footprint (the projected campus map), illustrating the difference

- "There is no campus B". This phrase I have added to this perspective to emphasize the urgencies – the need for sustainability, circularity and resource-efficiency – and to challenge the (ambitious) demand-driven campus strategies of the past and replace them with (scarce-)supply-driven strategies for the future.

What is considered a threat to "the table" is that the urgent agenda and activist attitude leaves no solution space for other perspectives and the campus decision making process stops, because it is "unnegotiable" for the rest. To avoid this impasse, the physical perspective could be encouraged to judge to which extent a building or "space" meets the physical criteria. Additionally, the engineers and other stakeholders from the green perspective could be encouraged to take the positions of other stakeholders at the table in serious gaming sessions (see part C for examples).

physical / environmental assessment criteria

In essence, the physical campus conditions and environmental restrictions can enable or disable the required solid-liquid-gas ratio on campus: how traditional, networked and virtual can our campus be? (see figure 41) Or how networked and virtual does it need to be to achieve our sustainability goals? Many state that the traditional model is the least sustainable, while it reserves space for designated groups, which negatively affects utilization rates. Others state that shared spaces are unpersonal and less attractive

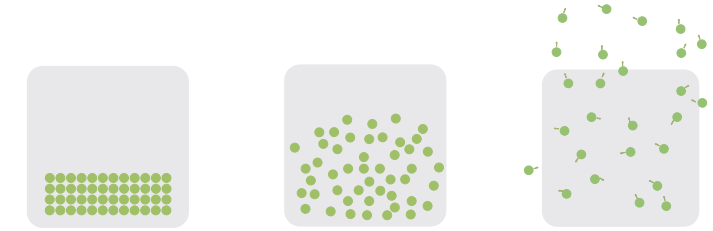


Figure 41: solid-liquid-gas ratio for physical perspective

physical added values

- maintaining technical performance
- preserving heritage
- providing quality of place
- reducing the m^2 footprint
- reducing the carbon footprint
- avoiding waste
- stimulating circularity

Figure 42: physical added values

to use (than territorial zones) and are therefore not convincing employees to come to campus. Quality of place matters. How do we encourage sharing space and can create a sense of belonging (like in a hotel room that temporary feels like home, while it is obviously time-shared space). This can be considered a design challenge as well as a managerial challenge.

One method to make physical goals tangible is assessing the current campus on physical criteria that matter, which is illustrated in Figure 43 with a "green stakeholder" next to a campus map and a spreadsheet. The question is which criteria could be used to determine which spaces or buildings add value – either positively or negatively – to the physical goals? See figure 42 (list) for organisational ways of "adding value" with campus decisions. Exemplary queries could be:

- which spaces have the highest and lowest energy use?
- what is the technical condition of our buildings?
- which spaces are (in)flexible to accommodate different types of use or user groups?
- which buildings have a national or municipal heritage status? (compare with queries for organisational assessment criteria like: which spaces most / least express the university's culture, identity and values?)
- which buildings are (most suitable for) applying circular solutions?
- which buildings are best and least prepared for climate change?
- which zones on campus (can) serve as water storage zones in case of heavy rain?

The questions above can be linked to added values (see figure 42) and can be answered for both the current situation as the campus of the future: what would, could or should be the most suitable spaces for traditional, network and (zooming out to city/region) virtual campus activities in education, research and valorisation? These preferences then should be matched with the preferences and conditions that come from the other sides of the table.

Figure 43: assessing the campus from a physical perspective: which spaces are most suitable to support our physical goals? (Illustration Mark van Huystee 2020)

Connecting four perspectives on managing the campus

Figure 44a: the Campus management perspective at the "management table": the campus manager. (Illustration Mark van Huystee 2020)

Figure 44b: Campus management keywords in random order from interviews Campus NL 2016 and 2020/2021. (Campus NL 2016, 2020)

The stakeholder in the middle represents "the campus manager", according to our own definition of campus management as the process of adding value to performance by balancing four perspectives, connecting organisational, functional, financial and physical variables in every decision. Obviously, by looking at the illustration, this stakeholder struggles with the complex task he has. Picking up the multi-coloured pieces of the campus management puzzle, he needs support in the process of finding solution space for all goals that are brought to the table, even though the conditions that the same stakeholders added easily leave no solution space at all.

"We want more space, but need to reduce the ecological footprint; we need to refurbish all our heritage buildings, but for half of the costs." These are just two examples of the contradiction that the campus manager has to deal with. Who is this campus manager? What does he need to know to play this role? How can we support him better? Those questions are answered below. In any case, the campus manager – or any stakeholder or politician in this position at negotiation tables – deserves more respect.

campus management matters

For making a campus decision, environmental conditions, regulations and ambitions need to be translated to quality and quantity requirements for the campus. Ideally, the campus supports all these goals, legal space standards and restrictions – the green, physical perspective will aim at maximizing this support. The following issues and notions from prior research are relevant for this perspective:

- "Who is the campus manager? The role of the campus manager can be played by many actors". In practice, the role of the campus manager is often taken on by a representative of an internal campus, (real) estate or facilities department, but it can also be played by an architect, consultant or external project manager. Universities (and other organisations with public real estate) should ask themselves the question: who is taking the role of the person in the middle?

- "It takes a generalist to play the role of campus manager". The educational, professional or scientific background of a campus manager can play a role in how he prioritises in making campus decisions. In practice, it is likely that someone with an economic background has better understanding of the financial criteria and might put them on top of the assessment criteria. The same goes for campus managers with an architecture background: they might give architectural value an extra weight in decision making. Ideally, the role of the campus manager is played by someone who has understanding of – and an equal affinity with – each of the four stakeholder perspectives, however hard to find. Like the campus, a manager can be enabling and disabling, depending on his quality.

- "The campus manager is preferably like a catalyst, not like an emulsifier." My preference for metaphors from chemistry, physics and biology, also made me make this statement about managers and management in a position paper I wrote in 2017. What I wanted to express with this statement is that (campus) managers should "help to bring about a change" without being too intrusive or indispensable in the long term, like a catalyst. The manager as emulsifier is quite the opposite, preventing liquids that ordinarily do not mix – like oil and water – from separating. Oil and water could be metaphors for the different types of stakeholders around the negotiation table whose goals do not easily mix. The added value of "emulsifier managers" will be hard to deny, but the disadvantage is that the manager cannot easily leave the process afterwards (see C1 for definitions and images in a text box). I prefer the catalyst over the emulsifier approach in management and leadership, while I think the manager should only enable and not be part of the solution.

- "It is much harder to be in the middle than in any other position around the table". There should be more respect for the (campus) manager as integrator. It is much easier to plead for and from only one perspective (one-dimensional) – and lobby for the maximum – than to be the campus manager in the middle who needs to optimize and (by definition) needs to disappoint some stakeholders around the table. Every stakeholder brings relevant goals, needs and conditions to the table, but they are often conflicting (expressed with different colours) and the person in the middle needs (to help) to solve the multi-coloured puzzle. The most common "threat" in management processes is that every stakeholder can bring their maximum request to the table and "expectations are not managed" that either the solutions require stakeholders to compromise or solutions are not possible (and processes are delayed). How stakeholders can be encouraged to co-create optimal solutions with "the person in the middle" is one of our research missions.

- "Respect the connector" - I plead for more respect for the person in the middle, both at universities and in other organisations that own and/or manage public real estate. In general, I respect connectors in society and politics, who strive for optimal solutions, while many negotiation tables have polarised.

What is considered a threat to "the table" is that all matters pile up and either the process pauses by lack of solution space or the campus manager gives up and resigns. Of course, one of the stakeholders can be very dominant and use his power to push his ideal solution. The challenge is to find an optimal solution. Our mission as a research team to support the campus manager with that task, however complex with the number of added values to balance.

campus assessment criteria – added values to consider and connect in campus decisions

Each of the stakeholders can bring urgencies to the table and propose solutions with added value. Their impact needs to be evaluated with the other stakeholders' assessment criteria, connected to their added values. Figure 45 summarizes the "added values" that the four stakeholders strive for, which can all be reasons to intervene in the campus. The collective of added values illustrates the complexity of the management challenge.

In all projects of TU Delft's Campus Research Team, the objective is to provide campus managers with information and tools to support decision-making on the campus, and as such to enable, adding value to the performance of the organisation.

campus assessment criteria – more and more issues to consider over the years

- Over the years, the complexity of campus management has only increased, as already introduced in part A for public real estate management (figure 5), with more and more "added values" to consider. This made the task of "the connector in the middle of the table" increasingly hard. Figure 45 demonstrates – based on the longitudinal observation of Dutch universities – that not only more perspectives are added in time, but also more aspects per perspective. An explanation from left to right is given, interweaving the "added values" of different perspectives, resulting in cumulative complexity:

- Naturally, the physical perspective was the first to consider in campus management: assessing the technical condition of the building as a logical foundation for (corrective) maintenance planning: (only) fixing what was already broken. Gradually, this approach moved to preventive maintenance, anticipating on the average lifecycles of building components.

- When functional matters were added to the decision-making table, supporting user activities (education and research) and the campus' influence on productivity and user satisfaction became important drivers for maintenance planning.

- When financial incentives were added, backlog maintenance was higher on the agenda: what are the costs and benefits of postponing maintenance or replacement, also considering the negative effects on primary processes and employees' satisfaction and well-being?

- In the meantime, organisational goals as attracting talent and supporting identity and the physical themes of preserving cultural heritage and architectural quality were added to the list.

- In the past decades, sustainability goals were higher and higher on the agenda, including themes as energy-efficiency, circularity (avoiding waste) and CO2 neutrality.

- Financially, the shift moved from cost control to a total costs of ownership (TCO) approach, from property value to co-funding facilities with partners from education and research.

- Functionally, physical and mental well-being of both staff and students became more important. Additionally, diversity, inclusion and user engagement got more weight.

adding value

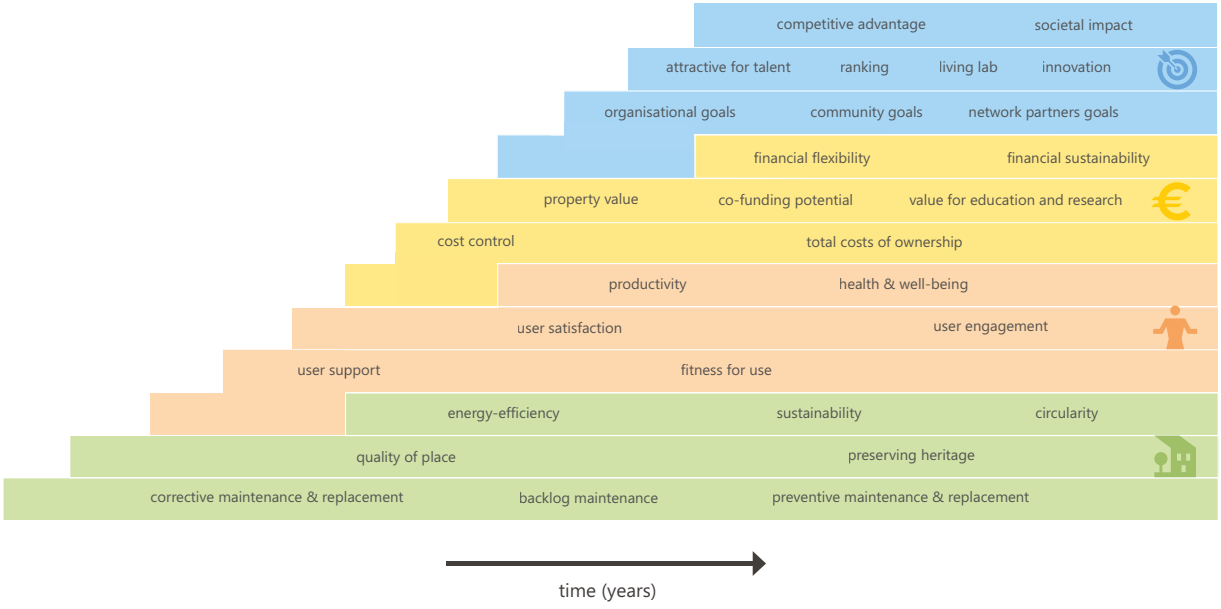
"Adding value is considered an activity or the sum of activities that (attempt to) influence the effect of the campus on performance: to prevent a negative effect or to realize a positive effect. That effect can be defined as "added value" and can be measured as a delta (Δ) in its performance, measured by comparing key performance indicators (KPIs) before and after the real estate intervention. This presumed impact of real estate on performance is the basis of real estate management." (this general definition also applies to campus management)

source: Den Heijer 2016

Figure 46 (R): stakeholders all suggest interventions for the campus from their perspectives, adding value to their goals; "which decisions do we agree upon and which not?"; how to prioritize and combine interventions is a collective campus management challenge that needs support. (Illustration Mark van Huystee 2020)

- Organisationally, the number of partners to consider increased, from univer-city collaboration to triple-helix and even quadruple-helix partnerships with industry and civil society (social engagement) and being part of a local community as much as a regional innovation cluster.
- At the same time, the focus moved from operational (short-term) criteria to strategic (long-term) criteria, even though the planning horizon became shorter and shorter because of uncertainty.

Figure 45: cumulative levels of campus management complexity and an increasing number of goals and conditions to consider, based on longitudinal observation of Dutch universities over the years.



Each of the added values can be reasons for stakeholders to intervene in the campus, as illustrated with the following examples:

- for the blue, organisational perspective that can be finding accommodation for a new research initiative, creating more space for living lab facilities, for state-of-the art hybrid learning facilities and for a merger between two faculties because of decreasing student numbers;
- for the yellow, financial perspective that can be budget cuts and the urgency to spend less on the campus or it can be finding co-funding partners for capital-intensive lab facilities or a strategy to sell (or demolish) buildings that are no longer feasible for the university;
- for the orange, functional perspective that can be a strong request for more quiet space to work or a need for more group space for students; it can also be a demand for more diversified restaurants or longer opening hours;
- for the green, physical perspective that can be an urgent call for climate-adaptive measures on campus to deal with more extreme weather (heat, heavy rain etc.) or ambitions for more energy-efficient buildings.

Each (suggested) intervention has not only effect on the goals of the stakeholder who initiated it, but also on the three others, since every decision has effect on all goals. This is illustrated with a simplified switchboard in figure 47 , with connected switches for organisational, financial, functional and physical goals: if you move one, all others move as well.

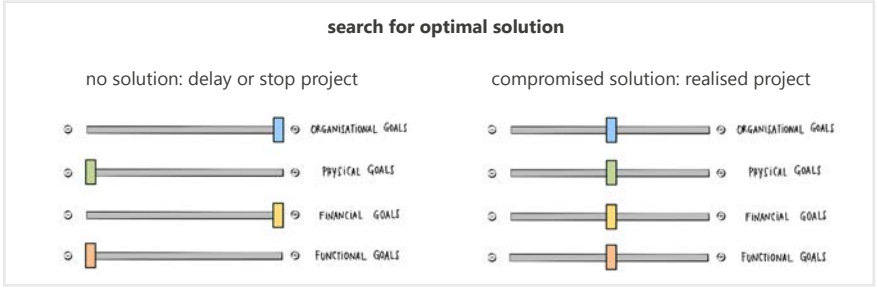


Figure 47: simplified illustration of connected "switches" in campus management - from minimal added value (switch to the left) to maximum added value (switch to the right) - if you move one, all others move as well. (Illustration Mark van Huystee 2020)

In reality, each switch in the switchboard represents multiple "mini-switches" with performance indicators that are connected to added values, as illustrated in figure 48 for only one of the four perspectives.

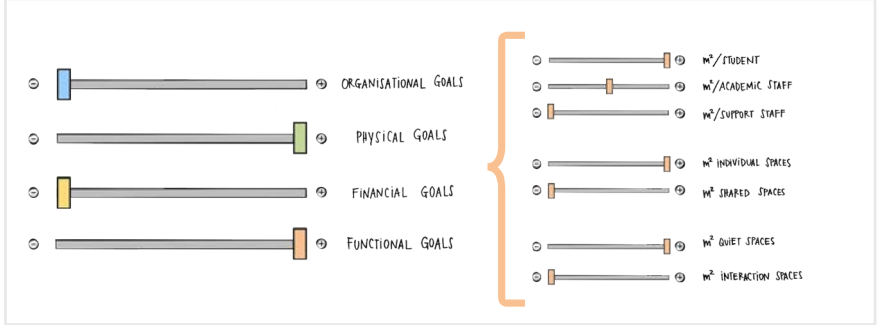


Figure 48: in reality, each switch in the switchboard represents multiple "mini-switches" with performance indicators that are connected to "added values". (Illustration Mark van Huystee 2020)

Needless to say, that overseeing the effect on all campus management indicators is too much to handle for the human brain and that support is required from management information systems, peer networks with expertise, theories, methods and tools. Over the years, as a campus research team, we have put effort in assisting not only campus managers, but the whole negotiation table with that challenge.

campus research agenda

The overall mission of TU Delft's Campus Research Team is to support universities' decisions about (managing) their campuses, resulting in (more) inspiring, meaningful, functional, affordable, resource-efficient and sustainable built environments. Supporting campus managers (and other facilities and real estate managers) in their connecting roles has been our mission for more than 25 years. How we do that will be briefly introduced below. Recent results can be found in part C. For my inaugural speech, I divided our research agenda into four missions, with matching illustrations, see figure 49.

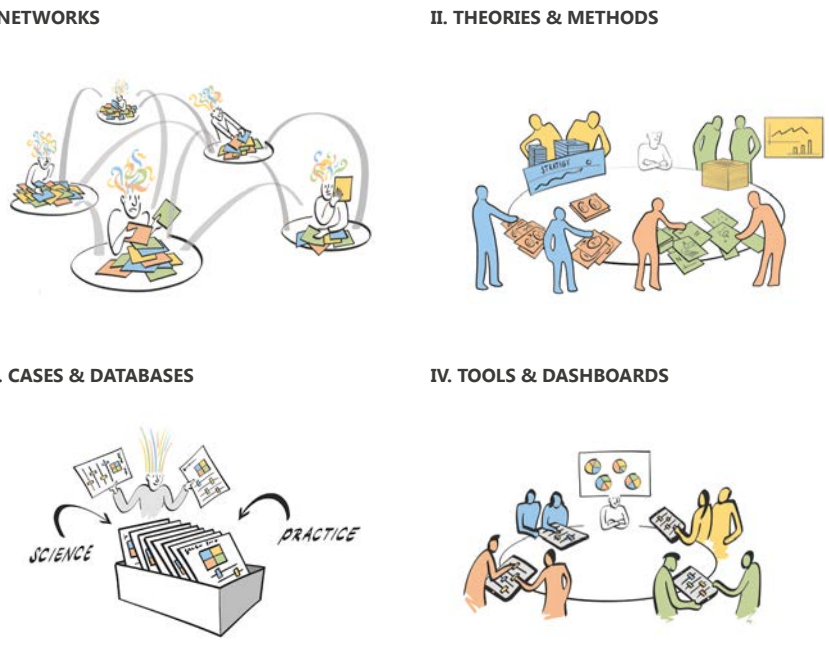


Figure 49: the agenda of TU Delft's Campus Research Team can be divided into four missions, which are chapters of part C. (Illustrations Mark van Huystee 2020)

These research missions have societal relevance – supporting the campus manager and other public real estate managers – and academic relevance, contributing to new knowledge, theories and innovations. When I started to present these topics in the year after my inaugural speech, I specified these research missions with more content:

I. Building **NETWORKS** – The campus manager in the middle of the table needs support from peers: other public real estate managers in the same position and campus managers at other universities. As a campus research team, we need a network of academic experts for knowledge exchange. Which (academic) networks are relevant to connect, depends on (who shares) our scientific view on campus management and the conceptual frameworks in our theories.

II. Developing **THEORIES & METHODS** – The campus manager needs methods to encourage the stakeholders around the table to think beyond their own goals, added values and conditions. Together, they need methods to find solutions. As

a campus research team, we need to gather theories and develop methods to support the decision-making process.

III. Collecting **CASES &** creating **DATABASES** – The campus manager needs benchmarks: references of solutions at other universities to compare with solutions of the own university. As a campus research team, we build databases of campuses and university projects to identify patterns in campus strategies, themes and trends. Any campus decision that has been taken – a new building or a refurbishment project – can be expressed in a "database card" with info about four perspectives, see figure 71 for example.

IV. Designing **TOOLS & DASHBOARDS** – The campus manager needs management information systems, dashboards and tools to oversee the consequences of decisions on multiple performance indicators; at the same time, tools can support each of the other stakeholders in finding solutions for their own goals with maximum added value for all stakeholders. As a campus team, we consider tools as a means to engage all stakeholders in finding optimal campus solutions, effectively making them all "campus managers".

Ideally, the person in the middle of the table can lean back and observe how the other stakeholders collectively find optimal solutions, with the help of methods, databases and tools, see figure 50. This situation illustrates that in my view – described earlier and in C1 – the campus manager is a catalyst instead of an emulsifier in the decision-making process.

Figure 50: ideally, all stakeholders' demands are negotiated with support of dashboards, smart tools and serious gaming, resulting in (more) inspiring & meaningful, functional, affordable, resource-efficient and sustainable campuses. (Illustration Mark van Huystee 2020)

As an academic that has supported campus managers for decades, I empathise with the person in the middle. Not only because I got to know so many of them and have heard their struggles, but also because I recognise their position. As an academic with "campus management" as scientific expertise – and public real estate in general – I often picture myself as being in the middle of a scientific table (or forcefield) with the same four perspectives: organisational sciences in blue, economics and real estate finance in yellow, psychology and other social sciences in orange and natural sciences, arts and technology in green. How to manage that in research, is the first topic of part C.




LEGO building blocks (photos Rosenke, Urteaga, Quintal / Unsplash 2019)

Chapter B4
Campus management strategies and themes

After stating that both the university and the campus of the future will be a combination of solid liquid and gas in section B2 and describing the management context in B3, this section B4 will be spent on specifying campus strategies and themes. These themes are based on evidence from the Campus NL study, which was published in Dutch at the end of 2016, and are updated with new insights from 2020/2021 interviews with all Dutch universities.

Campus strategy research: lessons from interviews, cases and databases

In the past decades, we – members of TU Delft's Campus Research Team– have collected the data of a broad range of university projects, supplied by all Dutch universities. For my dissertation in 2011, I could draw conclusions based on forty projects and I distinguished six project types and matching trends: (1) the changing academic workplace, (2) the flexible learning environment, (3) new faculty buildings, (4) state-of-the-art laboratories, (5) buildings for non-academic functions and (6) new life for old buildings. In 2013, seventeen new buildings were added to the database. For our Campus NL study in 2016, eight additional projects were assessed on basic variables, in order to draw conclusions about trends. In the resulting Campus NL report, ten trends were described, based on sixty-five projects in total. More about this database can be found in chapter C3.

From October 2020 – when most campuses were 'in lockdown' for more than six months – to January 2021 interviews with all thirteen Dutch universities were conducted, to reflect (up)on the most important trends and to discuss new ones. In the next sections, the most important campus themes will be described, also by using (project) examples. More scientific publications will be written about the patterns we identified in these interviews.

From the Campus NL study in 2016, campus themes have also been connected to the 'solid-liquid-gas' metaphors for the three future campus models, as already published (in Dutch) in the Campus NL report. As an example of a 'solid-liquid-gas' combination, universities can choose to accommodate the academic workplace (theme 1) as 'solid matter' with individual territory, the learning environment (theme 2) as 'liquid matter' with shared educational facilities and innovative laboratories (theme 4) as 'gas matter', off-campus and provided by research partners.

In the last section, the most-frequent combinations of campus themes are summarized and combined with management challenges in 'general campus strategies'. As a first step towards a campus strategy, each campus management stakeholder brings different interpretations of "solid, liquid and gas" as conceptual building blocks for the campus of the future. I will summarize these first.

Campus strategy components: four stakeholder interpretations of solid, liquid and gas

In essence, the four stakeholders have all brought elements for the solid-liquid-gas ratio of the campus decision (or strategy) to the negotiation table. Figure 51 demonstrates that the four stakeholder perspectives assign different characteristics to "solid, liquid and gas", which will be explained below.

The organisational choices have a huge influence on the solid-liquid-gas ratio on campus: how traditional, networked and virtual do we want to be as a university? Strategic choices determine how much space is assigned to designated groups, how much is 'to share' and how much takes place off-campus: at home or elsewhere.

The financial context substantially affects the solid-liquid-gas ratio on campus: how traditional, networked and virtual can we afford to be as a university? Financial criteria determine how much space we can afford to reserve for designated groups, how much 'shared space' can we co-finance with partners and how much takes place off-campus: at home or elsewhere (and who pays the bill for that).

The patterns of user behaviour determine the solid-liquid-gas ratio on campus: how traditional, networked and virtual do employees work and students learn? Top-down, the policy makers can set boundaries for this ratio. Nonetheless, their also have to take user needs and preferences into account.

The physical campus conditions and environmental restrictions can enable or disable the required solid-liquid-gas ratio on campus: how traditional, networked and virtual can our campus be? Or how networked and virtual does it need to be to achieve our sustainability goals?

solid-liquid-gas ratios on campus

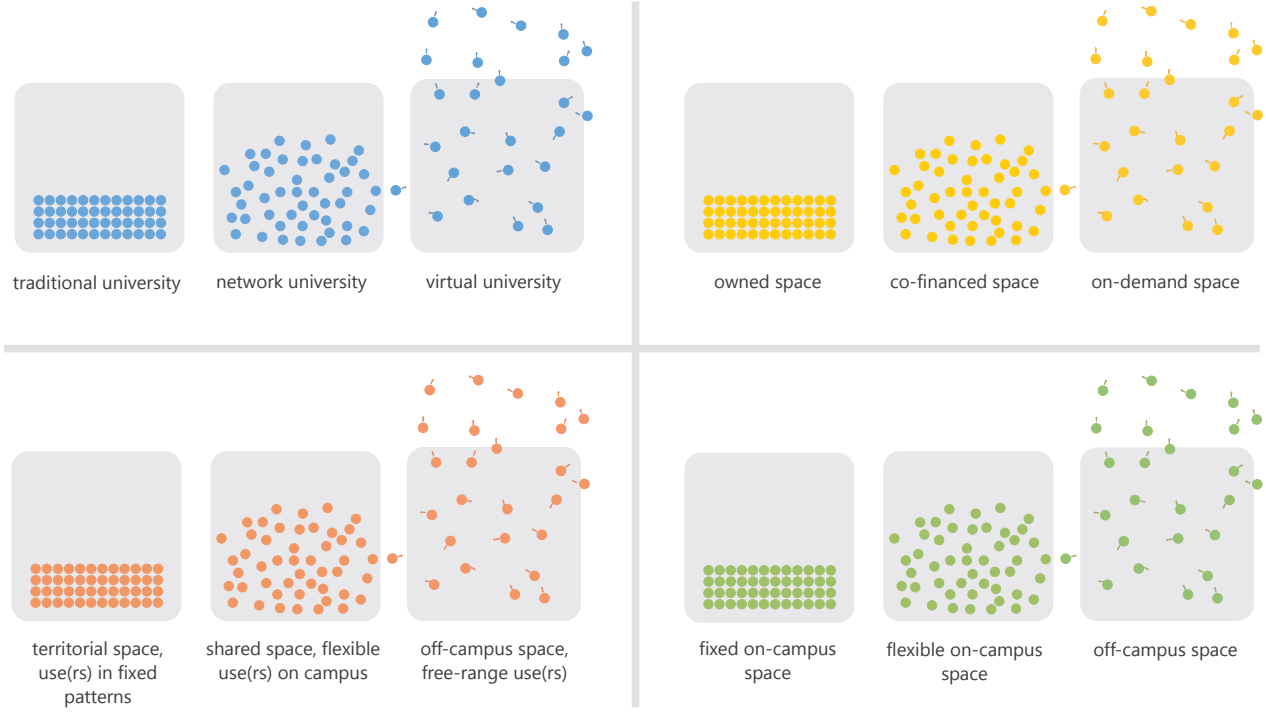


Figure 51: summary solid-liquid-gas ratios on campus for all four stakeholder perspectives.

These characteristics of "solid, liquid and gas" all represent degrees of flexibility of the campus of the future – organisational flexibility, user (functional) flexibility, financial flexibility and physical (technical and spatial) flexibility. I will elaborate on each of these flexibility types.

Campus strategy in uncertainty: add flexibility

In the past decades, flexibility in its various forms has already been essential in matching (increasingly) dynamic demand and (relatively) static supply. Due to the uncertain context of education and research and the university's ambitions to be more resource-efficient, flexibility will also be the key to success for future campus strategies.

If organisational demands on campus were 100% solid – predictable schedules in education, long-term research contracts and tenured academic staff with regular working hours – a fixed form of supply would suffice. Neither the organisation (and its users) nor the campus (and its finance) needed to be flexible. Nonetheless, as concluded earlier, the university community has become far more dynamic and supply has become more capital- and energy-intensive. Consequently, some forms of flexibility need to be implemented.

There are various types of flexibility (see figure 29) that are all connected to one of the campus management stakeholders and their preferences for "solid, liquid and gas" as introduced above.

"**Physical flexibility** is the degree in which the built environment can be changed in size, in structure or in lay-out, which requires technical measures (building extensions, removing or adding walls or floors)." This can be outside or inside the existing structure; the first form (outside) is referred to as "spatial flexibility" and the second form (inside) "technical flexibility". Expanding buildings with temporary tents is an example of spatial flexibility and so are rooftop supplements. Many universities have lecture halls that can be split or merged by mechanical "room dividers".

"**Functional flexibility** is the degree in which the built environment can be changed in function, for instance by changing the interior design, equipment or services in a room." Compared to physical flexibility, it does not require construction work, but it does need facilities services. Of course, there can be a thin line between physical and functional flexibility, if room dividers are very mobile. Where it differs: a space can also be functionally flexible by not changing anything physical, for instance by allowing both student activities and employee meetings in the same class room (at different times). Then, it is functionally flexible in scheduling and more versatile for campus management.

"**User flexibility** is the degree in which users are willing to share (and be less territorial) or time-share: the degree in which they are flexible in time." An example is the employee's willingness to (time-)share the workplace or to work late to avoid traffic jams.

"**Organisational flexibility** is the degree in which an organisation can reshape to align its activities and people with the (scarce) resources." An example is to use space – and schedule classes – during the evenings, to avoid having to build or rent more space during the day. User flexibility is connected, since the collective willingness of users determines the ability of the organisation bottom-up, regardless of top-down policies. Another example is a university's policy to work from home, when it is too crowded or to save space for sustainability purposes. Nonetheless, the success of this policy is dependent of the behaviour, possibilities and preferences of users.

"**Financial flexibility** is the degree in which the organisation can easily align the costs and benefits (of the built environment) with demand". An example is the

ability to rent additional space, on-demand, but also to end lease contracts as space is no longer needed. For owned space, it can be the extent to which other partners can be found for co-funding or as tenants for vacant space.

Physical and functional flexibility are linked to supply of space – and can be observed in the built environment – while user and organisational flexibility are related to demand for space and the willingness of people. Financial flexibility makes the demand-supply matching process more flexible or "fluid". In the metaphor of solid-liquid-gas: solidity of organisations, users, lease terms and built environments is by definitions least flexible, fluidity is more flexible, but the gas state is most flexible.

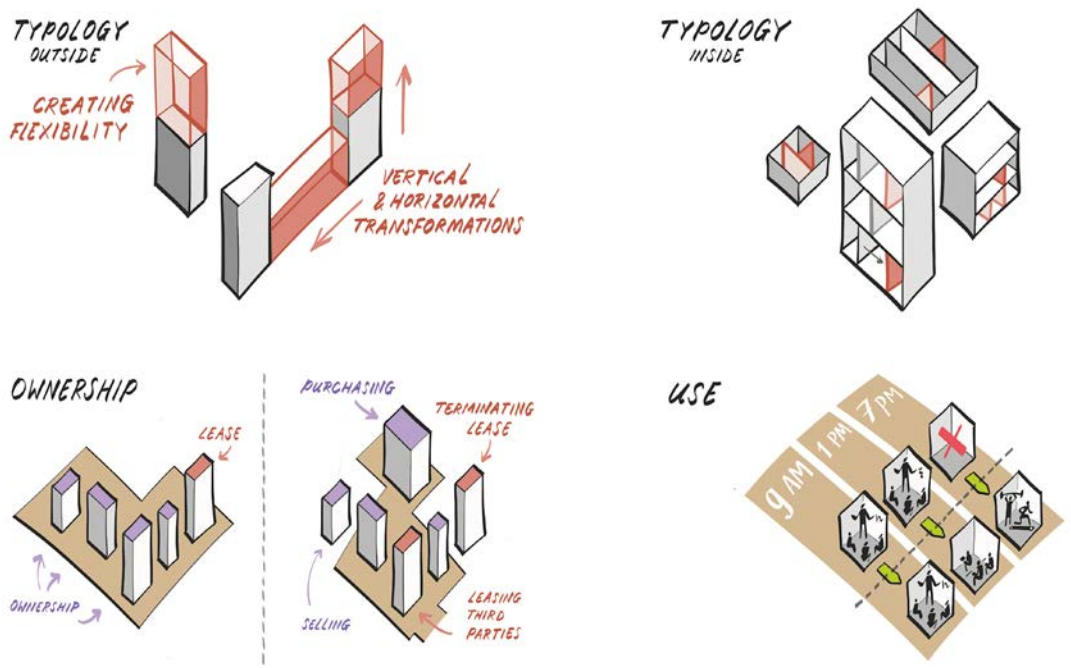
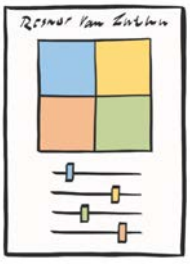


Figure 52: flexible strategies: (above) two types of physical flexibility – spatial (left) and technical (right) – and (below) financial flexibility (left) and organisational and user flexibility (right). (Illustration Mark van Huystee 2020)

For a demand-driven campus strategy – when supply needs to follow demand – the physical and financial flexibility need to be high. The resources need to be adjusted to the needs. For a supply-driven campus strategy – which is encouraged to meet sustainability goals – the flexibility is demanded from both the organisation and the users.

Recommendation for the campus strategy: carefully balance flexibility and resource-efficiency with community and identity. How to combine the best of solid-liquid-gas and prevent the down-side of each of these "physical states", as all described in chapter B2. The next paragraphs provide similar considerations for different campus themes.

Each solution or example that is given can be expressed in variables of the four stakeholder perspectives: in m^2, qualities per m^2, function types (for instance office or lecture hall), euros spent (per user or m^2) and ecological footprint. This is illustrated with the "database card" that was introduced in chapter B3.



Database card with variables in four colours, matching four perspectives (Illustration Mark van Huystee 2020)

And the other way around, the themes and examples in the following paragraphs have our databases and cases as source. More about these databases can be found in chapter C3.

Valentine's dinner in building TU Delft (photos Food&More TU Delft 2019)

Fourteen campus management themes

This section describes fourteen campus management themes; the first six originate from my 2011 dissertation, the next six were added for our Campus NL study in 2016, the last four based on research insights and 2020/2021 interviews with all Dutch universities. These themes influence various space functions on the campus. Academic and non-academic functions are distinguished, as introduced in chapter B1 and specified in the appendices.

Each campus management theme affects different space functions, which is demonstrated in the table below. For instance, the theme "safeguarding the silence" affects offices, study places, exam space and libraries (and possibly student housing as a non-academic residential function). The theme "make the campus sustainable" affects all space functions, academic and non-academic.

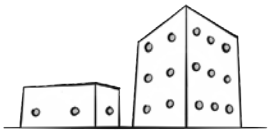
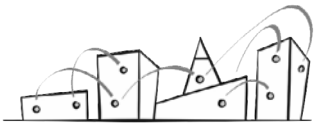
Table 10 (below): 14 campus management themes, which affect various space functions on campus. (Icons adapted from Campus NL 2016)

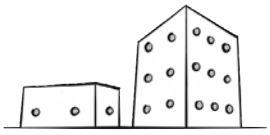
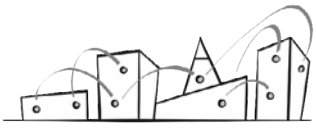
themes		space functions: office (desks)	meeting rooms	lecture hall (large)	classroom (small)	study places	exam space	event space	library	laboratory	workshop	storage	circulation (inside)	residential	retail & leisure	related business	infrastructure
theme 1	workplace	X	X						X			X				X	
theme 2	hybrid learning			X	X	X	X										
theme 3	faculty home	X	X	X	X	X	X	X	X	X	X	X	X		X		
theme 4	laboratories									X						X	
theme 5	non-academic													X	X	X	X
theme 6	heritage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
theme 7	opening hours	X	X	X	X	X	X	X	X	X	X	X	X		X		X
theme 8	circulation space												X				X
theme 9	smart tools	X	X	X	X	X	X	X	X	X	X				X		X
theme 10	sustainability	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
theme 11	silence	X				X	X		X					X			
theme 12	storage	X							X	X	X	X		X	X	X	
theme 13	showroom	X						X		X	X		X			X	X
theme 14	high- & no tech		X	X	X	X	X	X	X			X					X

Each solution or example that is given for a theme – for instance, in text boxes – can be expressed in variables of the four stakeholder perspectives: in m2, qualities per m^2, function types (for instance office or lecture hall), euros spent (per user or m^2) and ecological footprint. This is illustrated with the "database card" that was introduced in chapter B3.

Table 11 (on next pages 118-119): summary 14 campus management themes with solid-liquid-gas variations in basis from Campus NL 2016, with new insights and data. (Campus NL 2016, illustration Mark van Huystee 2020)

Langeveld building, Erasmus University Rotterdam (photo AdH)

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual	
			
own room individual territory meeting rooms per department	shared activity-related workspace concept	off-campus: at home, in cafes, rented by other universities	1. Changing academic workplace
study places at own faculty - closeby the teachers and professors	central study places - in new flexible education buildings	off-campus study places, for example in city library or at home	2. Creating a hybrid learning environment
(very) large autonomous communities on campus	small to medium sized, as home base, often without own library or restaurant	no or only a small home base as meeting place	3. Replacing faculty home bases
own labs per target group or research theme	shared labs by different faculties or even universities	using laboratories of third parties / industry	4. Investing in state-of-art laboratories
own restaurant per faculty, start-ups in own faculty building, research partners close by corresponding faculty	start-ups clustered in collective business building, student accommodation and research partners on campus	start-ups, student accommodation and research partners elsewhere in the city or region	5. Enriching campus with non-academic functions
transforming heritage for specific target groups or orginal user	transforming heritage for collective university facilities, conference rooms, study workplaces, etc.	transforming heritage by/for third parties: student accommodation, museums, hospitality or other functions	6. Giving new life to heritage
more evening use and weekend openings for faculty buildings and specific labs	more evening and weekend openings for central facilities such as libraries and study places	24/7-use: urban amenities, all lectures online, availability (all required applications at) home office	7. Extending opening hours

	model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
			
8. Utilizing circulation space	using corridors and staircases for informal conversations and gallery for presentations	making better use of outdoor spaces on campus, investing in areas and spaces between buildings	wifi network Eduroam on terraces in inner-city of student cities and on (train) stations
9. Applying smart tools	tools to improve insight on actual use of for example meeting rooms to prevent "unused reservations" and to improve use of existing space	navigation tools to improves use of (empty) study places on campus and to monitor quality requirements / performance (feedback users)	tools to find the best workplaces in the student city that match specific space demand
10. Making campus more sustainable	technological innovations: existing use with less energy	better occupation, utilization of existing buildings and spaces, more sharing, behavioral changes	much less m2, storage digitally or at home
11. Safegarding the silence	territorial private, silent workplace	university library, temporary silent zones on campus, on-demand quiet workplaces	public library in the city, home workplace, monasteries, (country) retreats
12. Rethinking storage	user-specific storage, individual bookshelves, personal archives online private storage, provided by the organisation	shared storage, shared bookshelves, shared archives online shared storage / file-sharing on university level	off-campus storage: at home online storage on non-university platforms
13. Showcasing performance and living labs	using territory to showcase pride and legacy (awards, diplomas on the wall, famous alumni)	using shared space to showcase pride and legacy (alumni, inventions)	using off-campus space and online platforms to showcase pride and legacy (repositories, social media)
14. Combining high-tech with no-tech	lectures without laptops, meetings without smart phones	lectures and meetings with functional use of laptops (versus lectures with dysfunctional use of laptops)	online lectures, online meetings

1. changing the academic workplace

Discussing the academic workplace is rightfully the number one theme on campus. On the Dutch campuses, about one third of the net floor area is office space (source: Campus NL 2016), so this is a substantial amount of space to consider. Consequently, policy changes in the working environment affect large numbers of employees. A shift from territorial offices (solid) to shared offices (liquid) and even off-campus offices (gas) can count on resistance. Not only in the Netherlands, but on a world-wide scale. Wherever I presented strategic choices about the campus of the future – and our own experiences in Delft after our fire – the audience would respond most emotionally to the idea the academic workplace might be less "solid" in the future. And then the corona crisis changed the academic workplace dramatically, at universities everywhere.

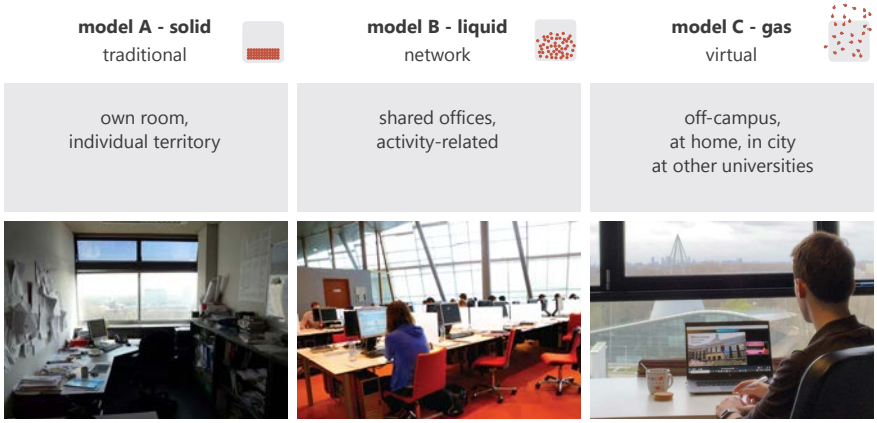
solid

Long before the corona crisis, almost all Dutch universities were rethinking the traditional individual academic workplace. Not only because the workforce had become increasingly dynamic - and more difficult to measure - but also because knowledge exchange and interaction between different target groups was limited by a "closed-door culture" and private archives. According to campus managers, the so-called cellular office also has a relatively large footprint, low occupancy rates and high operating costs per m^2, also because staff mutations require a lot of internal relocation and shifting with departments, sections and individuals. This is a sensitive subject at all Dutch universities, because academics attach great importance to individual territory and their satisfaction with the work is linked to it.

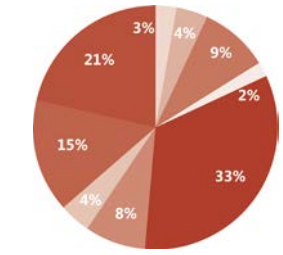
Almost all campus managers confirm: reconsidering the "solid" solutions was almost unnegotiable before the corona crisis. However, the corona crisis has shone a new light on the situation, according to Dutch universities. What stayed the same and even became more important, is that employees will only come to campus if their working environment expresses a sense of home, both being part of an "academic family" and having a sense of belonging, a home base and a "(faculty) club feeling". The worst that can happen is that they enter an anonymous, clean-desk environment. This is what needs to avoided, when creating "liquid" workplace solutions.

liquid

Most campus managers stated – in 2015/2016 as well as 2020/2021 – that not only the faculty community has become very dynamic with more temporary and short contracts,

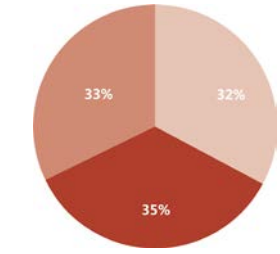


space types



- office - 33%
- specific (incl. labs) - 21%
- education halls - 15%
- storage - 9%
- support - 8%
- shed - 4%
- restaurative - 4%
- sanitary - 3%
- specific storage - 2%
- residential - 0%
- server - 0%

space usage for activities



- research- 35%
- education - 33%
- support - 32%

Figure 53: division of functional space types on campus (Campus NL 2016)

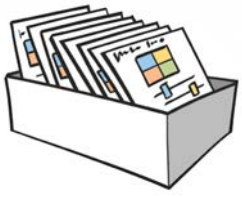
solid-liquid-gas variations of the academic workplace

source photos (L-R): AdH, Van der Heul 2009 and Ruben Vos 2021

Flexible office ACTIO for campus managers themselves: "Practice what you preach"
By WUR, edited for Campus NL 2016

In the building for the Facility Service Center, the "new way of working" housing concept was chosen to support the following organizational objectives: (1) improvement of core values: collaboration, knowledge sharing, meeting, creativity and working in an output-oriented way, (2) realizing lower accommodation costs and (3) an attractive employer for staff. In addition, the Facility Service Center wants to gain experience with this housing concept and be a well-founded example project for housing the other organizational units of WUR. With footprint of 8.1 m^2 NO (usable) office space per employee and 7.6 per fte, this ACTIO building is a successful example of a flexible working environment with a low footprint per user. The success is apparent from the expansion project that followed after a few years.

database: WU-4 ACTIO
NB More references of office space use in our database. (see page 168)



(Illustration Mark van Huystee 2020)

but also the number of visitors and network partners that have hospitality on campus. Both developments make it very hard to estimate how many people need a workplace on a daily basis. Organisational and user flexibility is required to accommodate everyone. Nonetheless, everyone fears anonymous "could-be-anywhere" workplaces that are standardised to fit all, but lack identity.

gas
At the same time, many university employees state that the corona lockdowns have convinced them of the advantages of working at home. Interviewees in 2020/2021 mentioned that working two weekdays from home (of a full-time job), or even 50% of the workweek, are early indications of the new solid-liquid-gas ratio. Also, employees are getting more sensitive to sustainability effects of "wasting energy" (also as a result of vacancy and low utilization rates) and might be more willing to time-share. More than sharing, time-sharing can provide the illusion of exclusive use. As at hotels, this is also dependent on frequent cleaning, guest customisation and a welcoming atmosphere. How smart tools can support this, is illustrated with some examples in chapter C4. This includes the description of a prototype "incentive model" in which employees receive a carbon budget to spend, for instance on a territorial workplace at the cost of "academic air miles" to visit conferences, or the other way around.

The solution seems to be that territoriality is moved from individual level to group level: not my office, but our team's home base. No time-sharing with everyone, but with the academic family that shares a library, a wall of fame (with what they are collectively proud) and shared memories. How large an academic family is, can differ. To some extent, one staff member can belong to communities of different sizes: the research team, the teachers, department X, faculty Y and the university. Sharing space with each of these communities only works, if spaces do not lose character. Silent workplaces can be shared on university level, if they have unique qualities that persuade employees to move to another location (also see theme 11 about silence).

The academic workplace in narrow sense is the employee's desk; in broader sense this includes formal and informal meeting rooms and storage space (see theme 12). The solid-liquid-gas possibilities of meeting rooms are summarized in the table below with characteristics and (photo) examples. The most important trend is that the division between meeting rooms for employees and group spaces for students is fading, which can be considered a culture change at many universities. Obviously, the COVID-19 pandemic was a game changer in workplace use. More post-pandemic trends with a focus on hybrid working and office utilization measurements have been studied in project Campus NL (Den Heijer et al. 2024), with data from more than ten Dutch universities.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
meeting rooms per department, meeting rooms reserved for individuals, meeting rooms with preferred users	meeting rooms to share, meeting rooms that are also used for education, "walking-meeting routes" on campus	anywhere off-campus, meetings rooms in city (restaurants, cafes, terraces), video meetings
		

solid-liquid-gas variations of meeting rooms

source photos (L-R): Schoonewille 2009, Van der Heul 2009 and AdH

2. creating a hybrid learning environment

The trend of creating a more flexible learning environment – with more shared study places – has been visible on campus (and in our project database) for more than a decade. Nowadays, educational buildings are more often created for the whole university and not only for certain groups or faculties. Decades ago, sharing space on campus started with sharing (large) lecture halls, also because of their size, costs and scarcity. Raising the utilization rates would generate enough benefits to cover the costs. Since then, many universities have invested in central facilities, to create flexibility for the dynamics in student numbers between faculties (while all Dutch universities also had rapidly growing student populations that needed to be accommodated).

Educational developments – blended learning, changed group sizes, other didactic methods and de demand for the newest audiovisual possibilities – forced universities to invest in quality. With limited budget, the quality often needed to be financed by reducing the quantity. Before the corona crisis, hybrid learning environments were already a trend on campus (Ninnemann et al. 2020). During and after the corona lockdowns, it has become the predominant trend according to campus managers. Scheduling space had already become a difficult puzzle on campus. In 2021, the simultaneous need for physical and virtual learning space brought an extra challenge, certainly considering the high demands on technology: the hybrid environment.

Apart from lecture halls, there are many other educational facilities that require change (in a hybrid learning environment): classrooms, studio space, library space, exam space and places for ceremonial events (Master / PhD thesis defences, diploma ceremonies). For all of these spaces, solid, liquid and gas options are available, which can be combined. Study spaces and libraries are subject of theme 11 and 12, safeguarding the silence and rethinking libraries and storage.

solid

Most faculty buildings still have lecture halls and class rooms that have the own community as preferred users, to create a home base for the community. What has been shifting, is that previously, no other user group would be allowed to reserve space and nowadays, that is more flexible and open. Faculty-specific lecture rooms are also often in a central pool (marked with preferred users). Internally, faculty-specific studio space used to be designated for certain groups for indefinite time, but that also became vulnerable in times of fluctuating enrolment. Territorial educational facilities are still valued by communities, but have become more open and welcoming.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
faculty facilities, lecture halls for preferred user groups	central facilities, lecture halls scheduled centrally	off-campus, theatres, cinemas, at other universities

solid-liquid-gas variations of the lecture halls and classrooms

source photos (L-R): AdH, AdH and Ruben Vos

Fifteen years of central educational facilities in Wageningen
By WUR, edited for Campus NL 2016

Fifteen years of central educational facilities in Wageningen In 2007, Wageningen built the Forum building for all Bachelor's students, as a central facility and also the only facility. In 2013, they added Orion as a new educational building on the same campus, to accommodate rising student numbers. Orion was the most sustainable building on the Wageningen campus at that time. Orion contains general facilities such as catering, lecture halls, instruction and practical rooms. The lecture halls have a flexible layout, can easily be changed in size (have functional flexibility) and can be linked to an auditorium with almost 800 seats.

liquid

On many campuses, such as Tilburg, Rotterdam, Delft and Eindhoven, central educational facilities have been developed in the past ten years. Also, smaller educational facilities like places for group work are centrally planned and flexibly scheduled. It is important to also use "smart tools" for this (see theme 9) to ensure that these are efficiently used. In addition, central scheduling saves m^2: for central facilities, 1-3 m^2 NO (usable space) per student, for decentralized more often 3-6 m^2 NO per student (source: Campus NL 2016). However, sharing facilities can also negatively affect productivity and student satisfaction. Nowadays, universities all provide a certain amount of flexible learning space to students, because it has a positive impact on study performance and community building.

Other universities place more emphasis on creating new faculty buildings, because they want to accommodate education and research in the same building to create synergy. It is a delicate balance between the efficient and effective facilitation of education on the one hand and research on the other, without separating students and scientists too much on campus. Most universities make a distinction between accommodating the Bachelor students (more in central facilities) and the Master students (in the vicinity of scientists and laboratories).

gas

Before 2020, many lectures were already recorded and digitally stored, which was an alternative for coming to campus. In 2020, students and teachers were forced to online education and discovered the advantages and disadvantages. What stays and is relevant for campus management, is the realisation that online education is always an option, if organisational flexibility is needed. What it showed, is that we can be more resource-efficient. Often, scarcity of space was a reason to reschedule meetings, lectures and classes. Chances are – when sustainability goals become more urgent – that online or off-campus options are more frequently chosen for education.

Due to the larger and larger groups, exam space has been more liquid and gas for quite some time: centrally scheduled on campus or even off-campus in large event spaces. In corona times, digital exams became urgent and possible: with a signed "code of conduct" or "honours pledge", the exam could take place anywhere. Smaller exams, especially the most important ones and the diploma ceremories, are more likely to take place on the territory of the faculty. When families and other visitors are invited – sometimes for once in a student's lifetime – the space needs to show identity and uniqueness of place. This has a link with theme 13: showcasing performance and living labs. For project Campus NL (2023-2027), our research team will keep track of utilization of educational space.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
exams at the faculty, supervised by teachers	exams in central, (sports) facilities on campus	off-campus, digitally at home



solid-liquid-gas variations of the exam space

source photos (L-R): Fotografische Dienst TU Delft 1955, AdH and Brandt / Unsplash 2021

3. replacing faculty home bases

Faculty buildings are the largest buildings of the university's portfolios and often also of the cities in which they are located, see figure 54. Analysing our campus project database, the largest university projects are faculty buildings, either newly built or refurbishments (see text box and figure). It is interesting to observe that some of these buildings accommodate faculties (with more than 1000 employees) that are larger than some universities. Consequently, the solid-liquid-gas ratio can be identified on different levels: between faculty (solid) and university (liquid) or between departments (solid) and faculty (liquid). Some faculties are villages – "where everybody knows your name" – others are cities with matching buildings with public and private zones. (Our own faculty building in Delft was named "BK city" for that reason – see Den Heijer 2017). With the rapid growth of many universities, not even the faculty or the department, but the section or research group represents "the academic family", which needs to be accommodated and feel at home on campus.

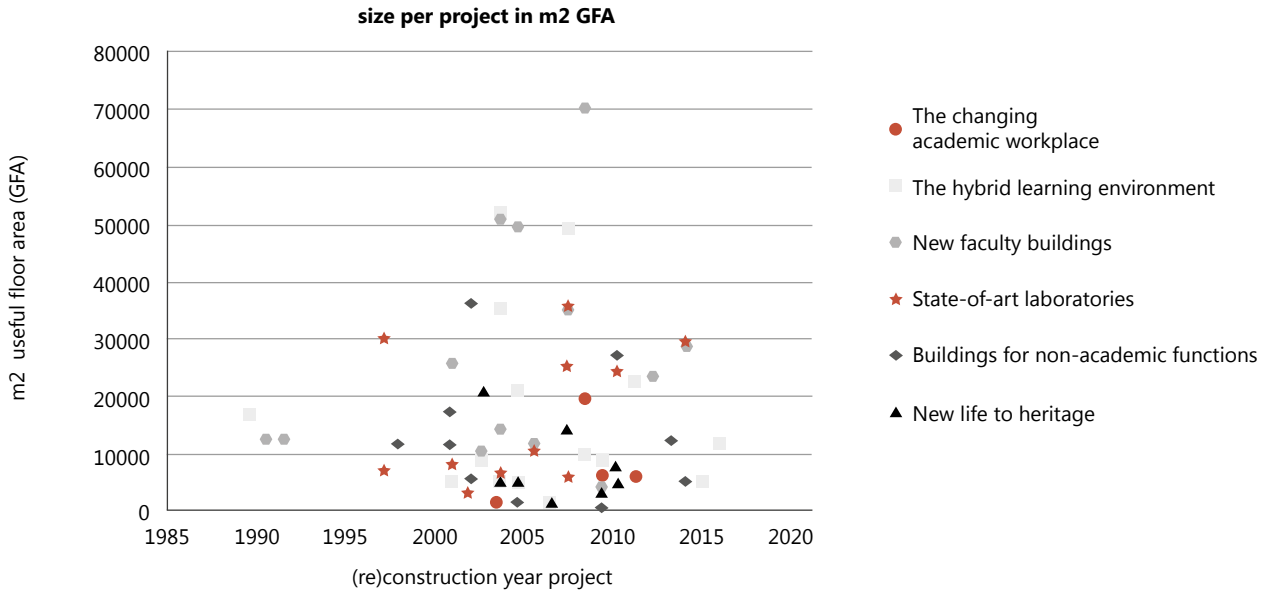
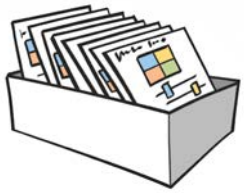


Figure 54: size in m² gross floor area (gfa) of university buildings in the project database, with many extra-large examples (Campus NL 2016).

Extra-large faculty buildings on campus NL
By WUR, edited for Campus NL 2016

On the Dutch campus, some extra-large faculty buildings are the T-building (EUR-2, Rotterdam) and the Huygens building (RU-2, Nijmegen), both with approximately 50,000 m², and the FNWI building (UvA-2, Amsterdam) with 70,000 m².





Database of campus projects (Illustration Mark van Huystee 2020)

Flexible and merged faculty building
By TU Eindhoven + Architect studio HH, from Campus NL 2016

At the end of 2014, the new building of the TU/e faculties of Applied Physics and Electrical Engineering - called FLUX – was realized (approximately 24,000 m^2). By bringing the two faculties together, teaching rooms and laboratories can be shared and utilization rates can go up. The building is built with heat and cold storage and is particularly energy efficient, which has led to a significant decrease in gas consumption. In the building, much use was made of transparent walls to ensure that the character was as open as possible to offer and encourage collaboration. In addition to teaching and practicum rooms, the building also has 50 lab rooms and a small supermarket. TUE-6 FLUX in database (page 168)

In contrast to the previous theme – which has shifted to central, flexible educational facilities - this theme emphasizes the (human) need for a home base with its own unique character. The themes are not mutually exclusive: for some educational activities central provisions are made, other educational activities are preferably housed in their own faculty buildings, close to the professors and scientists and their offices, labs and workplaces. Sometimes Bachelor and Master students are accommodated differently (central versus decentralized). The complete separation of education and research on campus would greatly reduce the chance of meetings between students and staff, with all the negative consequences that this entails. Traditionally, faculty buildings are among the largest buildings in the Netherlands. With a size of tens of thousands of m^2 of gross floor space - and often more than 40,000 m^2 - only government buildings of ministries in The Hague and head offices of multinationals are comparable in size.

Faculty buildings are considered to be strategic university property. Because of their size, very large buildings are financially inflexible: it is not easy to find another organisation with the same size. On top of that, the specific function mix and the location lower the buildings market value. Not many other organizations have similar demand and only multiple users could rent it. Transformation to housing is often an expensive or functionally impossible alternative. Consequently, faculty buildings are long-term assets in the campus portfolio and – considering that – decisions about them should be taken carefully.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
(very) large autonomous communities on campus	small to medium sized, as home base, often without own library or restaurant	no or only a small home base as meeting place



source photos (L-R): AdH, LYCS Architecture Unsplash 2018, Naus / Unsplash 2020

4. investing in state-of-art laboratories

Laboratories are generally indispensable for research, but they have a substantial impact on the university's resources and energy consumption. This was confirmed in 2020 interviews, after recent sustainability assessments of Dutch universities. Over the years, costs have also increased due to the stricter safety requirements and (rapidly changing) functional requirements. The functional lifespan of installations has also become shorter, under the influence of increasingly shorter time horizons of research projects. What the research themes are in five or ten years is considered to be very uncertain, so flexibility is necessary.

The realization that laboratories are expensive research infrastructure and that their construction or renovation must be carefully considered, is increasingly present among staff. There is therefore increasing support for sharing laboratories. It is not a matter of "your own lab or a shared lab", but "no lab or a shared lab", which makes sharing a positive choice.

In view of the relatively (very) high investment costs and operating costs (maintenance, energy & water, cleaning), it is important that the costs per m^2 are compensated by sufficient benefits per m^2. This is the main challenge. The easiest way to increase the benefits is by improving the utilization rates of laboratories. This can be achieved through shared use, which is increasingly happening on campus.

liquid
Previously there was more resistance from scientists to sharing - or traveling longer distances to - their labs, but the cancellation of various lab projects on cost grounds has made researchers aware of the consideration: it is often "choosing between sharing or nothing" ("to share or not to be "in Den Heijer 2011 dissertation).

In interviews, it was often indicated that the ever-changing research themes influence the demand for laboratory space the most. This was confirmed during the discussion. The collaboration with other universities and related companies or organizations (such as academic hospitals) also means that the university does not have to facilitate everything itself, as is also apparent from a number of recent projects on campus NL (see text boxes).

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
user-specific labs for exclusive use and designated groups	shared labs by multiple user groups, faculties and universities	off-campus labs, managed by industry, other universities, etc.

source photos (L-R): National Cancer Institute / Unsplash 2020, Jens Kok/ TU Delft 2021, AdH)

It is also striking that digitization is mentioned, which can replace part of the labs. However, practice on campus NL also shows that much research still requires a physical test environment, in addition to software simulated test setups. Digitization therefore has no (very) large influence on the demand for physical laboratories.

Healthy aging campus in Groningen
By Campus Groningen, from Campus NL 2016

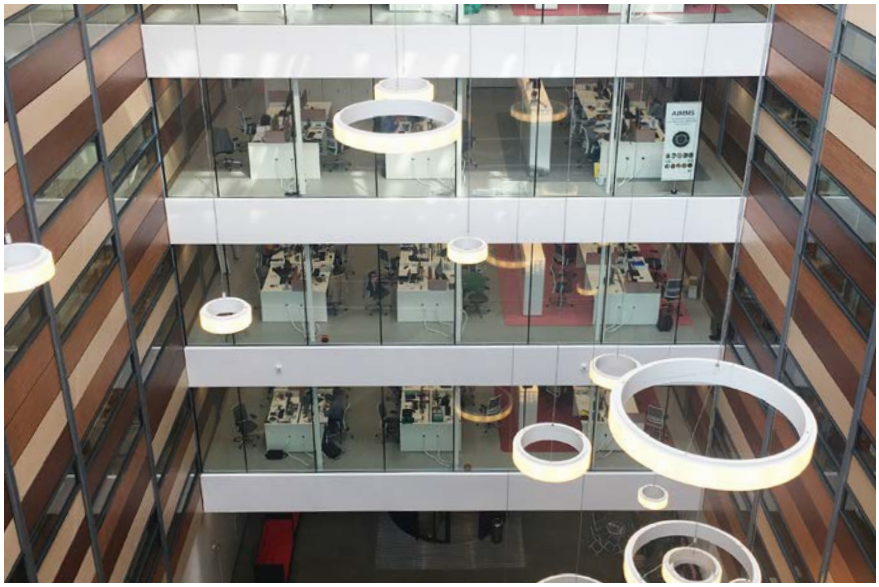
The University of Groningen is (re) developing a "healthy aging campus" in public-private partnerships with the University Medical Center Groningen (UMCG), industry and entrepreneurs (SMEs) and local and regional authorities. In this so-called "triple helix" organization (university, government and business) researchers, doctors, entrepreneurs and start-ups make joint use of facilities and work together on innovation.

Laboratories in TU/e use and not owned - a new business model
By TU/e, from Campus NL 2016

Although not owned by TU Eindhoven, DIFFER is an example of new parties that become one managed to make its way to the Dutch university campus. DIFFER is a fundamental research laboratory and contains very specific laboratories and experimental spaces with a high and specific installation level. A special aspect of the building is the challenge to bring the users of the building together. DIFFER was the first laboratory building in the Netherlands with a BREEAM Excellent certificate, to which triple glazing and utilization of the roof surface for PV cells makes a major contribution. TUE-7 DIFFER (see page 168)

O | 2 as an Amsterdam "lab hotel" for VU, UvA and VUmc
By VU website, from Campus NL 2016

The Human Health & Life Sciences building on the VU Campus in Amsterdam is one of the first buildings in the academic Netherlands to be developed for an institution-transcending research theme: Human Life Sciences. Scientists from the VU, UvA and VUmc have been working here since January 2016 on social issues in a mix of fundamental and applied beta-medical research.
Researchers use a state-of-the-art research infrastructure in the building, in which collaboration partners and commercial parties can also rent office and laboratory facilities (lab hotel). Joint investment in expensive research equipment for collective use ensures efficient and effective use of research funds. Working at "coffee-machine-distance" from each other stimulates knowledge exchange and accessible cooperation.



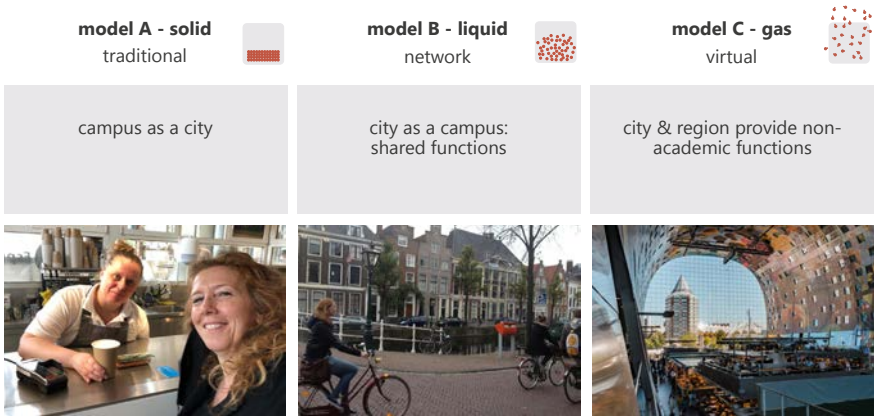
O | 2 as an Amsterdam "lab hotel" for VU, UvA and VUmc (photo AdH)

5. enriching campus with non-academic functions

Over the past twenty years, all universities have changed the mono-functional character of the university campus into a more multifunctional, urban area, see chapter B1 for the transition that took place. Adding - or allowing - residential functions, sports and retail facilities, hospitality and more related businesses has also promoted the viability of the campus outside opening hours. Most universities have added student housing to their campus in recent decades (a significant number of rentable units). Student housing is an enabler for attracting talent and also a disabler, if there is a shortage. Reasons for admitting third parties to the campus are linked to the university's primary tasks: better education and research and more opportunities for knowledge valorisation. However, financial incentives (not being able to add facilities without network partners) can also be a reason.

solid
When a university can accommodate all necessary campus functions on its own territory, that is referred to as "the campus as a city" and certainly an example of "solid". This is not only a matter of choice. Depending on the distance between campus and city, the university can more or less rely on urban facilities to meet the needs of students and staff for, for example, retail and restaurants. The following applies: the longer the distance from the city, the more the university itself has to provide the requested campus program.

liquid and gas
When universities can or have to rely the functions in the city, that is considered a "city as a campus". These are more liquid and gas solutions: shared on campus or accommodated off-campus. The renting, selling or making available strategies (of buildings or land) rarely lead to large (financial) returns, but contribute to better cooperation and more knowledge exchange with partners in education and research and other target groups. For example, the decision to facilitate start-ups on campus pays for itself in innovation and not in the rent that they (can) pay. This is an important principle in most campus plans: the "return on investment" or value for the primary processes.



Flexible catering concepts: from food court to food truck
By Campus NL 2016

Many universities are increasingly opting for flexible catering concepts in the form of food trucks or other temporary facilities that are increasingly adapting to the increasingly international campus population. An example is Erasmus Food Plaza in Rotterdam. Various restaurants provide the catering facility for the university concentrated in one building. A supermarket is also located in the same building, a phenomenon that has only manifested itself in recent years on campus NL. Supermarkets used to struggle with the business case due to such dynamics in use patterns, but with the rising student numbers, the disappearance of the 9-to-5 culture and more student housing on campus, has lowered the (financial) threshold for such facilities.

Incubators on campus – Nijmegen and Delft
By Campus NL 2016

With the Mercator building, Radboud University in Nijmegen was one of the first Dutch universities to build a multi-company building for start-ups, among others. YES! Delft labs is the second incubator building at TU Delft, in which start-ups have the possibility to rent a space on the university campus. The building contains a combination of office space and flexible laboratories, which are adjusted to the wishes of the specific tenant, in order to add extra facilities to the TU Delft start-up program. The building on the ground floor is linked to the first YES! Delft building that was realized earlier.

source photos (A-L-R): Food&More 2019, AdH, AdH ,and Mike van den Bos / Unsplash 2019

Maastricht cherishes monuments and heritage
By UM.nl, adapted from Campus NL 2016

Maastricht University (UM) started in 1974 in a former monastery, now School of Business and Economics. In 2016, UM uses a significant number of monuments in the city centre. In addition, UM recently decided to use the former Tapijn barracks for further expansion. With their heritage strategy, UM preserves valuable monuments and takes societal responsibility for the historic university city. threshold for such facilities.

European campuses contain many heritage buildings. Campus NL is no exception. A distinction is usually made between monumental and non-monumental buildings. It is important to mention that many university buildings from the 60s and 70s are also municipal heritage, due to their architectural-historical, industrial or cultural value. Since the transfer of the buildings in 1995, universities have been aware of the costs and benefits of their heritage: from the high energy costs and maintenance costs to the emotional value that users attach to it. The most important campus assignment concerns the reinvestment in the existing, because selling or renting out is not a large-scale alternative due to the specificity. Even transformations to housing are challenging, considering the lay-out and the investments that are needed for transformations. Demolition is often controversial due to the academic history involved or the monument status.

Projects (in our database) show that Dutch universities cherish their heritage, but also struggle with it (financially and environmentally). The average age profile of Campus NL can be found in chapter B3 (figure 39 on page 99). About 9% of the portfolio is more than 100 years old. In Maastricht, that percentage is 46% in Leiden 17%, in Utrecht 18%). Also, Groningen, Delft and Amsterdam own more than the average percentage. Their heritage underlines their identity as universities with a very long academic history. On many campuses and in many university cities, pressure is exerted to maintain public ownership, also in inner cities. Campus plans show that universities take their responsibility to protect or even purchase cultural and industrial heritage (such as in Utrecht, Delft and Maastricht in the past ten years), even though new alternatives often have higher performance scores. This social responsibility of universities is often underexposed and deserves more (public) attention and resources. All the more so because such monuments often have few other potential owners (and paying users) and universities with their long-term existence and a sustainable future can (continue to) bring life to meaningful buildings in historic cities.

Heritage can be used differently in different campus models: academic heritage can be used territorially by a traditional university (solid), flexibly shared by a network university (liquid) and sold to, for example, a student housing association by a virtual university (gas). In the latter case, the university can still benefit from this heritage that was previously in possession. One examples of this can be found in the following text box.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
transforming heritage for specific target groups or orginal user	transforming heritage for collective university facilities, conference rooms, study workplaces, etc.	transforming heritage by/for third parties: student accommodation, museums, hospitality or other functions



source photos: AdH

7. extending opening hours

While the former six themes are largely project-related and apply to new construction or to the transformation of existing buildings, this theme 7 (and some of the following themes) can also be found in campus plans and can be applied campus-wide or on a smaller scale than a building.

Extending the opening hours of (parts of) the campus is a campus-wide theme at most Dutch universities. Flexible opening hours for self-study and making better use of the space during educational periods (summer schools, congresses, etc.) is happening on an increasingly large scale and increasingly differentiated. For example, many universities only extend the opening hours of the study places in the library during exam weeks, some even to 2 a.m. at night. At the same time, they limit availability for non-university visitors, which appear to be substantial groups at some universities. So, opening hours can also be dependent on the target groups.

This theme mostly manifests itself in more evening use and weekend openings of faculty buildings and specific labs. Opening hours during the weekends are very dependent on the culture of universities: many are still closed during the weekends and holidays, others are open almost 24/7, 365 days a year. Extending opening hours often applies mostly to central facilities, such as library and study places. Consequently, extending opening hours also means providing some form of catering. The number of people determines if this is organised, flexible or on-demand. Unlike the physical campus, the virtual campus is always open. This means the availability of many lectures and study material online and all necessary applications at home workplaces. In addition, the student city offers various 'third places' (workplaces next to the home workplace and the workplace at the university) and accessibility of the university network (via Eduroam) in more and more public places, such as stations and city parks.

The extension of opening hours can be expressed differently for solid, liquid and gas: (solid) more evening use and weekend opening of faculty buildings and specific labs, (liquid) evening and weekend opening of central facilities such as library and study places and (gas) 24/7 use of urban facilities, all lectures online, availability (all necessary applications at) home workplaces. This trend is in line with developments such as the increasing study pressure and the presence of more and more international students who want to stay and work on campus in the evenings and on weekends, also because the university population is more often the only social network for them.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
more evening use and weekend openings for faculty buildings and specific labs	more evening and weekend openings for central facilities such as libraries and study places	24/7-use: urban amenities, all lectures online, availability (all required applications at) home office

source photos (L-R): TU Delft, TU Delft Library, and Bierwagen / Unsplash 2018

8. utilizing circulation space

"walk & talk" on campus
interview campus director TU Eindhoven 2020

During the corona crisis, many creative solutions were found to replace either the traditional physical meeting in a room and the online video meeting. An inspiring example is the idea of "walking meeting routes" on the TU Eindhoven campus. Why not take a walk on campus to brainstorm about research or to philosophize with colleagues? Of course, not suitable for any meeting or large groups, but a welcome change of scenery. At the same time, outdoor space is more often used (see theme 8), which adds to a sense of community and attractive, vibrant campus.

Temporary outdoor cinema on TU Delft library roof (TU Delft library 2022)

In the past decade, the universities have made better use of the "in-between space" on campus: corridors, atriums, staircases and outdoor space. The reasons for this were the (sharply) increasing student numbers, the ICT developments that made location-independent work possible and the ambition to promote interaction between target groups and to show more in the (semi-) public space what the university stands for. Not only was circulation space increasingly used for informal consultations and meetings, the performance of students and academics and other values of the universities became increasingly visible. The circulation space as a showcase for university achievements is a campus theme that promotes community spirit and pride. In addition, the utilization of circulation space contributes to the flexibility and liveliness of the campus. Better use of circulation space can be expressed differently in the solid, liquid and gas campus states.

solid
A more traditional way of territorial use of corridors and staircases is to utilize this space to showcase for performance. This can be past, present and future performance and has a link with theme 13. Many universities have designated places where alumni can leave their signature or name. The effect is that alumni (and former employees) who leave a mark, will come back to that place, even if they work and live abroad and decades have passed. Demonstrating "past performance" (in circulation space) highlights legacy, history and pride, "present performance" demonstrates living labs and work-in-progress and "future performance" presents the innovative agenda and the university's ambitions.

liquid
Making better and shared use of the campus outside space and the space between buildings. Welcoming more guests and showing them the university's societal impact makes circulation space increasingly public. Many universities have "a walk of fame" or "wall of fame" with people, inventions and artifacts they are proud of.

gas
Public space in university cities is also popular for group work or meetings. Eduroam on terraces in inner cities and at stations has lowered the threshold to make better use of the university city. At the same time, the university population contributes to a vibrant city. The collective challenge of campus managers and city planners is to make and keep the university and city attractive for both populations. In some cases (and during some timeslots), it is good to mix the populations and sometimes it is better to separate them.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
use circulation space to enhance identity of fixed user groups and showcase past, present and future performance	use indoor circulation space for informal meetings to share, use outdoor space for functional activities: informal meetings, walk & talk	Eduroam on terraces in university city and at railway stations



source photos (L-R): AdH, Geert de Jong for TU Delft, and Ruben Vos

9. applying smart tools

Universities increasingly use “smart tools” to increase user satisfaction, improve the use of space and reduce the footprint. This is concluded from our smart tools research projects, which started in 2016 (see chapter C4 for more information). The goal is a better allocation of spaces through self-management of users. More and more universities are using technological developments to measure where users are (and were they are not) via WiFi, Bluetooth and other sensors (because timetables and reservations often say more about planned use than about actual use).

On the basis of big data about actual use, users can navigate to available study places or vacant meeting rooms on campus, for instance via apps on their smartphones. The use of ‘smart tools’ can not only ensure more efficient and effective use of space, but can also increase user satisfaction, because they are more in charge of finding the most suitable space for their activities.

If real-time use is measured continuously, this provides big data about campus use, specified to places and timeslots. Campus managers can draw conclusions from the patterns and use those as input for campus strategies: which spaces are in high demand and which are underutilized and when? Big data can identify strong patterns, which could enable to predict space use in the future. Campus dashboards can provide these insights, see chapter C4.

The use of smart tools can be expressed differently for solid, liquid and gas: (solid) tools to get more insight in the actual use of - for example - meeting rooms to prevent “unused reservations” and to make better use of existing space and tools for technological innovations: adjust the light levels and temperature of space to presence or absence of people, (liquid) tools to encourage time-sharing of space and navigation to empty spaces anywhere on campus, (gas) tools to find the best workplaces in the student city that match specific space demand, like “a group of 6 persons who need to work in silence”.

Smart tools are considered to be essential to achieve the resource-efficiency goals. The combination of increased dynamics on campus, relatively fixed supply of space, high quality demands, high energy use and high costs of space, make it essential to avoid waste in the form of low occupancy and frequency rates. Campus management increasingly becomes a logistical challenge. Sensors, big data, tools and dashboards can support that challenge.

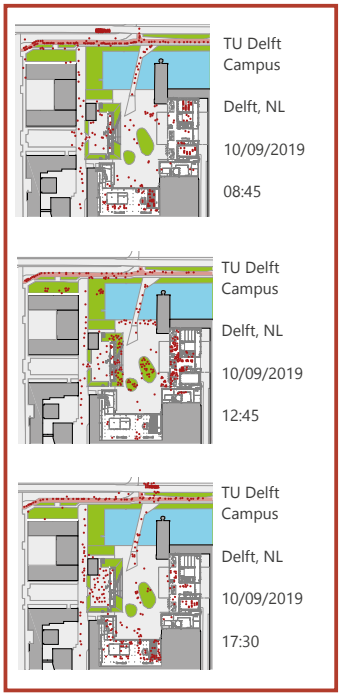
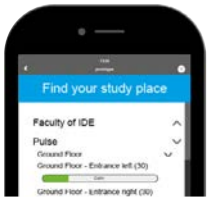


Figure 55: a simulated time lapse of a campus area at 3 different times during a day (Bart Valks 2019).

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
tools to improve insight on actual use of for example meeting rooms to prevent “unused reservations” and to improve use of existing space	navigation tools to improves use of (empty) study places on campus and to monitor quality requirements / performance (feedback users)	tools to find the best workplaces in the student city that match specific space demand



source photos (L-R): AdH, Bart Valks and Breakslow / Unsplash 2019

10. making the campus more sustainable

Field lab landscape architecture: trees play a key role in preventing heat stress and the design of climate-proof and healthier cities. (photo AdH, link to story: https://www.tudelft.nl/en/stories/articles/what-is-the-coolest-tree)

This theme has already been relevant on campuses – and high on the university's agenda – for more than ten years. In 2008, covenants were signed by all Dutch universities to reduce energy consumption and CO_2 emissions on campus by 30% in 2020 (and an ambition of 50% in 2030). Our research back then already concluded that reducing floor area was one of the most effective sustainable campus strategies.

In the meantime, universities have grown rapidly. The fact that the campus could not keep up with the growth in student numbers, had a positive effect on the footprint per user and on achieving sustainability targets (even though these targets are often related to the total emission or energy use, and not expressed per user). As illustrated for TU Delft in chapter B1 with figures over a longer period, Campus NL was more space-efficient in 2016 than in 2006, which contributed to sustainability goals.

Sustainability is an explicit theme in most campus (NL) plans and an important criterion for most campus projects. Many new construction projects meet the highest sustainability requirements, as evidenced by the energy labels and BREEAM standards. Naturally, innovation is sought in technological developments, both at campus level (energy generation, energy storage, geothermal energy, etc.) and at building level in facades, installations and equipment. In addition, flexibility in use is an important theme: extending both the technical and functional lifespan of buildings. The starting point for transformations of old buildings is that the (sustainable) reinvestment is earned back with lower operating costs (including energy costs).

But organisational and user flexibility are at least as important as physical and functional flexibility. More ambitious sustainability goals, change demand-driven strategies (putting the organisational and user needs central) into supply-driven strategies (putting the scarce environmental and financial resources central).

Subthemes as "avoiding waste" and circularity have become drivers for campus strategies. The limited lifecycles of many resources on campus (and off-campus) have made the university community more aware of their footprint. In combination with theme 9, this resulted in ideas for a carbon incentive tool (see chapter C4). More research about sustainable universities and campuses can be found in chapters C2 and C3.

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
technological innovations: existing use with less energy	better occupation, utilization of existing buildings and spaces, more sharing, behavioral changes	much less m^2, storage digitally or at home

source photos (L-R): Mclean Unsplash 2021, Communicatie Bouwkunde 2018 and Pepelnar Unsplash 2021

11. safeguarding the silence

In our Campus NL research (2016), quiet study places appeared to be the "most-wanted" space type on Dutch campuses. With "silence as the new scarcity" – not only on campus and even more relevant during the corona crisis from 2020 – quiet zones are demanded by both students and employees. Traditionally, libraries have been quiet zones by definition, which is why they are still and even increasingly popular, regardless of the books. Some campus managers even noted in interviews that "the books have increasingly become decoration and serve the acoustics of the quiet spaces". Observations of students in libraries confirm that many do not have books on their desks, but (only) laptops. Universities are challenged to check this at their own libraries. However, library study places have become more popular than ever, while transitions towards the virtual university and campus would have suggested otherwise.

solid
For many employees, the quiet zone is still the territorial office, but that can only be assured, if it is private and not shared with colleagues (at the same time). Nonetheless, having an individual office, reserved for only one employee, is also becoming scarce on campus (see theme 1). Sustainable ambitions, dynamics in human resources and budget reasons push towards more (time-)shared space, including quiet space.

liquid
University libraries are the oldest and best examples of quiet zones on campus. Many universities confirm that quiet study places are among the spaces with the highest utilization rates on campus and there is a constant demand for more (see also C4 smart tools for ways to allocate these scarce spaces and navigate users to vacant spaces on campus). Another strategy to create more quiet zones on campus, is temporarily changing zones of classrooms in "quiet zones" during exam periods. Less popular (until now), but a possibility, is "reserving a quiet office", which some universities are experimenting with. However, rules and regulations (time budgets for students and staff) and no-show behaviour can be a problem. This also became clear during the corona crisis (see Valks 2021). The oldest universities in Europe still have many buildings that once were spaces for contemplation and retreat, which do or could still serve as quiet space, see photos.

gas
Off-campus, public libraries have also been popular as quiet places to study for exams or to be secluded from colleagues. This emphasizes one of the advantages of working off-campus: not being seen or disturbed by others. While it is increasingly difficult to

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
territorial private, silent workplace	university library, temporary silent zones on campus, on-demand quiet workplaces	public library in the city, home workplace, monasteries, (country) retreats

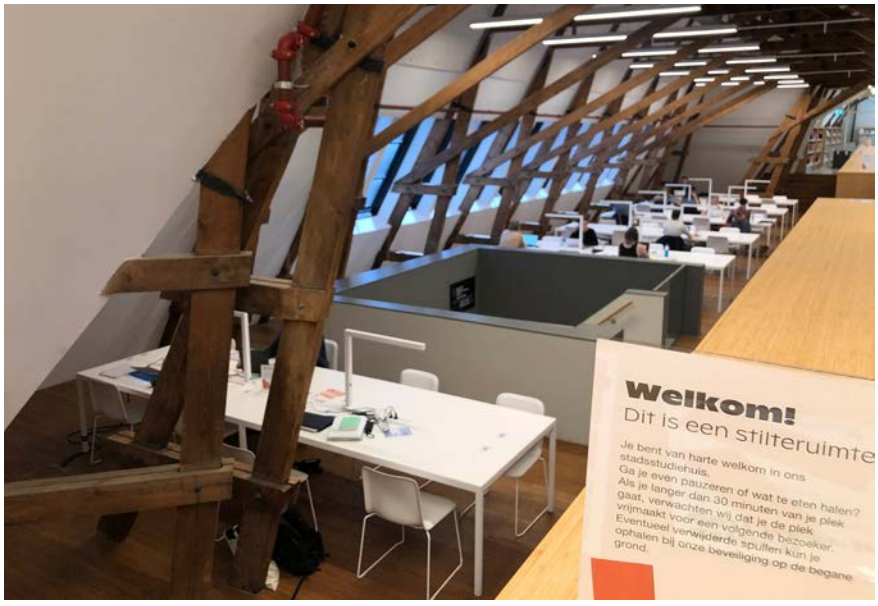

source photos (L-R): AdH

be offline, many long for academic "do not disturb" signs, when they need to finish an educational or research task. Some reserve (country) retreats or even check into monasteries to be able to finish publications. This aligns with another trend on campus: combining high-tech (digital) with no-tech (analogue), see theme 14. Campus of the future strategies could actively facilitate off-campus retreats.

"The university needs to facilitate silence"
by A. den Heijer, interview Delft Integraal 2020

Q: Can you make a prediction about the campus of 2045?

A: "People started wondering: does everything really have to be in English? Do I have to travel so much? There was a move back to basics and towards consolidation. There are certain biological conditions that are inevitable: territoriality, the need for silence, a lack of distraction, separation of work and private life. More than before, universities have to facilitate that because it's in such short supply elsewhere. But we need to do it in a new way because we can't afford to give everyone a place of their own."



Silent space in library Utrecht (photo AdH)

12. rethinking storage

Storage space represents a substantial amount of space on campus: more than 10% of campus NL has that exclusive label, which means that these are rooms that are only storage space. On top of that, part of the office space, laboratories and educational facilities is also reserved for storage, which makes "how and what the community stores" an important issue in the campus strategy.

In the past decades, digital storage has emerged, which was – to some extent – at the cost of physical storage. Nonetheless, physical storage was and will not be fully replaced, like the virtual campus will not replace the physical campus. In all cases, the combination stays.

As we know from our homes, the supply of storage space often also generates demand. Only when we move – or need space for other functions – we have an incentive to clean up. Since this is a time-consuming activity, it is often postponed. This is also the case for digital storage and on campus.

Storage is often a relatively hidden, digital and physical, space- and energy-consuming phenomenon, also on campus. While some of the storage space is used dynamically – still actively used – the majority of it seems static. On campus, this traditionally included exams that needed to be saved for years, files of graduated students and research projects that had been finished. Educational products, models, prototypes, numerous copies of book, old furniture etc. – the basements are full with storage. However, many (campus and other public real estate) managers state that physical storage will remain important as a physical back-up of digital data.

This also links to circularity on campus and opportunities for reuse of materials. But the stored materials are one thing, the space it utilizes can be of higher value (for other purposes) than the value of what is stored, which could get far more attention in campus strategies.

Storing learning and research material, is another topic under this theme. The library was already discussed in theme 11 for its highly valued quiet space. The storage function of the library is relevant under this theme. Solid examples of libraries are the ones that individuals keep to themselves. Liquid examples are – by definition – the shared libraries, which are (more) resource-efficient by definition. Libraries per research team,

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
user-specific storage, individual bookshelves, personal archives online private storage, provided by the organisation	shared storage, shared bookshelves, shared archives online shared storage / file-sharing on university level	off-campus storage: at home online storage on non-university platforms



source photos (L-R): Tingey / Unsplash 2020 , AdH and mitchell luo / Unsplash

departmental libraries and faculty libraries all still exist, even though many universities have shifted to more centralized libraries in the past decades. Gas examples of libraries are online libraries, which utilize server space. Librarians can assess how often books are used, also in comparison to digital use of libraries.

Concluding, more effective use of physical storage space is another possibility to make better use of the campus and to contribute to sustainability goals. Cleaning up physical and digital archives should be encouraged periodically and rewarded by the organisation. Expressing the benefits as much as the (environmental) cost could support this process.

Office in former TU Delft Architecture building, "Berlageweg 1" (photo AdH)

Oodi library building in Helsinki (photo AdH)

13. showcasing performance and living labs

This "showcase" theme is closely related to theme 8, the use of circulation space, to present past, present and future performance to the community and visitors. Nonetheless, the primary processes are more central in this theme 13: demonstrating the university's production in education, research and innovation. Not only to emphasize the heritage and pride of the university, but also to encourage serendipity on campus - the occurrence and development of new ideas by chance - which is essential in science.

For many reasons, it is fruitful to know what your colleagues are proud of, what they are working on now and what they are planning next. That goes for research and for education as well. Potential cross-overs between scientific fields (and professor's chairs) are numerous. For the university community, it is good to have an overview. The campus can enable this.

The campus can serve as a museum, (solid) using territory to showcase pride and legacy: awards, diplomas on the wall, famous alumni, (liquid) using shared space to showcase pride and legacy: famous alumni, past innovations the university is proud of and (gas) using off-campus space and online platforms to showcase pride and legacy: in repositories and on social media. Many universities have actual museums.

The campus can serve as a showcase for work-in-progress, (solid) using territory to demonstrate performance of current community, (liquid) using shared space for the same, reaching a far larger group and (gas) using off-campus space and online platforms on project websites, social media. Examples are also (dynamic) infographics in corridors and public space that highlight the diversity of the university community and their impact on society.

The campus can serve as as a living lab for innovations, (solid) using faculty territory to demonstrate and test innovations, (liquid) using shared space for the same purpose, engaging a larger target group and (gas) using off-campus space and online platforms to demonstrate and test innovations. Many universities "practise what they preach" and test innovations on (groups of) their own users. More background information can be found in chapter C2.

source photos (T-B): AdH, AdH and Marcel Bilow

	model A - solid traditional	model B - liquid network	model C - gas virtual
HISTORY campus as museum	using territory to showcase pride and legacy (awards, diplomas on the wall, famous alumni)	using shared space to showcase pride and legacy (alumni, inventions)	using off-campus space and online platforms to showcase pride and legacy (repositories, social media)
CURRENT campus as showcase for work-in-progress	using territory to demonstrate performance of current community	using shared space to demonstrate performance of current community	using off-campus space and online platforms to demonstrate performance of current community (project websites, social media)
FUTURE campus as a living lab (for innovations)	using territory to demonstrate and test innovations	using shared space to demonstrate and test innovations	using off-campus space and online platforms to demonstrate and test innovations

14. combining high-tech with no-tech

After the involuntary full-time transition to online learning and meetings during the corona pandemic, we discovered both the advantages and disadvantages of the virtual university. The more digital our daily activities become, the more we (also) appreciate old-school, analogue alternative as counterweights. Not to replace them, but in binary combinations. The following ideas came to mind during the 2020/2021 campus lockdowns and are still relevant:

- with all the online lectures, why not reintroduce some lectures without technology, with focus on discussion, not recorded and in a private setting;
- after days filled with online meetings, looking your colleagues in the eyes without distracting screens should be reinvented as an old-school meeting format;
- after Skype coffee breaks, Webex pub quizzes and Zoom drinks, any social gathering without smart phones would be very welcome.

Summarized, the high-tech campus should be combined with the no-tech campus. High-tech and no-tech could be combined by introducing high-tech and no-tech zones: this could be places or time slots. Libraries could have no-tech zones and employees could schedule no-tech time slots, to assure their focus and improve their mental health. As a counterbalance of our apps, the popularity of jigsaw puzzles and old-school board games has also been observed at the (academic) office.

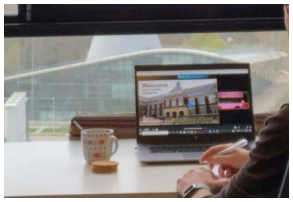
Longing for physical, analogue and old-school: combine high-tech with no-tech
by A. den Heijer, interview EUA 2020

Universities that succeed in facilitating both silence and buzz and both digital and analogue activities, and do so while achieving their education, research, finance and sustainability goals, could serve as examples for many others. "Silence is golden", but certainly not when it comes to sharing campus knowledge. This is an opportunity to learn from each other in our pursuit of an optimal balance.

Of course, this trend was already emerging on campus before 2020. The theme is connected to mental and physical health policies on campus: a healthy work-life balance for employees and students has been high on the agenda for years. Wanting to be offline as well as online, and our collective struggle with distractions from smart phones,

model A - solid traditional	**model B - liquid** network	**model C - gas** virtual
lectures without laptops, meetings without smart phones	lectures and meetings with functional use of laptops (versus lectures with dysfunctional use of laptops)	online lectures, online meetings





source photos (L-R): Thomassen 2011, Unsplash, AdH and Ruben Vos

was also already a subject before 2020. Off-campus, the love-hate relationship with the smart phone is also a (behavioral) discussion in restaurants and at concerts (where many are filming the concert instead of watching it).

The figures 56 illustrate three different settings of a lecture:

(a) while teachers often assume or hope that students are using their laptops to make notes about their lesson, reality is often different; their audience is also often distracted;

Figure 56a: laptop as a distraction in the classroom (Illustration Mark van Huystee 2020)

(b) of course, more interactive classes do help and make students focus on the content of the lecture, even though we know, that it is only human to be distracted by alerts and notifications of our other apps;

Figure 56b: more interactive classes with use of technology (Illustration Mark van Huystee 2020)

(c) the old-school, analogue solution could be to re-introduce some lectures without smart phones and laptops, not as a replacement, but as a diversification. This does not only apply to lectures, but also to meetings, brainstorm sessions and group work.

Figure 56c: the old-school, analogue solution without technology (Illustration Mark van Huystee 2020)

Universities that succeed in facilitating both digital and analogue activities, and do so while achieving their educational, research, finance and sustainability goals, could serve as examples for many others. Mixing high-tech with no-tech combines the best of both worlds: using state-of-the-art digital facilities while also acknowledging the need to focus on one activity to reduce stress and contribute to mental health.

Composing strategies for the campus of the future

As the themes demonstrated, there are many choices to make for the solid-liquid-gas composition of the campus, which all have their organisational, financial, functional and physical matters to consider. As a research team, we collect examples of solutions that universities choose and express them in (among other variables) footprint per user, costs per m^2 and their added values. These are part of our databases, which are illustrated in chapter C3.

On campus level, universities can use the themes to assess the current state of the campus – "how solid, liquid and gas are we today?" – and the preferred future state of the campus: "which composition do we prefer?". Figure 30 illustrates this method, in which percentages estimate both the current state of the campus on left and the (preferred) future state on the right. For instance: the current academic office is 70% "solid" (traditional, see theme 1) and needs to become 30% "solid" and more liquid and gas. The "campus strategy" describes the transition that needs to take place, for instance by changing the lay-out of office area (physical or functional flexibility), allocating desks in a different way or facilitating the home office (organisational flexibility). More specifically, the campus strategy could suggest zones on campus or particular projects.

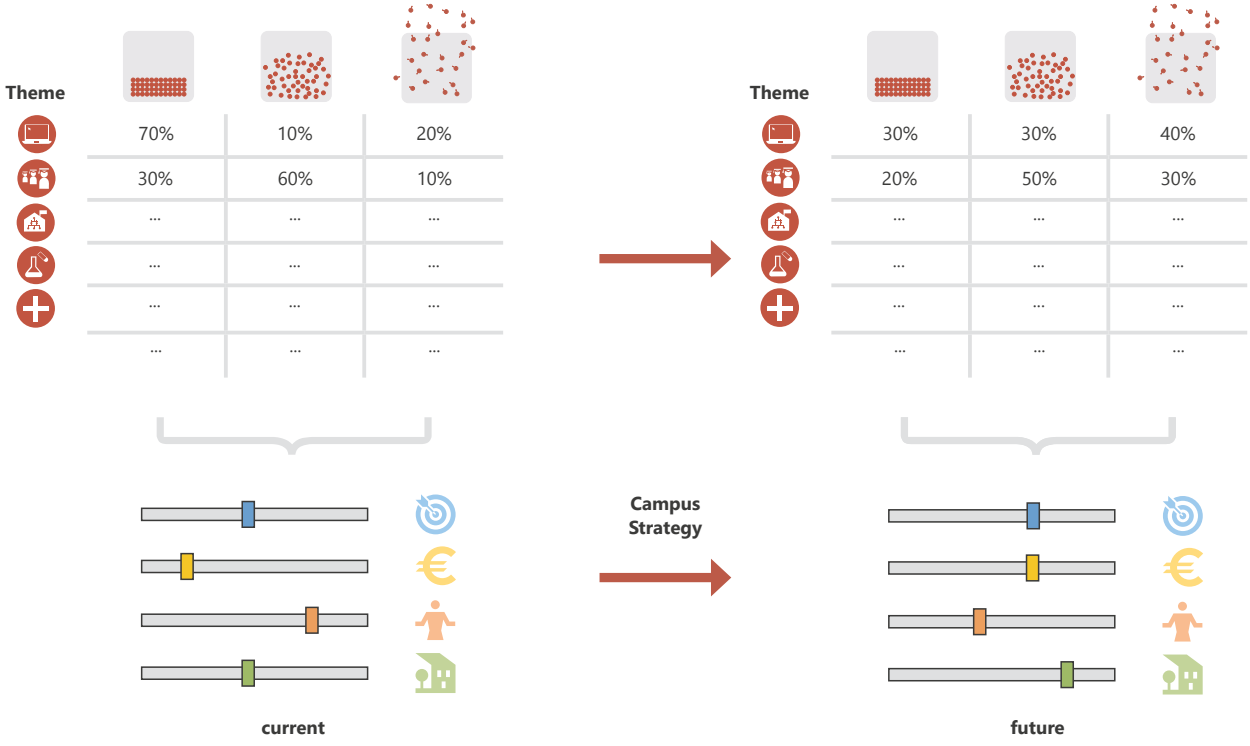


Figure 57: An example of a campus strategy involves choosing solid, liquid, or gas states for themes like academic offices and hybrid learning, impacting the university's organizational, financial, functional, and physical goals.

Figure 57 also shows that the composition of solid-liquid-gas has an effect on organisational, financial, functional and physical goals and resources of the university, both the current situation and the future situation. Incentives to change this composition can come from all four stakeholder groups around the negotiation table who represent these goals and resources. Policy makers can change the organisational goals, controllers are confronted with a tighter budget, users can have changing needs and engineers can bring even more pressing climate issues and environmental urgencies.

How to achieve the required effect by changing the composition of the space types - offices, lecture halls, storage space, laboratories etc. – easily becomes a puzzle that needs to be supported with dashboards and tools. This is what our campus research team has aimed to provide in past, present and future for campus managers (see chapter B4).

Summary of general strategies

After presenting the transition of the campus, the three physical states, the four stakeholder perspectives of campus management and fourteen campus themes, these summarizing paragraphs highlight some general conclusions for the campus of the future:

- **"from demand-driven to supply-driven"** – public real estate management has long focused on demand-driven (campus) strategies, following the needs of users and requiring physical and functional flexibility from the buildings and financial flexibility in the portfolio to adjust supply to demand; nowadays, the urgency to be resource-efficient, both environmentally and financially, has changed the scope from demand-driven to supply-driven, adjusting demand to scarce supply, demanding user and organisational flexibility;

- **"trade quantity for quality"** – the combination of resource-efficiency goals and many quality demands - for heritage, urban setting, landscape, interior design and minimal technical conditions for health & safety – requires smart solutions; quality is often only affordable or acceptable, if the footprint for the organisation is reduced;

- **"bipolar challenges"** – the functional demands include some contrasting needs for silence and buzz, analogue and digital, online and offline; the university community needs all, but they are not easily mixed and should carefully be separated in space or time; many of these needs can be achieved by changing behaviour in existing spaces;

In the appendices, more propositions for campus management and the campus of the future can be found. The previous paragraphs provide considerations for different campus themes. Our network of public real estate managers has confirmed that many of the themes and the general strategies are equally relevant for other types of public real estate.

One of the bipolar challenges on campus: combining digital and analogue. (photo Geert de Jong/ Cheesworks Fotografie for TU Delft)

Bipolar

adjective
1. having or marked by two mutually repellent forces or diametrically opposed natures or views

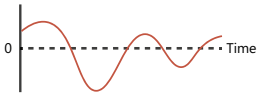
2. a: having or involving the use of two poles or polarities
b: electronics : relating to, being, or using a transistor in which both electrons and holes are utilized as charge carriers // bipolar generators

Source: Merriam-Webster (1999)

Analogue

adjective
1. a: of, relating to, or being a mechanism or device in which information is represented by continuously variable physical quantities
b: of or relating to an analog computer
c: not digital : not computerized

Source: Merriam-Webster 1999



Digital

adjective
1. of, relating to, or using calculation by numerical methods or by discrete units
2. composed of data in the form of especially binary digits
3. electronic: digital devices/technology

Source: Merriam-Webster 1999

Silence

noun
1. forbearance from speech or noise : muteness - often used interjectionally
2. absence of sound or noise:
stillness // in the silence of the night

Source: Merriam-Webster 1999

Buzz

noun
1. a persistent vibratory sound
2. a: rumor, gossip
b: a flurry of activity
c: speculative or excited talk or attention relating especially to a new or forthcoming product or event

Source: Merriam-Webster 1999

(Illustrations Ruben Vos 2020)

New University Building,
Vrije Universiteit Amsterdam
(photo AdH)

Part C

CAMPUS RESEARCH MATTERS

Part A – INTRODUCTION PUBLIC REAL ESTATE

A1 Defining PRE	A2 Managing the impact of PRE	A3 TU Delft's PRE legacy

Part B – PAST, PRESENT & FUTURE CAMPUS

B1 The campus matters	B2 Three physical states: solid, liquid & gas	B3 Management matters	B4 Strategies & themes

Part C – CAMPUS RESEARCH MATTERS

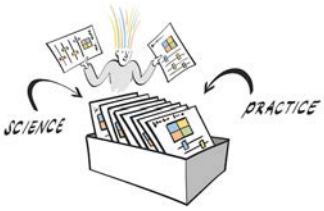
C1 Networks	C2 Theories & Methods	C3 Cases & Databases	C4 Tools & Dashboards

Part C – CAMPUS RESEARCH MATTERS

I. NETWORKS

II. THEORIES & METHODS

III. CASES & DATABASES



IV. TOOLS & DASHBOARDS

Figure 58: the agenda of TU Delft's Campus Research Team can be divided into four missions, which are chapters in this part of the book. (Illustrations Mark van Huystee 2020)

The overall mission of TU Delft's Campus Research Team is to support universities' decisions about (managing) their campuses, resulting in (more) inspiring, meaningful, functional, affordable, resource-efficient and sustainable built environments. Supporting campus managers – and other public real estate managers – in their connecting roles has been our mission for more than twenty-five years. For my inaugural speech, I divided our research agenda into four missions, with matching illustrations, see figure 58 in the caption.

These research missions have societal relevance – supporting the campus manager and other public real estate managers – and academic relevance, contributing to new knowledge, theories and innovations.

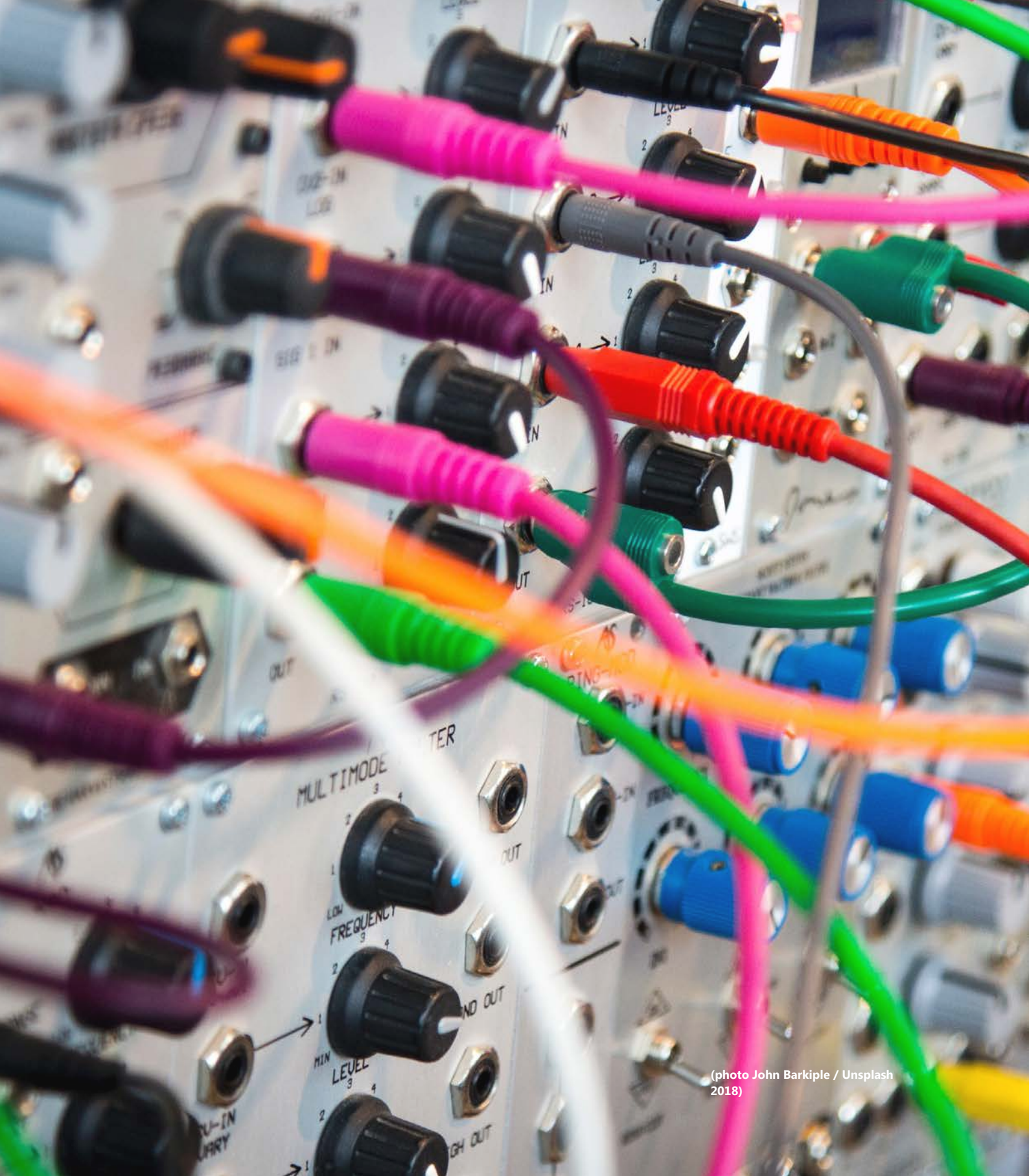
I. Building **NETWORKS** – Not only does the campus manager in the middle of the table need support from peers, but so does our campus research team (from both academic peers and decision makers in practice). The complexity of the integrating task (of organisational, financial, functional and physical perspectives) requires a good network to compare and exchange theories, methods, cases, databases, tools and dashboards, which are components or our other three missions.

II. Developing **THEORIES & METHODS** – The campus manager needs methods to encourage the stakeholders around the table to think beyond their own goals, added values and conditions. He can do so by turning the negotiation table and challenging the stakeholders to change roles, as demonstrated in the illustration.

III. Collecting **CASES &** creating **DATABASES** – The campus manager needs benchmarks: references of solutions at other universities to compare with solutions of the own university. As a campus research team, we build databases of campuses and university projects to identify patterns in campus strategies, themes and trends.

IV. Designing **TOOLS & DASHBOARDS** – The campus manager needs management information systems, dashboards and tools to oversee the consequences of decisions on multiple performance indicators. As a campus team, we consider tools as a means to engage all stakeholders in finding optimal campus solutions, effectively making them all "campus managers".

Ideally – with the output of all research missions – the campus manager can lean back and observe how the other stakeholders collectively find optimal solutions, which is also illustrated in figure 50, for research mission IV. In this part (C) of the book, I elaborate on all four missions with recent, current and planned projects in four chapters with the same titles.



(photo John Barkiple / Unsplash 2018)

Chapter C1
Research mission (I): building networks

Figure 59: our first research mission is to build networks to support the person in the middle of the table: peers in similar organisations or roles, who can learn from each other and help one another. (Illustration by Mark van Huystee 2020)

The first mission of TU Delft's campus research team is to build networks, professionally and academically. Again, the negotiation table as introduced in chapter B3 (see figure 24) is the basis. It represents both the force field in practice and in academia, with similar problems and solutions, which I will explain.

- Professionally, the campus manager in the middle of the table needs support from peers: other public real estate managers in the same position and campus managers at other universities. I have playfully referred to networks of campus managers as "therapy groups", in a positive way, since no-one understands the task of the person in the middle as good as people in the same position. They require each other's help and understanding as much as each other's knowledge. And considering the fact that the campus manager in the middle of the table is often confronted with complex decision-making and not always appreciated and respected accordingly, this is more than necessary.

- Similarly, in academia, our campus research team also takes the middle position, connecting insights from different scientific perspectives. I also often pictured myself in the middle of this table: the academic campus management table. The perspectives are the same and the academic languages that are spoken (on each side of the table) are equally different.

- Both in practice and in academia, the person in the middle can be "lost in translation", listening to stakeholders with different (scientific) languages, who express their goals, ambitions and conditions in text, emoticons, figures, equations and images.

The networks of "persons in the middle of the table", in academia and practice, need theories & methods (research mission II), cases & databases (research mission III) and tools & dashboards (research mission IV) to support their tasks. I will elaborate on each of these in the next chapters.

Our scientific position in networks

Which (academic) networks are relevant to connect, depends on our scientific view on campus management and the conceptual frameworks in our theories: our scientific position. Before I give examples of networks and network partners, I will start with our scientific position, see figure 60, which resembles the negotiation table since that

illustration was derived from the four-stakeholder model for real estate management (REM model), see part A.

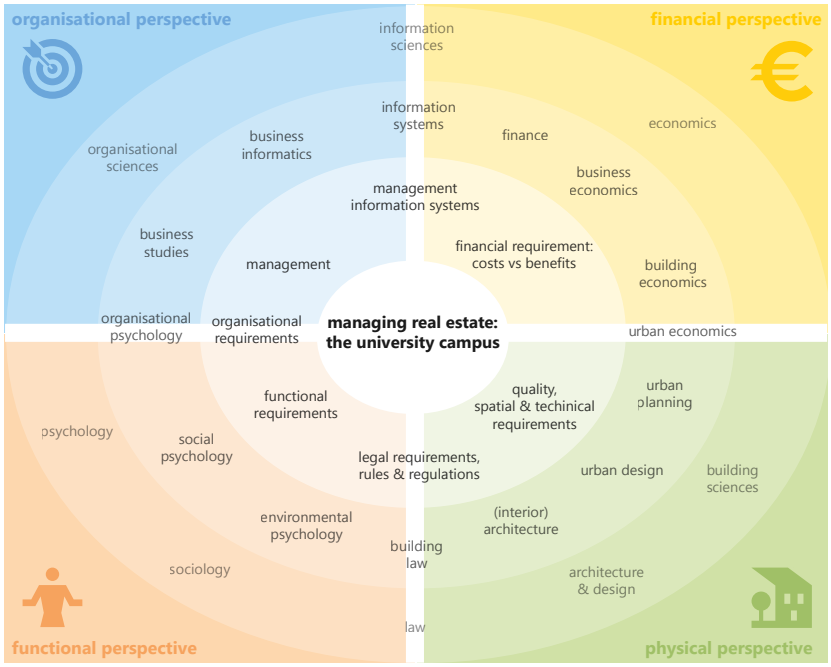


Figure 60: (public) real estate management in general, and campus management specifically, aims to connect the insights from many scientific disciplines, which can be related to (at least) one of the four stakeholder perspectives: organisational, financial, functional and physical. (Den Heijer 2011, adapted from dissertation *Managing the unversity campus*)

This figure shows that (public) real estate management in general, and campus management specifically, aims to connect the insights from many scientific disciplines, which can be related to (at least) one of the four stakeholder perspectives: organisational, financial, functional and physical. The closer to the middle of the figure, the more applied these disciplines are. The middle circle contains some of the requirements these scientific disciplines have for managing real estate. And the other way around, these requirements, as connected to stakeholder perspectives in chapter B3, all have scientific foundations.

The composition of the campus research team

It is our challenge – as campus research team – to collect these insights and translate them for campus decision-making. In that role, we can be considered or aim to be "scientifically multilingual" and "scientific interpreters" for campus management. Nonetheless, this also requires team members that speak at least two scientific languages, referring to the four colours in figure 60:

- either they are generalists, close to the middle of the figure, being able to connect the different requirements, which is a role that managers and designers, but also many politicians frequently take on;

- or they are specialists who speak at least two different scientific languages; this can be a combination of physical and financial, able to express physical choices in financial consequences, or functional and physical, able to connect user behaviour to environmental impact; of course, more combinations are possible.

What we want to avoid is that the "lost-in-translation" situation of the campus management table illustration is mirrored in our team. The composition of the campus research team can also be considered a combination of "solid-liquid-gas":

- "solid", long-term members, as my co-chair Monique Arkesteijn as tenured staff member who I have leading the team with for a long time;
- "liquid", our valued PhD and postdoc researchers, who have a multilingual scientific background; examples of (former) team members are Flavia Curvelo Magdaniel, Malgorzata Rymarzak, Naif Alghamdi, Juan Azcarate Aguerre and Bart Valks with whom we co-authored many scientific campus publications;
- "gas", as our extended team members in Europe, for instance, at universities as illustrated in figure 61 (European map) which we collaborated with in education and/or research, short-term research assistants and guest (PhD) researchers like Du Yawei, who visit our team for limited time to collectively write a publications or write research proposals.

1. Norwegian University of Science and Technology Trondheim, Norway

2. University College London London, United Kingdom

3. University of Gdansk Gdansk, Poland

4. Technical University of Berlin Berlin, Germany

5. Aalto University Greater Helsinki, Finland

6. Tampere University of Technology Tampere, Finland

7. University of Glasgow, Glasgow, Scotland

Figure 61: the locations of universities in our research network, highlighting some in particular.

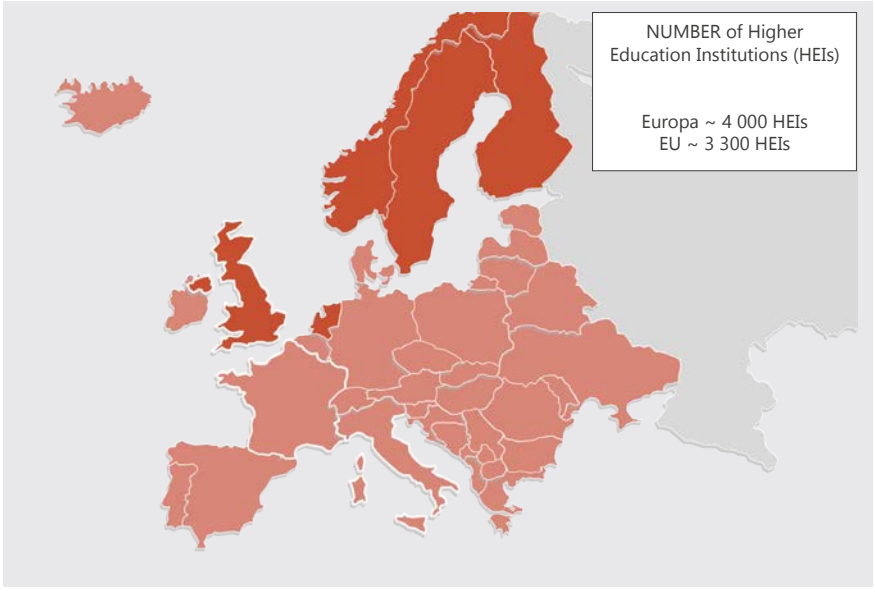
Scientifically, the campus research team needs a network of academic experts for knowledge exchange, with academic roots in the four stakeholder perspectives.

Campus management networks in practice

As an academic that has supported campus managers for decades, I empathise with many of them. Not only because I got to know so many of them around the world and have heard their struggles, but also because I recognise their position. As an academic with "campus management" as scientific expertise – and public real estate in general – I find myself in their position, but at an academic negotiation table, with the same four perspectives: organisational sciences in blue, economics and real estate finance in yellow, psychology and other social sciences in orange and natural sciences, arts and technology in green. Being a connector, communicator or interpreter in a complex decision-making process about campuses was a challenge I took on. It matched my ambition to never really choose one scientific field, but it also demanded "enough knowledge" about many scientific fields to have a basic vocabulary to communicate.

In the past decades, we shared our work with many universities and their campus managers. Figure 62 shows a map of Europe with an indication of the number of universities or HEIs (higher education institutions). This map also includes some of the (network) organisations in campus management that we frequently connected with. Examples are (with data retrieved for the inaugural speech in 2019):

- EUA: the European University Association, representing about 800 HEIs;
- UNL, formerly known as VSNU: the association of Dutch universities, representing 14 universities and network organisations "HOI" and "DFB" which manage 4,4 million m² at Dutch campuses and represent 14 directors of campuses and facilities;
- AUDE: the Association of University Directors of Estates in the United Kingdom, representing about 166 HEIs and 22 million m² campus buildings;
- Akademiska Hus in Sweden, representing 51 educational centres and 3,3 million m² buildings;
- Statsbygg in Norway, managing campus buildings of 17 HEIs (among other public real estate) and in total 2,9 million m²;
- SYK, University Properties of Finland, managing campus buildings of 10 HEIs and 1,1 million m².



Europe - about 800 HEIs

the Netherlands -
14 universities - 54 HEIs
HOI + DFB - 4,4 million m² (7 million m²)

UK - about 166 HEIs
22 million m²

Norway - 17 HEIs
2,9 million m²

Sweden - 51 education centers
3,3 million m²

Finland - 10 HEIs
1,1 million m²

Figure 62: map of Europe with the number of higher education institutions (HEIs) – universities and institutions for higher professional education – and the university networks or campus management (network) organisations, the number of HEIs they represent and/or the floor area (m²) campus buildings they manage (data retrieved from network websites for inaugural speech in 2019, sources: EUA, AUDE, Akademiska Hus, Statsbygg, SYK and UNL, in 2019 known as VSNU)

Each of these network organisations have supported our research with their experiences, cases and (parts of) databases. In return, we provide lessons from our cross-case analysis, databases, tools, dashboards, theories and methods, which I will elaborate in the next chapters.

Workshop Campus Research Team at TU Delft (photo AdH)

Presentation Campus Research Team with Sykoy in Tampere, Finland (photo AdH)

LocHal Tilburg, popular as a place to study for university students (photo AdH)

Chapter C2
Research mission (II): developing theories and methods

Figure 63: our second research mission is to develop methods to encourage the stakeholders around the table to think beyond their own goals, turn the table and take each other's perspectives. (Illustration Mark van Huystee 2020)

The second mission of TU Delft's campus research team is developing theories and methods. The campus manager needs methods to encourage the stakeholders around the table to think beyond their own goals, added values and conditions (as summarized in table 12 and explained in chapter B3). Together, they need methods to find solutions.

icon	colour	perspective	performance	key variable	stakeholders
	blue	organisational	continuity community connectivity	organisational goals	policy makers
	orange	functional	functionality health & safety productivity	users	users
	yellow	financial	responsibility feasibility accountability	euros	controllers
	green	physical	sustainability quality circularity	footprint	engineers

Table 12: the four-perspective REM model, as also introduced in chapter A2, with examples of performance criteria for campus management (Den Heijer 2011, adapted from dissertation *Managing the university campus*).

As a campus research team, we need to gather theories and develop methods to support the decision-making process. One way of doing so is to encourage the stakeholders around the table to think beyond their own goals, change positions at the table and take each other's perspectives. Again, the negotiation table is the basis, but in figure 63 it is turned one quarter (counter clockwise) to force stakeholders to look at the campus challenge from another perspective:

- the green stakeholder now takes the role of the yellow stakeholder, which means that the engineers are confronted with the financial consequences of their environmental demands and might search for smarter business models;
- the orange stakeholder now takes the role of the green stakeholder, which means that the users are confronted with the environmental consequences of their own demands and could decide to rethink them;
- the yellow stakeholder now takes the role of the blue stakeholder, which means

that the controllers are confronted with the organisational goals that need to be achieved with their (often limited) budget; this might stimulate them to explore more funding options;

- the blue stakeholder now takes the role of the orange stakeholder, which means that the policy makers are confronted with the functional consequences of their organisational (campus) strategy; this might stimulate them to reconsider this in close collaboration with the users it affects.

This method could encourage all stakeholders to think about optimal solutions instead of (only) their own maximum solution. The campus manager in the middle facilitates and observes. Ideally, tools and dashboards are used to support this process (see chapter C4).

As stated in chapter B3, preferably, the campus manager is a catalyst, not an emulsifier. What I wanted to express with this statement is that (campus) managers should "help to bring about a change" without being too intrusive or indispensable in the long term, like a catalyst (see text box for more background catalysts and emulsifiers). I think the manager should only enable and not be part of the solution.

"preferably, the campus manager is a catalyst, not an emulsifier"

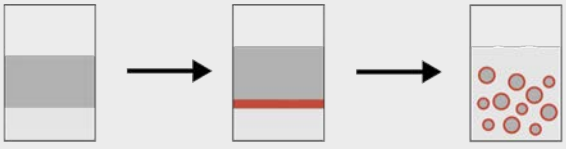
My preference for metaphors from chemistry, physics and biology, also made me make this statement about managers and management in a position paper I wrote in 2017.

In general, my view on leadership is that a manager or coordinator should "help to bring about a change" without being too intrusive or indispensable in the long term, like a catalyst is "causing or assisting a chemical change in another substance without itself undergoing any permanent chemical change". The advantage of the manager as a catalyst is that the manager will no longer be part of the system in the changed state. This allows the manager to take on new challenges. The disadvantage is that the added value of "catalyst managers" can be downplayed afterwards.

The manager as emulsifier is quite the opposite: an emulsifier is a compound or substance that acts as a stabilizer, preventing liquids that ordinarily do not mix – like oil and water – from separating. Oil and water could be metaphors for stakeholders in the built environment with very different goals and characteristics that need to collaborate in a different way. The added value of "emulsifier managers" will be hard to deny, but the disadvantage is that the manager cannot easily leave the process afterwards. It is obvious that I prefer the catalyst over the emulsifier approach in management and leadership.

emulsifier

An emulsion is a stable mixture of two or more immiscible liquids, maintained in suspension by small amounts of substances known as emulsifiers (also referred to as "emulgents").

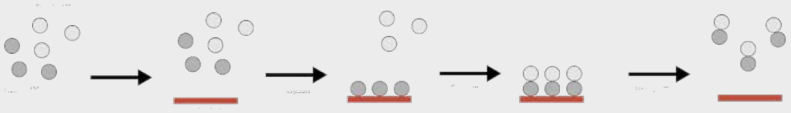


scientific explanation of "emulsifier": re-interpretation from secondary educational textbooks (Illustration Ruben Vos 2020)

catalyst

A catalyst accelerates both the forward and backward reactions equally, enabling the reaction to reach equilibrium more quickly, thus saving time.

A catalyst is a substance that increases the rate of a chemical reaction while remaining chemically unchanged itself.



scientific explanation of "catalyst": re-interpretation from secondary educational textbooks (Illustration Ruben Vos 2020)

Serious gaming as a didactic method: management games in education

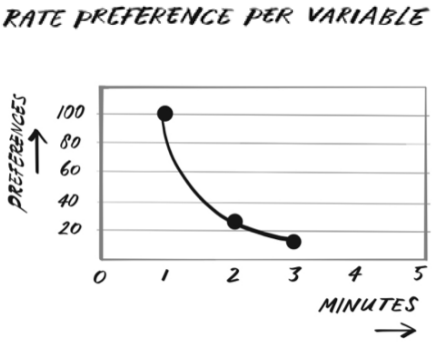
While any intervention in the built environment is team work, serious gaming has become a successful didactic method in our curriculum in Delft. Since the 1990s, management games have been effective methods to teach students both the complexity and the problem-solving capacities of the group. Our Real Estate chair – followed later by the chair in Urban Area Development – has applied this method from the very first academic year of our Master track, now called Management in the Built Environment (MBE). From the start, it has been popular among students, while they acknowledge that they learn most - and most effectively - by doing. As a course coordinator and teacher, I have been involved in management games for decades. Colleagues have published about the importance of serious games in design and management education (Qu et al. 2019).

Studio space with students playing a management game (Bachelor education, Faculty of Architecture and the Built Environment, TU Delft, photo AdH)

A preference-based design and decision method for real estate managers

"No-one wins unless everyone wins". In theory, the negotiation table should come up with the optimal support for any goal of any stakeholder. In practice, it requires creativity, flexibility and engagement of every stakeholder. In Arkesteijn's dissertation (2019) mathematical methods are given, involving all stakeholders to formulate their preference scores, design alternatives and collectively find the best alternative with the highest overall preference score (see figure 64).

Corporate Real Estate alignment, a preference-based design and decision method



Corporate Real Estate alignment (Monique Arkesteijn 2019)

Figure 64: stakeholders formulate their preference scores, design alternatives and collectively find the best alternative with the highest overall preference score (Arkesteijn 2019). (Illustrations Mark van Huystee 2019)

Arkesteijn's real estate portfolio strategy approach deals with one of the longstanding issues in corporate real estate (CRE) management is the alignment of an organisation's real estate to its corporate strategy. Even though extensive research into existing CRE alignment models has provided valuable insights into steps, components and variables needed in the alignment process, these models still fall short in a number of ways. To name but one, most models pay little to no attention to the design and selection of a new portfolio that adds most value to the organisation. The PAS approach is a decision-support tool that remedies these shortcomings and thereby enhance CRE decision making.

Monique Arkesteijn has tested her method in a campus setting, with the real policy makers, controllers, users and engineers around the table. She tested it on campus decisions about lecture halls and restaurants. She observed the process and helped to formulate the assessment criteria: which aspects matter for this decision? (also see chapter B3, in which I described these aspects for the four stakeholders) Iteratively, the stakeholders collaboratively generate the alternative solution with the highest preference.

Arkesteijn's method demands the stakeholders to use tools, which connects her to research mission II as well as IV (tools and dashboards). The test cases of her methods are good examples of using the campus as a living lab and implementing innovations on campus, which is also a research subject of our campus research team.

Implementing campus innovations: practise what you preach in living labs

Successively, post-doc researchers Malgorzata Rymarzak and Mathilda du Preez studied the possibilities of the campus as a living lab. Before, Malgorzata focused on university governance in the European context (Rymarzak et al. 2019). With innovation as the third mission of universities – next to education and research – "living labs" are opportunities to practice (in operations) what the university preaches (in education and research) on its own campus (Rymarzak et al. 2022).

Figure 65 illustrates that living labs connect the primary process (research and/or education, left) with the secondary process (campus operations, right). In-between, there are drivers (opportunities) and barriers.

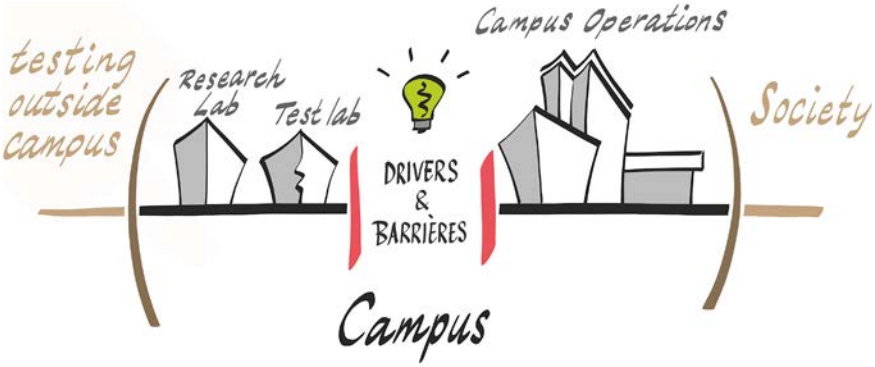


Figure 65: in living labs, the primary process (research, left) needs to be connected with the secondary process (operations, right); in-between, there are drivers (opportunities) and barriers. (Illustration Mark van Huystee 2020)

This research project started in 2019, when TU Delft's executive board wanted support with connecting innovation supply from research theory with innovation demand from campus practice. In return, campus practice could supply space to accommodate the living labs that demand space. In 2020/2021, we interviewed all Dutch universities about the drivers and barriers they experience on their campuses. This also resulted in an overview of the living labs of Campus NL. Malgorzata, Mathilda and I have analysed interviews with all thirteen Dutch universities about the drivers and barriers for living labs and testbeds (which I conducted with research assistant Iris Moons).

During the interviews, I used another metaphor from physics to illustrate both the problem and the solution. The problem is that the frequencies in (for instance) goal setting, funding acquisition and planning are very different. The theoretical solution is "synchronising" these aspects with different wavelengths, which demands – of course – an urgency to do so.

Figures 66a (on next page) demonstrates the different frequencies of research labs with ideas on one side of a bridge and campus operations with the space to test them on the other side of a bridge. Figure 66b demonstrates that a match between both sides is possible if the different frequencies are synchronised and aligned.

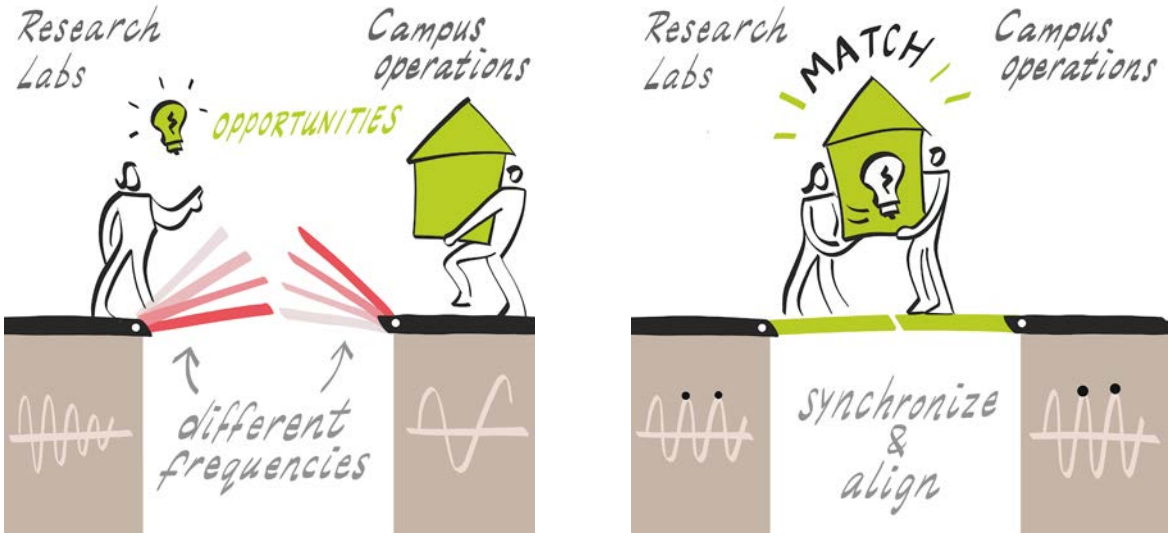


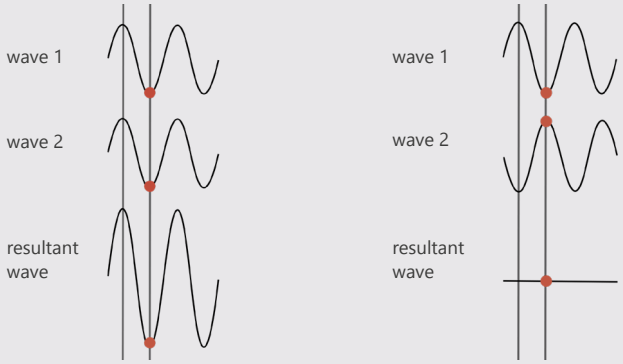
Figure 66:
(a) (L) this image demonstrates the different frequencies of research labs with ideas on one side of a bridge and campus operations with the space to test them on the other side of a bridge.
(b) (R) this image demonstrates that a match between both sides is possible if the different frequencies are synchronised and aligned.

While this research also provides an overview of the living labs on Campus NL, it aims to result in a roadmap or decision tree for assessing which procedure should be followed for implementing campus innovations, initiated either from science or from practice.

Wavelength/frequency alignment

When two waves intersect, their displacements combine by addition.

The principle of superposition of waves states that the overall displacement at a point where waves meet is the sum of the individual displacements. This rule applies not only to two waves but also to multiple waves and all wave types.



scientific explanation source: Den Heijer 2024 (re-interpretation from secondary educational textbooks) (Illustration Ruben Vos 2020)

Testing innovative methods on campus: product-service systems

An example of a living lab connected to our own campus research team, is exploring product-service systems on TU Delft's campus. From 2014, "facade leasing" has been a cross-disciplinary research topic, combining innovations in facade technology with innovations in management. This Circular Business Models PhD research project is co-funded by EIT Climate KIC since 2015, and led by colleagues from Architectural

Engineering and Technology (professor Tillmann Klein and Juan Azcarate Aguerre). Together, we have published about the results (Azcarate Aguerre et al. 2017). With post-doc research Luz Maria Vergara d'Alençon, we have published about case studies of circular business models (Vergara d'Alençon et al. 2019), of which many are campus projects or other public real estate.

The TU Delft has served as a living lab for this research, demonstrated by replacing four façade panels of the EWI building in 2016 as a pilot and using the east facade of the CiTG building as a test case in 2018-2019 (see figures 67). Accelerating the rate and depth of energy renovations in buildings is one of the biggest challenges currently facing the construction industry. Across Europe, many buildings constructed during the post-war boom of the 1950's to 1970's are quickly reaching the end of their original service life, including many university buildings.

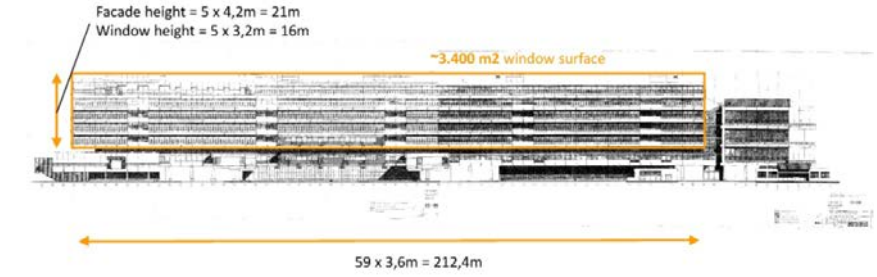


Figure 67: two living labs to test product-service systems for facades on the TU Delft campus, co-funded by Climate KIC (European Institute of Technology, EIT).

link to research: Juan Azcarate Aguerre, https://www.tudelft.nl/bk/onderzoek/projecten/green-building-innovation/facade-leasing/facade-leasing-pilot-project-at-tu-delft) (source photos (L-R): Marcel Bilow 2016, Juan Azcarate Aguerre 2019)

more information about circularity and living labs: https://www.tudelft.nl/bk/onderzoek/onderzoeksthemas/circular-built-environment)

Climate-KIC is supported by the EIT, a body of the European Union

AE+T: chair Building Product Innovation
MBE: chairs PRE, Public Commissioning, Law

Campuses are ideal test grounds, while - more than many other users and operators of commercial real estate – universities tend to have a long-term commitment and attachment to their locations and buildings. The size of their campuses also provides an economy of scale, which is difficult to replicate. More significant still, they have a social responsibility to lead the way towards better and more efficient practices, particularly those that involve a more efficient and responsible management of energetic and material resources. These and many other factors make them ideal living labs for new methods of construction, organization and collaboration. As demonstrated in the past decades, they also serve as a living lab for our campus management research (source: https://www.tudelft.nl/bk/onderzoek/projecten/green-building-innovation/facade-leasing/facade-leasing-pilot-project-at-tu-delft/). In 2023, Juan Azcarate Aguerre defended his PhD thesis and published his dissertation "Facades-as-a-Service" (Azcarate Aguerre 2023).

Library at Faculty of Architecture and the Built Environment (photo Geert de Jong/Cheeseworks for TU Delft 2022)

Chapter C3
Research mission (III): collecting cases & creating databases

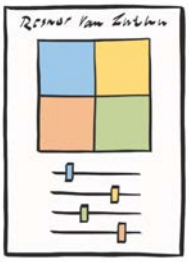


Figure 68: database card with info about four perspectives (Illustration Mark van Huystee 2020)

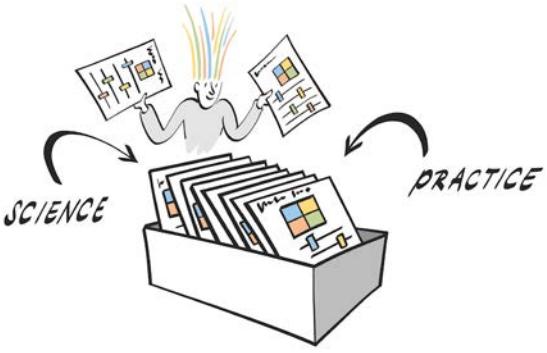


Figure 69 (R): our third research mission is to collect cases and create databases to identify patterns and to provide references for campus decision-making. (Illustration Mark van Huystee 2020)

The third mission of TU Delft's campus research team is collecting cases & creating databases. The campus manager needs benchmarks: references of solutions at other universities to compare with solutions of the own university. As a campus research team, we build databases of campuses and university projects to identify patterns in campus strategies, themes and trends. Any campus decision that has been taken – a new building or a refurbishment project – can be expressed in a "database card" with info about four perspectives, see figure 68, with data about (at least) supported goals (blue), spent euros (yellow), involved users (orange) and quality and quantity of (green).

As introduced in part A, the strategy process framework – of REM in general and campus management specifically – requires methods, management information and tools for four management steps: assessing the current campus, exploring changing demand, generating future campus models and defining projects to transform the campus (see table 13). Databases are both filled and used during this process.

step #	step	evaluation tasks	planning tasks	methods and tools	required information
1	assessing the current campus	compare current with past campus	benchmark current with other universities	portfolio database "the containership"	
2	exploring changing campus demand	analyse past demand	forecast future demand	scenario analysis	
3	generating future campus models	evaluatie current models (which were once 'future')	compose future models based on strategic choices	serious gaming dashboard design co-creation	
4	defining projects to transform campus	evaluate past projects: lessons learned	benchmark with innovative campus projects	project database "the sailboat"	

Table 13: the four steps of the REM process framework (also known as "DAS framework", De Jonge et al. 2009), combined with the required information from the four-perspective REM model (Den Heijer 2011, adapted).

Over the years, our (campus) research team has developed methods and tools to support the four management steps. Campus portfolio databases with data about goals, users, euros and footprint (in line with the four-perspective campus management model) to compare and benchmark the current campus (step 1), using scenario analysis to explore developments and trends in demand, including extrapolating from the past to future (step 2), applying serious gaming – changing roles for stakeholders in management games – to co-create future campus models (step 3) and filling project databases to learn lessons from the past and benchmark with innovative campus projects (step 4).

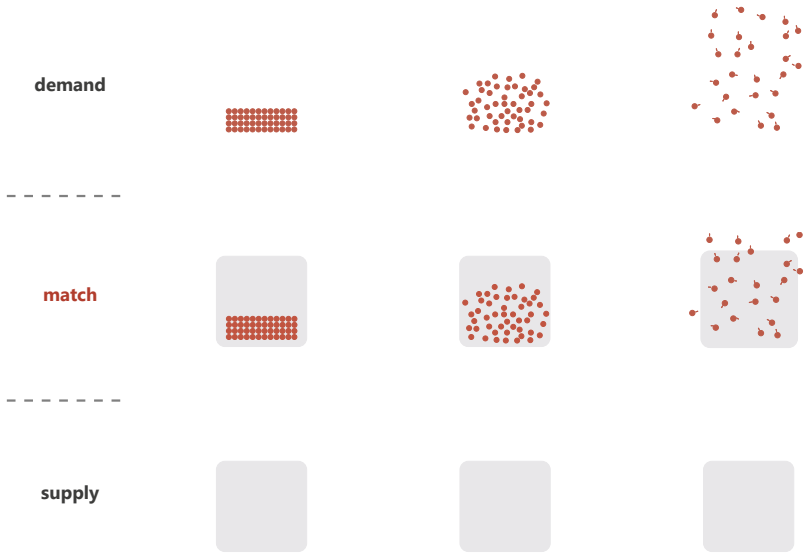


Figure 70: managing the match (middle) of demand (top) and-supply (bottom), for solid, liquid and gas.

The campus project database can contain both new buildings - which experiment with new trends - and refurbishments, which bring new life to old buildings. I refer to this type of database as "the sailboat", which can easily change course compared to "the containership", the metaphor I use for the portfolio database with data that shows more stable, long-term developments. Both databases are necessary to determine campus trends. From 2021, research has focused on updating and expanding the databases and exploring more the themes for the campus of the future (with postdoc researcher Özlem Altinkaya Genel).

Other databases, contain country data, as Campus NL represents the aggregated campus data of the Netherlands (Den Heijer et al. 2016, 2024) or campus-city data, including the urban context (politically, economically, socially and environmentally) in the database.

Campus portfolio database

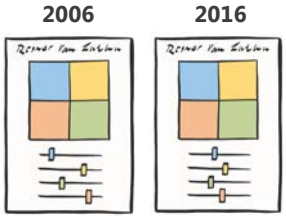
Referred to as "the containership", this database contains campus management data on campus level. For instance, data is collected about floor area (m^2), total costs of ownership (euros), total number of students and employees (users) and the priorities in organisational goals that need to be achieved (added values).

As demonstrated in figure 71, the two-page datasheet not only contains data from the four perspectives, in the structure of our conceptual framework, but also a short text about the university, the vision on the campus, campus maps of the various locations, photos of the variety of their buildings. The latter is connected to our other database – "the sailboat" – with university projects.

Figures 71: example of two-page data sheet (see also next page) in the campus portfolio database – the "containership" (Den Heijer 2011).

In the past decades, our team frequently collected general campus data, like total floor area, number of students, employees etc. In 2006 and 2016 we collected more comprehensive datasets. As a result, detailed campus comparisons can be made between data of 2006 and 2016 (longitudinal). Patterns can be identified about the ratio "floor area per user" or "costs per m²". Also, the age profile and condition of the campus can be monitored over time. Universities can use their peers as benchmarks to assess their own data. More general data can be compared over a longer period of time, from the moment of campus ownership transfer to the universities (1995).

Apart from comparing Dutch universities, our team also assessed a set of European universities of technology. These datasets were analysed in published in the book "The European campus – management and information" (2019).



follow a solution in time 2006-2016
(Illustration Mark van Huystee 2020)

LEI Campus profile

Notes:
data is provided by the university and from the year 2007 for comparison; how campus changed since 2007 can be found in strategy text; strategy text written by author based on documents, interviews and questionnaires 2007-2010

goals

past		future	strategy
4%	representative	5%	1%
17%	meeting place	29%	11%
78%	plain & efficient	66%	-12%

1 support identity user (faculty, department or institution that uses the building)
2 stimulate innovation / collaboration (staff-staff, staff-students, student-student)
3 save accommodation costs

€

total income	405	mln €
total expenditure	416	mln €

values	*mln €*	*€ / m2 gfa*	
WOZ value	312	790	
insurance value	633	1.600	
book value campus*	173	440	*buildings & land

	total in mln €	*€ / m2 gfa*	*% expenditure*
costs of ownership	44	111	11%
energy & water	7,4	19	

CREM

users

students	15.330		
staff	total	academic	supporting
head count	4.010	2.110	1.900
fte	3.330	1.830	1.500

office space (m2 ufa) / staff member	16,0
office space (m2 ufa) / fte	19,3
educational space (m2 ufa) / student	2,1
- lab space / academic staff member	7,9

m2

gross floor area	395.000	*m2 gfa*
usable floor area	210.000	*m2 ufa*
ufa / gfa	53%	
rented m2	3%	from external parties
let out m2	3%	to external parties
land property	81	hectares
% office space	30%	(100 % = no)
% educational space	15%	
% specific space	22%	
- % lab space	14%	

CONDITION	% m2
excellent	6%
good	27%
reasonable	25%
moderate	29%
bad	14%
very bad	
	100%

AGE	% m2
< 1900	4%
00s	1%
10s	
20s	0%
30s	1%
40s	0%
50s	5%
60s	27%
70s	14%
80s	34%
90s	5%
> 2000	8%
	100%

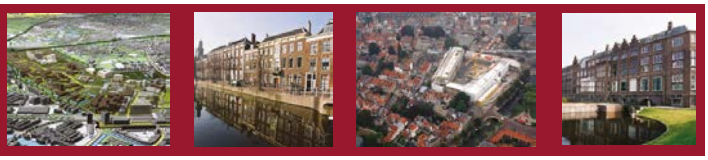
Campus strategy

Traditionally, the university is fully integrated with the inner city. Their strategy is to cherish the 'univer-city' Traditionally, the university is fully integrated with the inner city. Their strategy is to cherish the 'univer-city' and to gradually renovate the inner city buildings to meet current and future demand. The limited resources force them to intensify use and trade quantity for quality of space. On their new university college location in The Hague (Lange Voorhout) they also value the relation with inner city.

At the Leeuwenhoek location, the campus strategy is to encourage university-industry interaction, both with the Academic hospital (LUMC) and the bioscience and life science businesses. This location is increasingly becoming a vital part of the city, with more student housing, other institutions (Hogeschool Leiden) and museums (Naturalis). Other strategic goals are increasing flexibility, stimulating collaboration and reducing the footprint. The university combines a more traditional university campus model with an increasingly open network model.

Based on questionnaire 2007, LEI 2006 and www.leiden.edu

future



Appendix I Dutch university campuses 299

Campus project database

Referred to as "the sailboat", because it changes course much easier than the campus portfolio data in the "the containership", this database contains data of a range of university projects: from extra-large faculty buildings (larger than 50.000 m^2) to small-scale heritage refurbishments in inner cities.

Figure 72 shows that the datasheet resembles the illustration of the 1-page database card, with data about the four perspectives: floor area of the project (m^2), investment costs (euros), also per m^2, number of users involved or accommodated (students and staff) and "added values" (or goals) to achieve with this building. These match the added values that were introduced in chapter B3 for each of the stakeholders.

Figure 72: example of one data sheet in the campus project database – the "sailboat" (Den Heijer 2011).

The total database consists of 65 projects. Figure 73 shows these projects, as assessed for the Campus NL research project (2016), with icons matching the predominant themes. These match the icons of the first ten themes in chapter B4.

With this database, a timeline can be made to acknowledge themes and trends. Both databases – campus portfolio and campus projects – served as a foundation for part B of this book.

Campus NL references

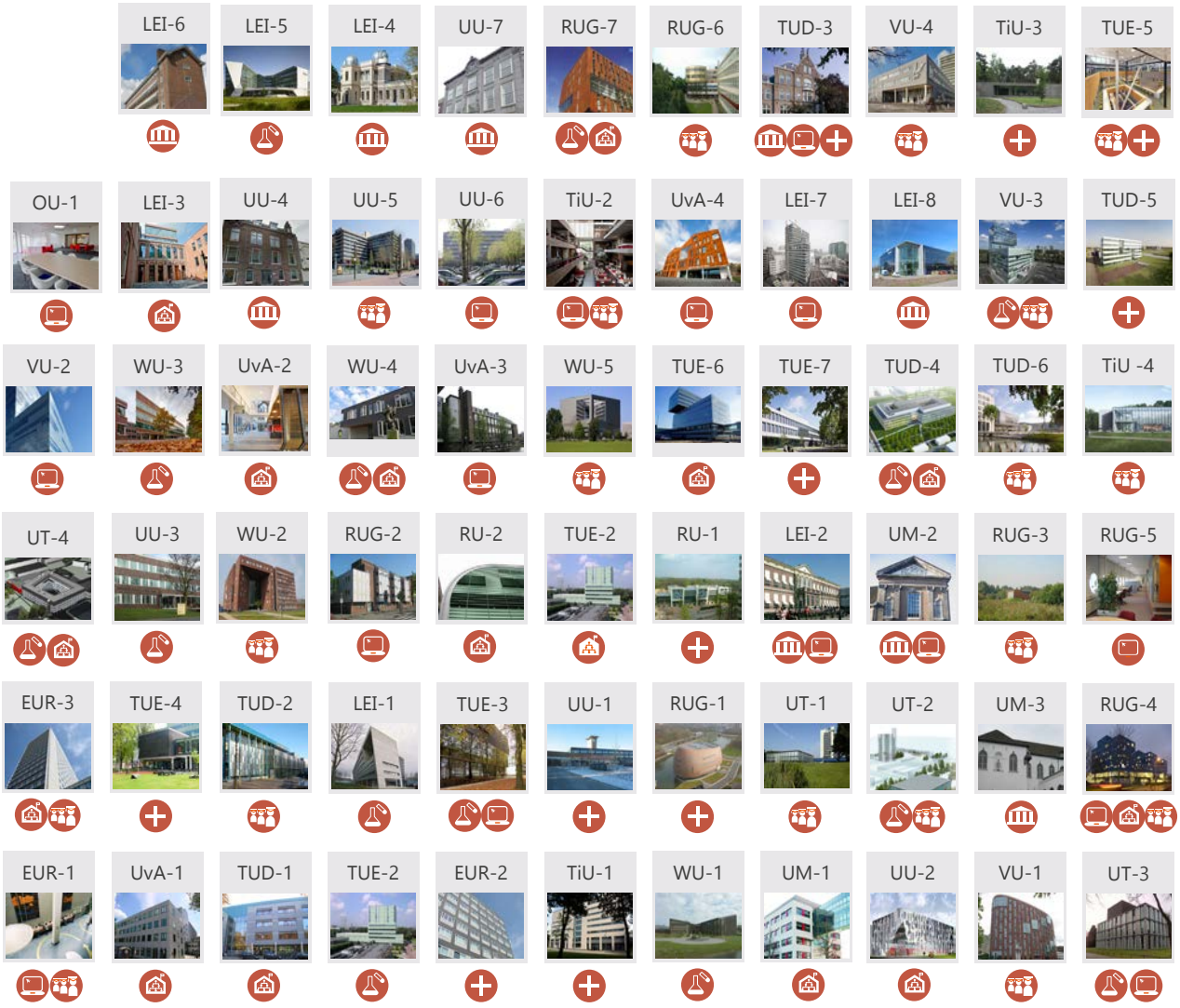


Figure 73 shows 65 projects, as assessed for the Campus NL research project (2016), with icons matching the predominant themes. These match the icons of the first ten themes in chapter B4. (photos retrieved from Campus NL 2016, provided by corresponding universities)

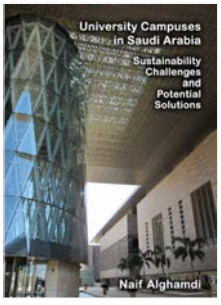
The European Campus (Den Heijer et. al, 2014, 2019)

Cases on country level

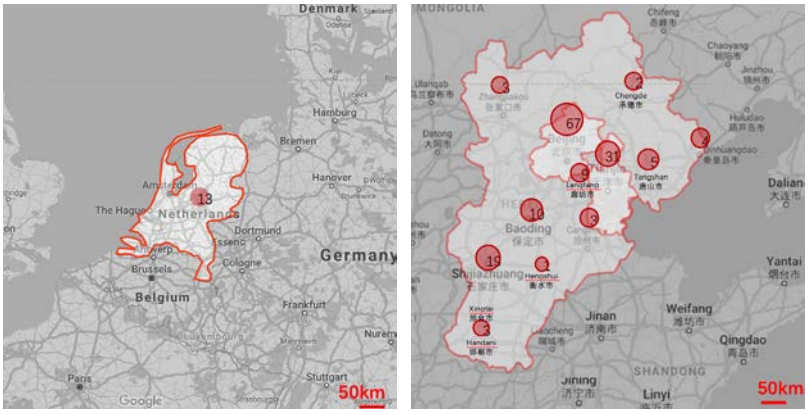
From 2011, our team shifted the focus to the European campus. This resulted in the book "The European campus – heritage and challenges" (Den Heijer and Tzovlas 2014). For this research project, campus-level data was collected for European universities (Den Heijer and Tzovlas, 2014). The data regard the state of the campus in all EU member states, (number of) students and employees, funding, locations, iconic buildings and (number and state of) m^2 floor area. Part of this European campus research is the ambition to design a decision-support tool: "a campus stress test". This stress test contains a set of key performance indicators (KPIs) to assess current European campuses and new campus plans, using European best practices as references and benchmarks. A second book was based on data of thirteen universities of technology in 2019 "The European Campus – Management & Information" (Curvelo Magdaniel, Den Heijer and Arkesteijn 2019). That book also contained numerous developments in the context of universities and scenarios for the future of higher education, not only in Europe. Again, it was emphasized that a substantial number of universities is dealing with similar challenges.

Increasingly, that challenge was sustainability. TU Delft's campus research team has studied the sustainable campus since the Dutch universities signed agreements to reduce CO2 emissions in 2008. Through the years, this research has focused on various international case studies. The Sustainable campuses in Saudi Arabia PhD research project focused on campus management in Saudi Arabia (Naif Alghamdi, PhD defence in 2018). The research covered the recent campus development of many universities in the country, with a strong focus on sustainability. During academic year 2019/2020, Chinese PhD student Du Yawei joined Delft's Campus Research Team to explore sustainability at Chinese universities and their campuses, which resulted in a paper (Du et al. 2020).

As the basis of their studies, both Naif Alghamdi and Du Yawei collected data about the universities in their country or region, providing references of university size and floor area use for example, see figures 74 and 75.



University campuses in Saudi Arabia (Naif Alghamdi 2018)



Netherlands vs Beijing-Tianjin-Hebei province of China

Population (min. inhabitants)	Number of University	Number of Student (min) (vsnu,2018)
17	13	0,3 est.

Population (min. inhabitants)	Number of University	Number of Student (min) (MOE,2018)
113	157	2,2 est.

Figure 74 (R): universities in the Beijing region, China (Du Yawei 2019)

Together with his PhD supervisors, Naif Alghamdi published a journal paper "Assessment tools' indicators for sustainability in universities: an analytical overview" (Alghamdi et al. 2017), which has been cited frequently ever since.

Cases on campus-city level

The PhD thesis "Technology campuses and cities" (Flavia Curvelo Magdaniel, 2016) examined the development of technology campuses with the aim to gain and provide understanding about the role of the built environment in stimulating innovation. By developing more knowledge on the subject, it can lead to more efficient and effective use of the resources. The research included an exploratory study of 39 technology campuses and two explanatory case studies of HCTE, Brainport-Eindhoven and the MIT campus. The 39 cases were also published in a separate publication "Campuses, cities and innovation" (Curvelo Magdaniel et al. 2017).

39 technology campuses compared in their urban setting (PhD 2012-2016)

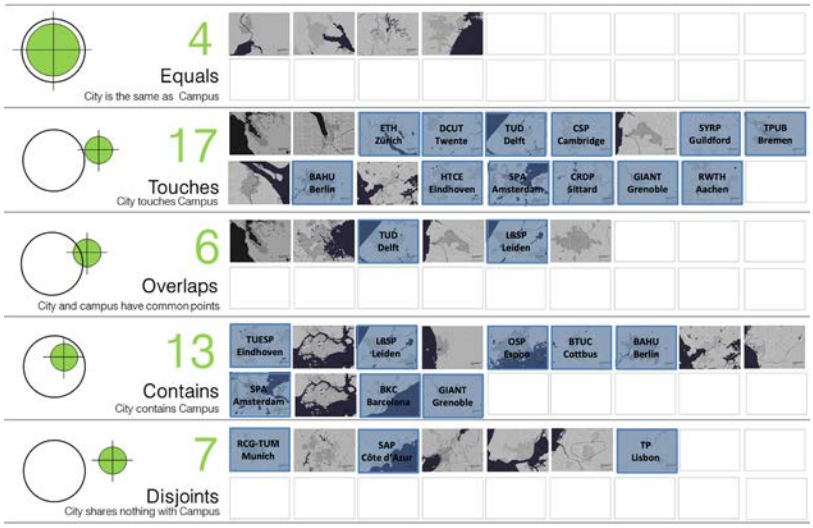


Figure 75: in papers and books, the development of technology campuses was examined with the aim to gain and provide understanding about the role of the built environment in stimulating innovation. (Curvelo Magdaniel 2016, 2017).

Campuses, Cities and Innovation (Curvelo Magdaniel 2017) & Technology campuses and cities (Curvelo Magdaniel 2016)

Over the years, the team wrote many publications about the connection between university and city, starting around 2006 with our research theme "Building knowledge cities". With Flavia Curvelo Magdaniel, this theme was strengthened and expanded to innovation areas. One publication that gives an overview is a chapter in the book "Geographies of the university" with the title "Campus-city relations: past, present and future" (Den Heijer and Curvelo Magdaniel 2019).

Collecting PRE cases and data: public real estate in powers of ten

The campus research team is frequently involved in assisting specific universities, government organisations and academic hospitals with their "campus" strategy processes and/or rethinking management information for PRE decision making in general. Solid-liquid-gas patterns in their PRE portfolio are often recognised. Hospitals for instance, have also gone through transitions from traditional to network and virtual: (solid) local hospital with broad care spectrum, patient visits one hospital for all specialisations, (liquid) patient moves to regional or national hospital with best specialist care, hospitals form a network of specialisations and (gas) care at home, with support of apps and smartwatches for patients.

contract with the Netherlands police

In September 2020, the chair of Public Real Estate agreed a four-year contract with the Netherlands police, which is one of the biggest owners of public real estate in the Netherlands. From police station to forensic laboratory, from monuments in the centre of The Hague to large-scale facilities in Driebergen: the task of accommodating the police is as diverse as it is challenging.

Campus themes such as innovation and sustainability, health and safety, as well as identity, flexibility and affordability – as many other subjects in part B of this book – are also relevant for the police's accommodation strategy. Finding a new balance between the physical, mobile and digital workplace is one of their tasks, just like at the university. Providing support for decision making about the police's highly varied facilities will be one of the main objectives of this contract.

Researchers will connect academia and practice by working part-time in the Facilities sector of the police Services Centre. Short-term educational and research projects are also organised, in which the research team will involve students and colleagues from the faculty and university.

public real estate in powers of ten

For almost a year, the working title of my inaugural speech was "Public real estate in powers of 10", highlighting both the extra-large, multi-faceted impact of PRE and the ambition to express this impact in an order of magnitude, ultimately to determine the value of public real estate.

PRE buildings are among the largest buildings in each city – "PRE is extra-large in gross floor area", university faculty buildings are often fifty to hundred thousand m^2, ministries and hospitals exceed hundred thousand m^2. They match corporate headquarters in size, which are the rare competitors for extra-large size for single-tenant buildings.

Figure 77 contains estimations of the size of the total PRE portfolio in NL. The uncertainties in these figures – and the difficulties to collect these data – demonstrate that finding PRE data is not easy. It is a research challenge worth further exploration, which will be part of my research agenda, together with Public Commissioning professor Marleen Hermans.

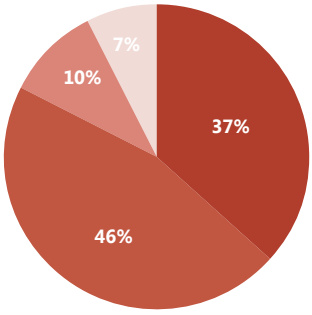


Figure 76 the "public real estate" portfolio in NL is XL in size; the pie chart contains estimations (based on Heijnders en Hermans 2013; Hermans 2014).

Table 14: source of the table is the inaugural speech of Marleen Hermans in 2014 (Hermans 2014)

Due to data sources from different years, there is a difference between the piechart and table in size of PRE portfolios.

Segment	Description	GFA* mln m^2
1. Health	Healthcare and nursering. Healthcare for children.	52
2. Education	Secondary and higher education. Primary schools.	18 27
3. Decentralised Administration	Municipality, Provinces, Waterschap. Mainly Municipality Real Estate, partially for own use (offices), partially specific as museums, sport buildings, neighboorhood centra.	25
4. Central administration	Royal Real Estate and non-departmental, where 50% are offices and the rest is specific as museum, palaces, prisons or asylum center.	15
Total		137

(photo Alexey Ruban / Unsplash 2016)

Chapter C4
Research mission (IV): designing tools & dashboards

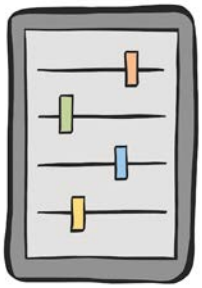


Figure 77: smart tool with info about four perspectives (Illustration Mark van Huystee 2020)

Figure 78: our fourth research mission is to design tools & dashboards to engage all all stakeholders in finding optimal campus solutions, effectively making them all "campus managers". (Illustration Mark van Huystee 2020)

The fourth mission of TU Delft's campus research team is building networks, professionally and academically. Again, the negotiation is the basis, but supported by tools and dashboards. The campus manager needs management information systems, dashboards and tools to oversee the consequences of decisions on multiple performance indicators; at the same time, tools can help each of the other stakeholders in finding solutions for their own goals with maximum added value for all stakeholders. As a campus team, we consider tools as a means to engage all stakeholders in finding optimal campus solutions, effectively making them all "campus managers" (see figure 78).

Smart campus tools to support campus users

In 2016, our "smart campus tools" research started with a presentation about the "towel problem" on campus and the unanimous request of the Dutch campus managers to make this our next research mission. The following issues were at the basis of this mission:

- "No-shows" are reservations that are neither kept nor cancelled. Reservations that are not followed by actual use are an organisational, financial, functional and environmental problem for any facility or service that requires reservations. That is because they are scarce by definition, since "if they were not scarce", a reservation would not be necessary. Again, the scarcity of those facilities makes it all the more annoying for service-providers and (other) users, if reservations are left unused. Some charge the no-shows for their claim, like some restaurants.

- "The difference between stated and revealed preferences" has been a challenge for campus managers. What users claim that they need, is not necessarily what they use in reality. Even though many state that a certain gap is logical, they also agree that the gap is quite considerable. Many campus managers have mentioned this as a missing link in campus management. In fact, the lack of reliable (big) data about space utilization indicated the start of our "smart campus tools" research theme in 2016.

- Universities aim at using smart tools for better use of space and higher user satisfaction. It is not only the problem of campus managers that utilization rates are low and workplaces or meeting rooms are claimed but not used. It is certainly also a frustration of the users themselves, which – ironically – could force them to make more reservations.

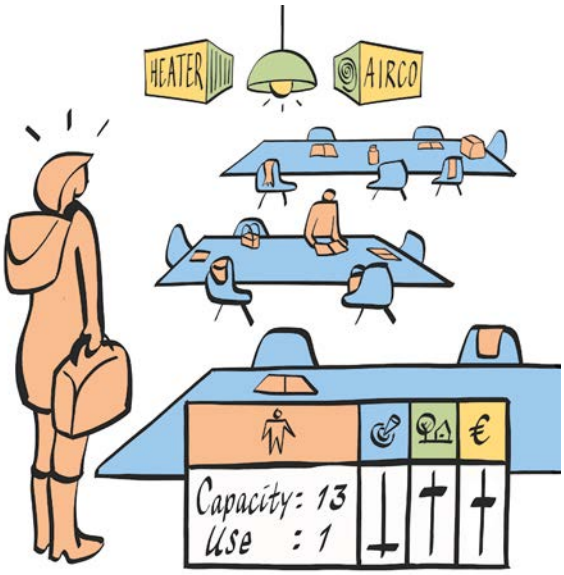


Figure 79a: the "towel problem" at the pool: many claim sunbeds, even if they are not (yet) there. (Illustration Mark van Huystee 2020)

Figure 79b: the "towel problem" at the campus: many claim study places, even if they are not (yet) there. (Illustration Mark van Huystee 2020)

- The "towel problem" is the phenomenon that sunbeds at the poolside are claimed by putting towels on them, but are left unused for considerable time. Campus managers identify the same this on campus. Figure 79a illustrates the "towel problem" at the pool: many claim sunbeds, even if they are not (yet) using them; similarly, figure 79b illustrates the "towel problem" on campus: many claim study places, even if they are not (yet) using them.

- The goal is of smart tools in general is a better allocation of study places and meeting rooms through self-management of students and employees. More and more universities are using technological developments to measure where users are - and where they are not - on campus via WiFi, Bluetooth and other sensors (because timetables and reservations often say more about planned use than about actual use).

- On the basis of big data about actual use, students and employees can – for example via apps on their smartphones – get a real-time overview of empty spaces and can be navigated to available study places or vacant meeting rooms on campus. The use of smart tools can not only ensure more efficient and effective use of space, but can also promote user satisfaction, because they have more self-direction in finding the most suitable space for their activities. On top of that, resource-efficiency contributes to a sustainable campus and university.

- It is obvious that this subject is also sensitive on both sides of the equation: monitoring space use is often perceived as "big brother is watching you", while investing public resources – taxpayers' money – in underutilized facilities is also reason for debate. The ambitious sustainability and circularity goals add to the discussion, while "avoid wasting resources" is increasingly higher on the university's agenda.

- Last but not least, the corona crisis has made "monitoring space use", "capacity control" and allowing only limited numbers of users on campus a world-wide campus theme from 2020.

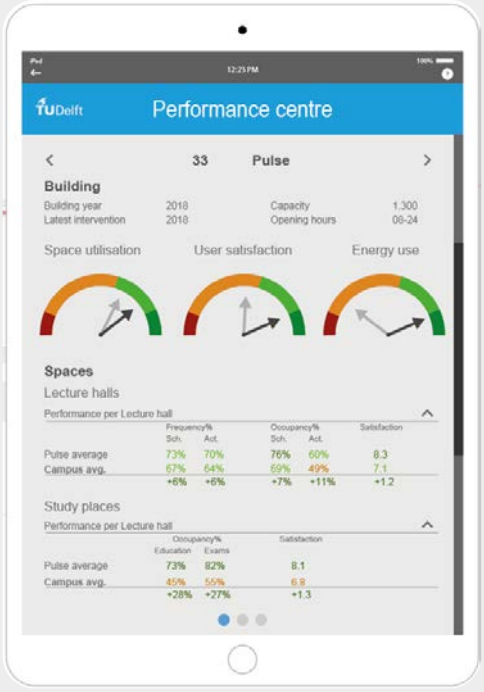
The "Smart campus tools" research – which started parallel to the Campus NL research in 2016 - has since then been a key theme for the campus research team, with Bart Valks as the main researcher and specialist.

Claiming space (and not using it) creates a demand for more space among students and teachers, while at the same time campus managers know that the available spaces are not being fully utilized. It seems that smart tools can make an important contribution to solving this problem and thus of added value for various stakeholders on the campus. By helping users book or find a room, they can use the available space better in the current situation. By providing facility and property managers with (real-time) data on the actual use of different types of space on campus, they are assisted in decision-making about future investments. In 2016, Dutch universities already used more than 26 smart tools; these are primarily aimed at the more effective use of space on campus. Since then, and certainly in corona times and with more ambitious sustainability goals, their relevance increased.

More about this research can be read in Bart Valks' dissertation "Smart campus tools – technology to support campus user and campus managers" (Valks 2021). Since 2016, Bart Valks has become a specialist in this field, with strong ties to theory and practice about this theme. With the team, he also published two books and a range of journal papers (Valks et al. 2016, 2018a, 2018b, 2019, 2020, 2021).

Smart Campus Tools (Valks 2016, 2018 & 2021)

for more effective and efficient use of the campus



Project partners

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TU Delft, Campus and Real Estate

Figure 80: the combination of smart apps for campus users and smart dashboards for campus managers (Valks 2021).

examples of smart tools

On various campuses, there are many prototypes or ideas for smart tools, also on TU Delft's campus and in our research team. Many are summarized in the books "Smart campus tools" (2016 and 2018) and in Bart Valks dissertation (2021). Some are illustrated and explained on these pages.

- Students are often looking for available study places; they are usually doing that by walking around, which costs time and could lead to frustration. They lack overview and might conclude "that everything is full". Smart tools could navigate them to vacant places in buildings all over campus. This avoids frustration and adds to user satisfaction. It raises the utilization rates and add to sustainable campus goals. By allocating (study) places more efficiently and effectively, scarce financial and energy resources can be saved for other purposes (see figure 81).

- Smart campus tools can also support the search for a workplace that is most comfortable in (extreme) weather circumstances. Considering the number of old buildings on campus and their limited ability to adjust the indoor climate to (extreme) outdoor temperatures, the users are more often searching for workplaces that are (for instance) cool in summer or warm in winter. Smart campus tools can navigate users to the place that meets their criteria (see figure 82).

- Both students and staff members often need a (relatively) quiet place to work. Smart tools could navigate them to less crowded and more silent zones in buildings all over the campus. Apart from the search function for a vacant workplace, users could also add search criteria for silence or buzz (noise level), indoor climate (temperature) and technology (with or without software and hardware options). Smart tools could add to making a better qualitative match between demand and supply of space (see figure 83).

- Meeting rooms are often booked but not used, so the smart tool information should not be based on the reservation system, but on real-time use data. Tools with more reliable data about meeting rooms are welcomed for both education and research. At universities (and many other organisations), meeting rooms are frequently claimed for certain repetitive meetings by default – like weekly team meetings or monthly board meetings – with spatial claims that are often not deleted, when meetings are cancelled (see figure 84). The same goes for educational claims on lecture halls or classrooms: they are often reserved, but not cancelled if education activities are cancelled (or timeslots are shortened). Finding an empty meeting room or classroom "by walking around" is often effective, but time-consuming and uncertain (while the room could still be claimed for the reservation). Smart tools could support the process of finding an available meeting room (with quantity and quality specifications) on campus.

- Office space has low utilization rates, which – in times of more pressure on human, energy and financial resources – demands more attention and engagement of users themselves, see separate paragraph "academic air miles" for an example (see figure 85).

Smart campus tools can contribute to a better quantitative and qualitative match between supply and demand. They could do that on the basis of real-time data about "actual use", in contrast with data about reservations, bookings and schedules, which only indicate "planned use".

Figure 81: Smart campus tools can provide an overview of vacant study places in buildings all over campus. This avoids frustration of users and raises utilization rates of the campus, adding to sustainability goals. (Illustration Mark van Huystee 2020)

Figure 82: Smart campus tools can also support the search for a work-place that is most comfortable in (extreme) weather circumstances. (Illustration Mark van Huystee 2020)

Figure 83: Smart campus tools could navigate students and staff members to less crowded and more silent zones in buildings all over the campus. Users could also add search criteria for space qualities. Smart tools could add to making a better qualitative match between demand and supply of space. (Illustration Mark van Huystee 2020)

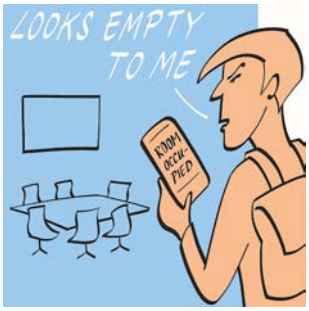

Figure 84: Meeting rooms are often booked but not used, so the smart tool information should not be based on the reservation system, but on real-time use data. (Illustration Mark van Huystee 2020)

Figure 85: Office space has low utilization rates, which – in times of more pressure on human, energy and financial resources – demands more attention and engagement of users themselves, see separate paragraph "academic air miles" for an example. (Illustration Mark van Huystee 2020)

While many campus and facility managers at universities have the impression that the utilization of – for instance – the academic workplace has decreased (due to digitization, working from home and more mobility through conferences and international research teams), the challenge is to allocate space in a more effective and efficient way. This also avoids building extra space, as the use of space shows that this is not necessary.

Smart tools and smart dashboards can support the process of both supporting user needs and becoming more resource-efficient on campus. The requirement for both is more real-time (big) data about campus utilization.

Smart dashboards for campus managers, based on big data

The information that (smart) tools both generate and use is big data about space utilization. Together with the insights from cases and databases from our third research mission (see C3), the campus manager has gradually more grip on the connections between organisational, financial, functional and environment matters. This helps to support the other stakeholders.

If real-time use is measured frequently, this provides big data about campus use, specified to places and timeslots. Campus managers can draw conclusions the patterns and use that as input for campus strategies: which spaces are in high demand and which are underutilized and when? Big data can identify strong patterns, which could enable to predict space use in the future. Campus dashboards can provide these insights.

Dashboards, in general, provide a visual overview of the most important decision-support information to perform a task or achieve a target. The analogy with the dashboard of a car emphasizes that decision-makers can only handle a limited number of meters and indicators. This is as also demonstrated in figure 80 of a "performance centre", which Bart Valks designed as a smart dashboard for campus managers at TU Delft. More findings about smart dashboards can be found in the 2021 paper that he wrote with his PhD supervisory team (Valks et al. 2021).

Summarizing, the following figures demonstrate the problem statement and goal of smart dashboards:

- The amount of data can easily be overwhelming for campus managers (see figure 86a); as demonstrated with the negotiation table, the number of aspects to combine and match are numerous: organisational, financial, functional and physical goals and conditions; the meters in the dashboard should relate these aspects in a selection of key performance indicators (KPIs, see Den Heijer 2011 and Valks 2021).

Figure 86a: the amount of data can easily be overwhelming for campus managers. (Illustration Mark van Huystee 2020)

- More structure to dashboards can be provided by the databases, which express both the characteristics and the performance of portfolios and buildings in (for instance) number of workplaces per employee, number of study places per student, costs per m^2 and energy use per building (see figure 86b); depending on the type of campus decision different KPIs can be visualised on the dashboard; according to campus management theory, at least all "colours" should be on the screen, related to each other.

- Preferably, with smart dashboards (with input from smart tools), alternative solutions can be compared more easily (see see figure 86c). The more database cards (about campus projects or campus portfolios in total), the more references are available for all campus managers that can serve for comparisons.

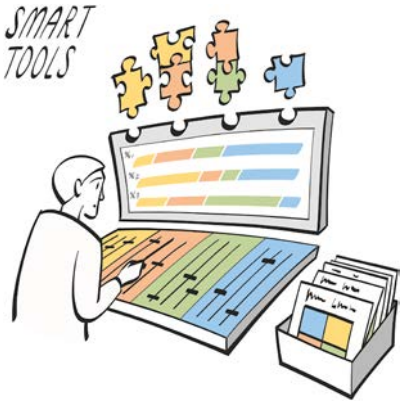

Figure 86b: more structure can be provided by the databases and theories. (Illustration Mark van Huystee 2020)

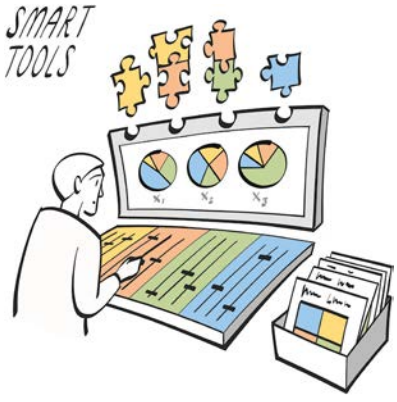

Figure 86c: alternative solutions can be compared more easily. (Illustration Mark van Huystee 2020)

Campus management dashboards are already used by many universities, based on their own campus projects or comparing data in time (longitudinal). Together, by exchanging cases and databases, they can benefit from each other's experiences (which also demands a good campus management network). Our smart campus tools research supports them with this.

Additionally, big data about real-time use of space is crucial management information to evaluate if the benefits (or added values) of space exceed the costs. Especially this type of data is still missing in many dashboards. With this research mission, our campus research team aims to provide insights about (innovative) tools and dashboards that provide this management information or add to sustainability goals. The last section of this chapter demonstrates one of these conceptual tools.

Carbon incentive tool "academic air miles" – how to save and spend my carbon budget

In the beginning of 2019, when discussing the goals of smart tools and the urgencies for a sustainable campus, the idea came up to make campus users more aware of their carbon footprint. It was my impression, based on my observation during various workshops with campus users (students and employees), that they are more sensitive to the effect of the campus on sustainability goals than on the university's limited budget. In other words, their incentive for being more resource-efficient was more connected to scarce energy resources than to scare financial resources. This brought me to the idea to design a prototype gaming tool for campus users, in which you can save energy but also earn energy credits to spend. The first idea I pitched at a conference about campuses in Norway, early June 2019.

Figure 87: every chair has a price tag and carbon footprint, if you put a towel on a chair and you do not use it, you waste both money and energy – and no one else can use the chair – in the gaming tool "academic airmiles", you would loose miles. (Illustration Mark van Huystee 2020)

From the beginning, I referred to this gaming tool as "academic air miles", because I also noticed how much the average employee and student valued the study trips and academic conferences abroad. Nonetheless, in 2019, the impact on the ecological footprint of university communities flying around the world already became more delicate and under discussion. This brought me to the idea to reward resource-efficient user behaviour on campus with air miles.

With smart tool specialist Bart Valks (see Valks 2021), I brainstormed about the tools resemblance with TU Delft's benefits choice model for employees: "you can tailor part of your terms and conditions of employment to your specific wishes, by mixing and matching (trading) one benefit for another". Similarly, our "carbon incentive model" would not only stimulate employees to save energy, but also provide them benefits to choose from, and not only academic air miles. We assumed that we would need "both the carrot and the stick": a reward-system for resource-efficiency.

Before I explain the concept, I will sum up the ideas and considerations for this "academic airmiles" gaming tool:

- "Ask not what your university can do for you, but what you can do for your university"; for many, the policy makers at universities are considered most responsible to implement the sustainable university and campus measures, while the users have an enormous collective power to make a difference, and should be encouraged accordingly. In other words, the focus should be as much on individual behaviour as on institutional behaviour. This requires the individuals be have more insight into "what they can do".

- "Empower users in sustainability goals"; users are often unaware of the largest influences on the university's carbon footprint and how to help. Carbon campus models are very valuable and add to the awareness and understanding of the composition. An example from my colleague professor Andy van den Dobbelsteen, "TU Delft's carbon roadmap", is illustrated in figure 40 (on page 100). While food, catering and (business and commuter) travel are easiest to relate to for individual users, their influence on electricity, gas and water use is also huge, as these are related to space use.

- "Express user choices in environmental consequences" (more advanced tools could also combine this with organisational, functional and financial consequences); this is expressed in figure 88 with the metaphor of the empty sunbed with "price tags" expressed in euros (yellow) and carbon footprint (green). The message is the university want to support user activity, but that every chair has a price tag and

carbon footprint. If you put a towel on a chair and you do not use it, you waste both money and energy. On top of that, no-one else can use the chair. In the gaming tool "academic airmiles", if you claim space and do not use it, you would lose air miles.

With these foundations Bart Valks and I generated ideas and made preliminary designs for user interfaces, which can be found in figure 88 and in his dissertation (Valks 2021). The user interface demonstrates various ways to save energy and to earn air miles: by choosing different modes business travel, the space claimed as a workplace, the bookings for meeting rooms and the hours spent in a laboratory. To avoid negatively affecting productivity, an employee could also get a budget based on the claimed space that is actually used (stated as well as revealed space demands) and would lose miles for claimed space that is not used. Note that "no-show behaviour" for reservations is a substantial problem on campus, as confirmed by all Dutch campus managers during interviews and smart tools workshops (Valks 2021).

These are some other examples to contribute to resource-efficiency and sustainability goals (and to "earn airmiles" in our prototype carbon gaming tool):

- deleting unneeded room reservations
- time-share your laboratory
- use your smartphone and laptop one extra year (prolong functional lifecycle to avoid waste)
- business travel by train
- join a webinar instead of an international seminar
- avoid printing
- schedule your lecture on off-peak hours (assuming that the scheduling department has big data about occupancy and frequency rates)
- share left-over lunch bags and other over-estimated catering services (connected to no-shows, to avoid waste)
- minimize the use of storage, both physical and digital storage
- eat vegetarian (more often)

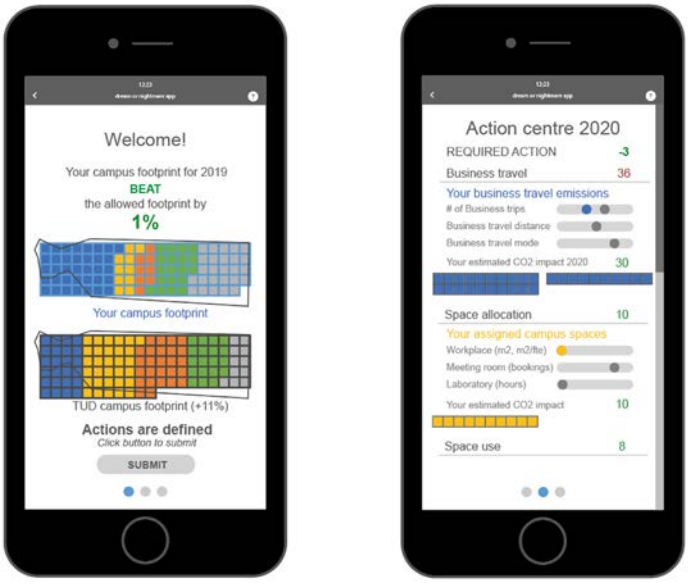

Figure 88: carbon incentive model "academic air miles", prototype user interfaces for smart phones: how can earn academic airmiles by helping to reduce the university's carbon footprint? (Valks 2021)

You can spend air miles on "claiming your own workplace" (for more hours than you need it), on other campus privileges and on business travel by airplane. The latter seemed more obvious in 2019 than it was from 2020. In November 2019, two weeks after my inaugural speech, I presented this tool at TU Delft's annual professors dinner, which led to valuable discussions afterwards. In the beginning of 2020, I included a brief description in our book "Hybrid environments for universities: a shared commitment to campus innovation and sustainability" (Ninnemann et al. 2020).

Ironically, the corona crisis from 2020 has made air travel for academic conferences both impossible and more open for discussion. The large-scale exploration of the virtual campus for academic conferences and the even more urgent and ambitious targets for the sustainable university are additional reasons for change. Nonetheless, engaging and empowering campus users in climate action is even more relevant than before. Smart tools like this one can support that. "Ask not what your university can do for you, but what you can do for your university, to collectively contribute to sustainable development goals."

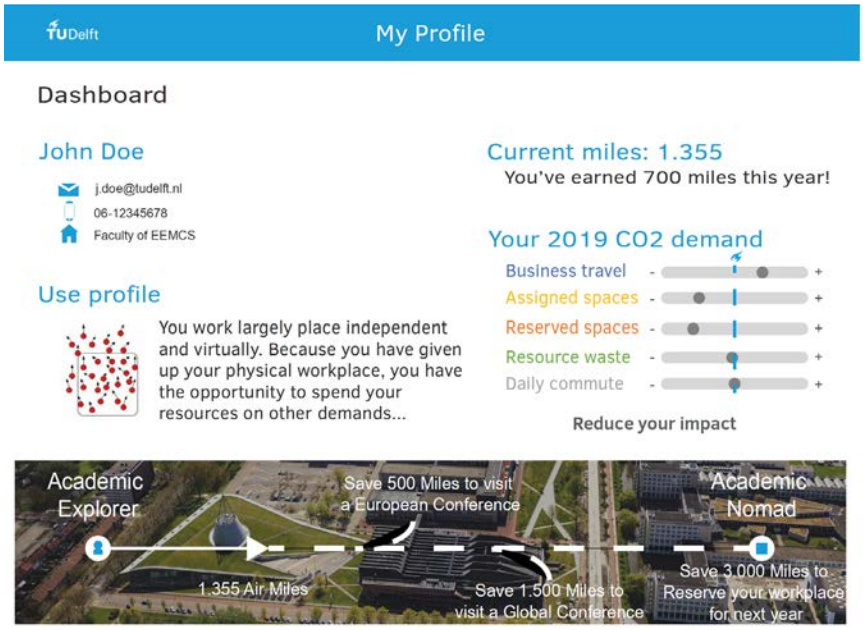

Figure 89: prototype for carbon incentive tool (Valks 2021)

References

Alghamdi, N., den Heijer, A., & de Jonge, H. (2017). Assessment tools' indicators for sustainability in universities: an analytical overview. *International Journal of Sustainability in Higher Education*, 18(1), 84-115. https://doi.org/10.1108/IJSHE-04-2015-0071

Alghamdi, N. (2018). *University Campuses in Saudi Arabia: Sustainability Challenges and Potential Solutions.* Retrieved from https://doi.org/10.4233/uuid:7e494678-0bef-44e6-ab22-f6332eb9a525

Arkesteijn, M. (2019). *Corporate Real Estate alignment: a preference-based design and decision approach.* Delft University of Technology. Retrieved from https://doi.org/10.7480/abe.2019.12

Arkesteijn, M., De Jonge, H. (2012). *Eigendom vastgoed rijksmusea - lessen voor een eventuele overdracht.* Delft University of Technology.

Arkesteijn, M., van der Voordt, T., Remoy, H., & Chen, Y. (2016). *Dear is Durable: Liber amicorum for Hans de Jonge.* Delft: TU Delft OPEN Publishing. Retrieved from http://resolver.tudelft.nl/uuid:02789dc2-eb6f-41a7-9d64-21212c2a3da8

Azcarate Aguerre, J., den Heijer, A., & Klein, T. (2017). Integrated Facades as a Product-Service System: Business process innovation to accelerate integral product implementation. *Journal of Facade Design and Engineering,* 6(1), 41-56. https://doi.org/10.7480/jfde.2018.1.1840

Azcarate Aguerre, J. F. (2023). *Facades-as-a-Service: A cross-disciplinary model for the (re)development of circular building envelopes.* [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.7480/abe.2023.11

BBN Adviseurs (2011), *'Cijfers maatschappelijk vastgoed 2011', Bouwstenen voor sociaal.* Retrieved from https://www.sociaalwerknederland.nl/?file=4284&m=1321017836&action=file.download

Blyth, A., Worthington, J. (2001). *Managing the brief – for better design.* London: Spon Press.

Buck Consultants International (2018). *Inventarisatie en meerwaarde van campussen in Nederland. ["Inventory and added value of campuses in the Netherlands"]* Report for Ministry of Economic Affairs and Climate Policy and the Dutch Network of Knowledge Cities.

Chapman, Perry M. (2006). *American Places: In Search of the Twenty-First Century Campus.* American Council on Education ACE/Praeger Series on Higher Education.

Curvelo Magdaniel, F. (2016). *Technology campuses and cities: A study on the relation between innovation and the built environment at the urban area level.* A+BE | Architecture and the Built Environment. Retrieved from https://doi.org/10.7480/abe.2016.12

Curvelo Magdaniel, F. T. J. (2017). *Campuses, Cities and Innovation. 39 international cases accommodating tech-based research.* (A. C. Den Heijer, M. H. Arkesteijn, & H. De Jonge Eds.). Delft: TU Delft, Faculty of Architecture, Department of Management in the Built Environment. Retrieved from http://resolver.tudelft.nl/uuid:408d42a3-7c46-4db4-9b58-58264a9f86ae

Curvelo Magdaniel, F. T. J., den Heijer, A. C., & Arkesteijn, M. H. (2019). *The European Campus: Management and Information.* TU Delft OPEN Publishing. Retrieved from http://resolver.tudelft.nl/uuid:fdba660e-acb5-442c-8f5b-bd756a1846b7

De Boer, Harry (2021). COVID-19 in Dutch higher education, *Studies in Higher Education*, 46:1, 96-106, https://doi.org/10.1080/03075079.2020.1859684

De Jonge, H., Arkesteijn, M.H., Den Heijer, A.C., Vande Putte, H.J.M., & De Vries, J.C. (2009). *Corporate Real Estate Management, Designing a Real Estate Strategy.* Delft, Delft University of Technology.

De Moel, I. (2014). Maatschappelijk vastgoed in de etalage. *Bouwstenen voor Sociaal.*

De Vries, J. (2007). *Presteren door vastgoed, onderzoek naar de gevolgen van vastgoedingrepen voor de prestatie van hogescholen (The influence of real estate on performance - PhD thesis, TU Delft).* Delft: Eburon.

Den Heijer, A.C. (2002a). *Universitair vastgoed management deel B: kosten & baten* Delft: TU Delft, Architecture, Real Estate & Housing.

Den Heijer, A.C. (2002b). *Universitair vastgoed management deel A: onzekerheid & flexibiliteit.* Delft: TU Delft, Architecture, Real Estate & Housing.

Den Heijer, A.C. (2009). The making of BK City: the ultimate laboratory for a faculty of architecture. In D. T. L. Geenen, A Calabrese, E, & K. U. Heintz, J (Eds.), *The architecture annual 2007-2008: Delft University of Technology* (pp. 20-25).

Den Heijer, A.C. (2011). *Managing the university campus. Information to support real estate decisions.* Delft: Eburon. Retrieved from http://resolver.tudelft.nl/uuid:337ca4e3-2895-4fcf-aee9-752141bc6104

Den Heijer, A.C. & de Jonge, H. (2012). Adding value – linking decisions and performance. In PA. Jensen, T. van der Voordt, & C. Coenen (Eds.), *The added value of facilities management: Concepts, findings and perspectives* (pp. 181-198). Technical University of Denmark. Polyteknisk Forlag.

Den Heijer, A.C., & Tzovlas, G.E. (2014). *The European campus - heritage and challenges.* Delft: Delft University of Technology. Retrieved from http://resolver.tudelft.nl/uuid:9f461a53-f5e2-42f5-8950-7357d5965ab7

Den Heijer, A.C., Arkesteijn, M., de Jong, P., & de Bruyne, E. (2016). *Campus NL: Investeren in de toekomst.* Delft: TU Delft, Architecture, Management in the Built Environment. Retrieved from http://resolver.tudelft.nl/uuid:3a2d0cfd-6ed0-4f7d-bc88-b2253641ebb6

Den Heijer, A. (2016). "Managing university campuses – in theory and practice." In M. Arkesteijn, T. Van der Voordt, H. Remoy, & Y. Chen (Eds.), *Dear is Durable: Liber Amicorum for Hans de Jonge* (pp. 97-103). TU Delft OPEN Publishing. Retrieved from http://resolver.tudelft.nl/uuid:02789dc2-eb6f-41a7-9d64-21212c2a3da8

Den Heijer, A. (2017). Lessons from BK City – after the fire – for university buildings of the future. In M. Schewenius, P. Keränen, & R. al Rawaf (Eds.), *Dreams and seeds: the role of campuses in sustainable urban development* (pp. 60-63). Stockholm Resilience Centre / Metropolia University of Applied Sciences. https://indd.adobe.com/view/56aa9baa-77bf-449a-9b48-9802545097f1

Den Heijer, A., & Curvelo Magdaniel, F. (2018). Campus-city relations: past, present and future. In P. Meusburger, M. Heffernan, & L. Suarsana (Eds.), Geographies of the University (pp. 439-459). *(Knowledge and Space (KNAS); Vol. 12).* Springer. https://doi.org/10.1007/978-3-319-75593-9_13

Den Heijer, A. (2019). "Campus Matters", inaugural speech given on 13 November 2019 (installation as professor of Public Real Estate at TU Delft), https://collegerama.tudelft.nl/Mediasite/Showcase/public/Presentation/7e5285d563a149d8976d1c3c0809b45a1d

Den Heijer, A., Arkesteijn, M., Pelosi, C., & Bacani, J. (Eds.). (2024). *Campus NL - Knowledge sharing and hybrid working: Annual report 2023-2024.* TU Delft, Faculty of Architecture and the Built Environment, Department of MBE. https://research.tudelft.nl/en/publications/campus-nl-knowledge-sharing-and-hybrid-working-annual-report-2023/

Dewulf, G., Krumm, P, and De Jonge, H. (2000) *Successful Corporate Real Estate Strategies.* Nieuwegein: Arko Publishers.

Dewulf, G. P. R. M., Den Heijer, A. C., De Puy, L., & Van der Schaaf, P. (1999). *Het managen van vastgoed binnen een publieke organisatie.* Delft, DUP. Retrieved from http://resolver.tudelft.nl/uuid:251c149e-d675-46b5-9a73-61ca9101e627

Du, Y., Arkesteijn, M. H., den Heijer, A. C., & Kun, S. (2020). Sustainable Assessment Tools for Higher Education Institutions: Guidelines for Developing a Tool for China. *Sustainability*, 12(16), [6501]. https://doi.org/10.3390/su12166501

EPRA (2021). *The European Public Real Estate Association.* Retrieved from: https://www.epra.com/about-us/about-listed-real-estate

Evers, F. W. R., Van der Schaaf, P., & Dewulf, G. P. R. M (2002). *Public real estate: Successful management strategies*. DUP Science.

Heijnders, L. & Hermans, M. (2013). *Overheid moet rol als 'marktmeester' beter invullen, in: Vastgoedmarkt, September 2013*, p. 24.

Hermans, M. (2014). *'Is a little more alright?'*. Delft University of Technology. Retrieved from http://resolver.tudelft.nl/uuid:07a6b737-b3c0-4a00-b600-fb569b22f613

Jager, J., & Naus, M. (2012), *Onderzoek Kadaster en Vitale stad; Inwoner Enschede bezit meeste maatschappelijk vastgoed, Vitale Stad,* 15 (januari), pp. 22-37.

Krumm, P.J.M.M. (2001). History of real estate management from a corporate perspective. *Facilities* 19, 7/8, 276-286. https://doi.org/10.1108/02632770110390757

Leent, M. van (2012), *Publiek Vastgoed: Analyse, Concepten, Voorbeelden.* Haarlem: Trancity.

Lind, H., & T. Lindqvist (2005), Real estate management in the Swedish public sector. *Journal of Corporate Real Estate*, 7(2), pp.178-190.

Maslow, A.H. (1954), *Motivation and Personality.* New York: Harper and Row.

Merriam-Webster. (1999). Merriam-Webster's Collegiate Dictionary. *Merriam-Webster's Collegiate Dictionary.* https://www.merriam-webster.com/

Ninnemann, K., Liedtke, B., den Heijer, A., Gothe, K., Loidl-Reisch, C., Nenonen, S., Nestler, J., Tieva, Å., & Wallenborg, C. (2020). *Hybrid environments for universities: A shared commitment to campus innovation and sustainability.* Waxmann. https://doi.org/10.31244/9783830991793

Planbureau voor de Leefomgeving, (2017). *Maatschappelijk vastgoed in verandering.* VNG. Retrived from https://vng.nl/sites/default/files/analyse-maatschappelijk_vastgoed_in_verandering.pdf, February 6th, 2020.

Prins, L., Zuidema, M.V., Tillema, M.P. (2017) Maatschappelijk Vastgoed in Gelderland. *Inventarisatie van aard en omvang van het maatschappelijk vastgoed in de provincie Gelderland.*

Qu, L., Chen, Y., Rooij, R., & de Jong, P. (2019). Cultivating the next generation designers: Group work in urban and regional design education. *International Journal of Technology and Design Education*, 30 (2020)(5). https://doi.org/10.1007/s10798-019-09540-6

Rijksvastgoedbedrijf (2020). *"Den Haag, Binnenhof*". Retrieved from https://www.rijksvastgoedbedrijf.nl/vastgoed/projecten-in-uitvoering/den-haag-binnenhof

Rymarzak, M., den Heijer, A., Curvelo Magdaniel, F., & Arkesteijn, M. (2019). Identifying the influence of university governance on campus management: lessons from the Netherlands and Poland. *Studies in Higher Education.* https://doi.org/10.1080/03075079.2019.1616167

Rymarzak, M., den Heijer, A., Arkesteijn, M., & Du Preez, M. (2022). Practice what you preach: Adoption of internal campus innovations at Dutch research-intensive universities. Higher Education Quarterly, 77 (2023)(3), 447-464. https://doi.org/10.1111/hequ.12412

Stevenson, A. (2010). *Oxford Dictionary of English*. Oxford University Press.

Teuben, B.J.J., Waldmann, M., & Hordijk, A.C. (2007). An Inventory of Municipal Real Estate; The case of the Netherlands. *Paper presented at the European Real Estate Society, ERES 2007*, London, UK.

Theater de Veste (2019). *Jaarverslag 2018.* Retrieved from https://www.theaterdeveste.nl/cms_files/File/Jaarverslag%20Theater%20de%20Veste%20-%202018%20Facts%20&%20Figures.pdf

Valks, B., Arkesteijn, M., den Heijer, A., & Vande Putte, H. (2016). *Smart campus tools: Een verkenning bij Nederlandse universiteiten en lessen uit andere sectoren.* Delft University of Technology. Retrieved from http://resolver.tudelft.nl/uuid:82822eef-c3f7-432a-b33f-10ebeba77134

Valks, B., Arkesteijn, M., & den Heijer, A. (2018a). *Smart campus tools 2.0: An international comparison.* Delft University of Technology. Retrieved from http://resolver.tudelft.nl/uuid:ab1788d3-6a92-4c2c-a035-a1e73fcc4c25

Valks, B., Arkesteijn, M. H., Den Heijer, A. C., & Vande Putte, H. J. M. (2018b). Smart campus tools: Adding value to the university campus by measuring space use real-time. *Journal of Corporate Real Estate,* 20(2), 103-116. https://doi.org/10.1108/JCRE-03-2017-0006

Valks, B., Arkesteijn, M., & den Heijer, A. (2019). Smart campus tools 2.0 exploring the use of real-time space use measurement at universities and organizations. *Facilities, 37(13/14)*, 961-980. https://doi.org/10.1108/F-11-2018-0136

Valks, B., Arkesteijn, M. H., Koutamanis, A., & den Heijer, A. C. (2020). Towards a smart campus: supporting campus decisions with Internet of Things applications. *Building Research and Information*, 49(1), 1-20. https://doi.org/10.1080/09613218.2020.1784702

Valks, B., Blokland, E., Elissen, C., van Loon, I., Roozemond, D., Uiterdijk, P., Arkesteijn, M., Koutamanis, A., & Den Heijer, A. (2021). Supporting strategic decision-making on the future campus with space utilisation studies: a case study. *Property Management*, 39(4), 441-465. https://doi.org/10.1108/PM-09-2020-0054

Valks, B. (2021), *Smart campus tools – Technologies to support campus users and campus managers.* (dissertation) Delft: TU Delft.

Van den Dobbelsteen, A., Blom T. (2019). *CO_2 roadmap TU Delft.* TU Delft, Faculty of Architecture and the Built Environment, Department of Architectural Engineering + Technology, Chair Climate Design & Sustainability. Retrieved from: https://www.tudelft.nl/en/2021/tu-delft/tu-delft-maps-own-co2-emissions-in-detail

Van der Geest, M. (2018) *Het nieuwe Erasmus MC is klaar voor 525 duizend patiënten.* De Volkskrant. Retrieved from https://www.volkskrant.nl/nieuws-achtergrond/het-nieuwe-erasmus-mc-is-klaar-voor-525-duizend-patienten~b264758d/

Van der Schaaf, P. (2002). *Public real estate management challenges for government: An international comparison of public real estate strategies.* DUP Science. Retrieved from http://resolver.tudelft.nl/uuid:f2ab1b27-0d73-4942-960a-6b0338851331

Van der Voordt, T. (2017). Facilities management and corporate real estate management: FM/CREM or FREM? *Journal of Facilities Management*, 15(3), 244-261. https://doi.org/10.1108/JFM-05-2016-0018

Van der Zwart, J. (2015). *Building for a better hospital: Value-adding management & design of healthcare real estate.* TU Delft. Retrieved from http://resolver.tudelft.nl/uuid:8fd82874-7ef2-48d6-bfb5-2f99ca26e254

Vergara d'Alençon, L. M., Arkesteijn, M. H., Azcarate Aguerre, J. F., den Heijer, A. C., & Klein, T. (2019). *Circular Business Models: Building a Database of Case Studies.* Delft University of Technology.

Veuger, J. (2014). *Materieel immaterieel.* Rotterdam: Erasmus Universiteit Rotterdam.

White, A.D. (2011), "A review of UK public sector real estate asset management", *Journal of Corporate Real Estate, Vol. 13 No. 1,* pp. 6-15. https://doi.org/10.1108/14630011111120314

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AdH / Alexandra den Heijer (2019-2025) Various photos. (pp. 8, 10, 17, 28, 34, 48, 55, 61, 74, 99, 117, 120-123, 125, 127-129, 131-139, 144, 153-154, 157, 190, 198-199)

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Communicatie Bouwkunde / TU Delft (2018). Making the campus more sustainable (liquid). (pp. 60, 133)

Edward Lich / Pixabay (n.d.). Mauritshuis Museum, The Hague. (pp. 8)

Ellibi / Pixabay (2015). Den Haag city hall, The Hague. (pp. 8)

Food&More TU Delft (2019). Flexible catering concepts: from food court to food truck. (pp. 128)

Food&More TU Delft (2019). Mekelpark TU Delft. (pp. 42)

Food&More TU Delft (2019). Valentine's dinner in building TU Delft. (pp. 115)

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Hans Krüse (2019). Inaugural speech AdH November 13, 2019. (pp. 201)

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Marcel Bilow (2016). Living lab case study: Facade-as-a-service. (pp. 161)

Mark van Huystee (2019-2021). Illustrations made in close collaboration with author Alexandra den Heijer for inaugural speech or this book (pp. 15, 47, 49, 51, 53, 57, 59, 63, 65, 77, 79, 83, 86, 89, 90, 93, 94, 97, 98, 101, 102, 105-108, 114, 116, 124, 140, 147, 149, 155, 158-159, 163, 166, 173-174, 176-179)

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Rob 't Hart (2009). Aerial photo BK City. (pp. 71)

Rob ’t Hart (2009). Aerial photo Faculty of Architecture and the Built Environment. (pp. 18)

Rob Van Der Meijden, Pixabay (2016). Binnenhof, The Hague. (pp. 8)

Rob Van Der Meijden, Pixabay (2016). Hofvijver, The Hague. (pp. 6)

Ruben Vos (2020). Combining high-tech with no-tech (gas). (pp. 120, 139)

Ruben Vos (2020). Utilizing circulation space (gas). (pp. 131)

Ruben Vos (2024). Creating a hybrid learning environment lecture halls (gas). (pp. 122)

Ruben Vos (2024). Theater De Veste, Delft. (pp. 8)

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Steve Morgan (2016). Diapositives. (pp. 40) (CC BY-SA 4.0)

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Oodi central library, Helsinki (photo AdH)

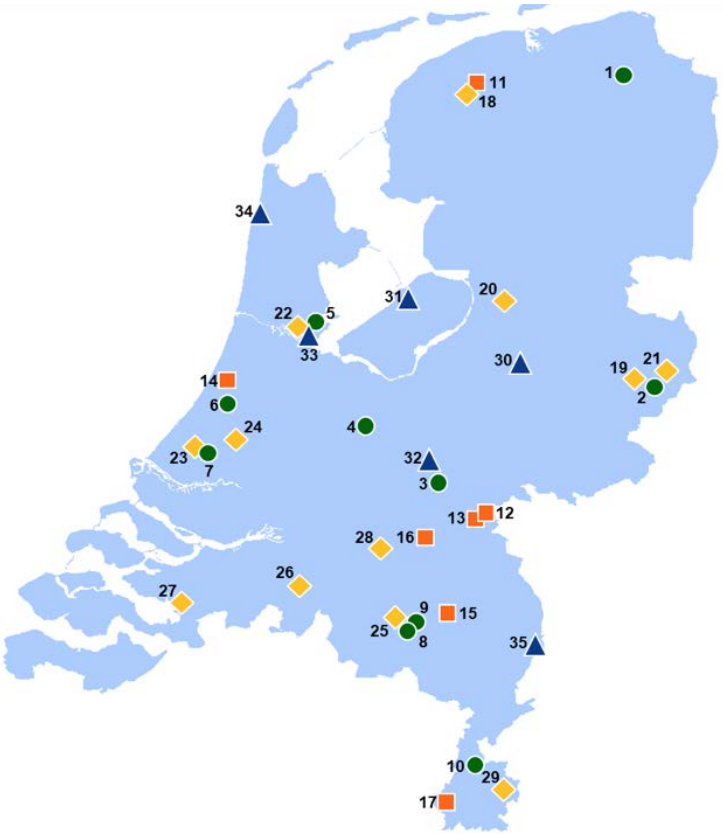
Appendices

Different types of campuses in the Netherlands

Next to the academic campuses of the Dutch universities, there are more types of campuses in the Netherlands. Many more organisations - both public and private - own or manage portfolios of buildings on one location and refer to this as "campus".

Medical campuses, business campuses and innovation campuses are examples. This map illustrates a different typology, as determined by Buck Consultants International in 2018 for the Ministry of Economic Affairs and Climate Policy and the Dutch Network of Knowledge Cities, 2018: mature ("volwassen"), growth ("groei"), start-up ("opstart") and idea ("idee"). This map originates from the report "Inventory and added value of campuses in the Netherlands" (Buck Consultants International 2018, original title: "Inventarisatie en meerwaarde van campussen in Nederland").

The specialisations of the campuses can often be derived from their names. Many can be considered as part of a network, also of universities. Their collective facilities on the scale of the Netherlands give opportunity for (time-)sharing. This is potential for less "solid" and more "liquid" and "gas" on Campus NL.



Mature / Volwassen

1 Campus Groningen - Groningen
2 Kennispark Twente - Enschede
3 Wageningen Campus - Wageningen
4 Utrecht Science Park - Utrecht
5 Amsterdam Science Park - Amsterdam
6 LeidenBio Science Park - Leiden
7 TU Delft Science Park - Delft
8 High Tech Campus Eindhoven - Eindhoven
9 TU/e Science Park - Eindhoven
10 Brightlands Chemelot Campus - Sittard-Geleen

Growth / Groei

11 Watercampus - Leeuwarden
12 Mercator Science Park - Nijmegen
13 Novio Tech Campus - Nijmegen
14 Space Business Park - Noordwijk
15 High Tech Automotive Campus - Helmond
16 Pivot Park Oss
17 Brightlands Maastricht Health Campus - Maastricht

Start-up / Opstart

18 Dairy Campus - Leeuwarden
19 High Tech Systems Park - Hengelo
20 Polymer Science Park - Zwolle
21 Technology Base Twente - Enschede
22 VU Campus - Amsterdam
23 Biotech Campus Delft - Delft
24 Greenport Horti Campus - Bleiswijk
25 Brainport Industries Campus - Eindhoven
26 Gate2 Aeroparc - Gilze-Rijen
27 Green Chemistry Campus - Bergen op Zoom
28 Grow Campus - 's Hertogenbosch
29 Brightlands Smart Service Campus - Heerlen

Idea / Idee

30 S/Park - Deventer (i)
31 Emerging Disease Campus - Lelystad(s)
32 World Food Center - Ede (s)
33 AMC Medical Business Park - Amsterdam (s)
34 Energy & Health Campus Europe - Petten (s)
35 Brightlands Greenport Campus - Venlo(s)

Figure 90: "Inventory and added value of campuses in the Netherlands" [original title: "Inventarisatie en meerwaarde van campussen in Nederland"], Buck Consultants International for Ministry of Economic Affairs and Climate Policy and the Dutch Network of Knowledge Cities, 2018 – Buck Consultants International 2018, used with permission.

Space functions on campus, shared on different levels

For my dissertation (2011), I made overviews of the five function types on campus, according to my functional definition of the campus: (in red) academic, (in blue) residential, (in green) retail & leisure, (in orange) related business and (in black) infrastructure.

Figure 91: the functional definition of the campus: five main space functions (source: Chapman (2006), adapted by Den Heijer 2011)

For this book, these five figures are flipped horizontally to match the solid, liquid and gas scale, from left to right. All five figures illustrate how functions can be shared with different partners, on different levels and physical scales. Additionally, their impact on footprint, autonomy, resources etc. is indicated on the bottom of the figures. These are assessment criteria that are important to one or more campus management stakeholders, as introduced in chapter B3.

More background information about this functional campus definition can be found in chapter B1 of this book and in chapter 9 "Strategic choices for the campus of the future" of "Managing the university campus" (Den Heijer 2011).

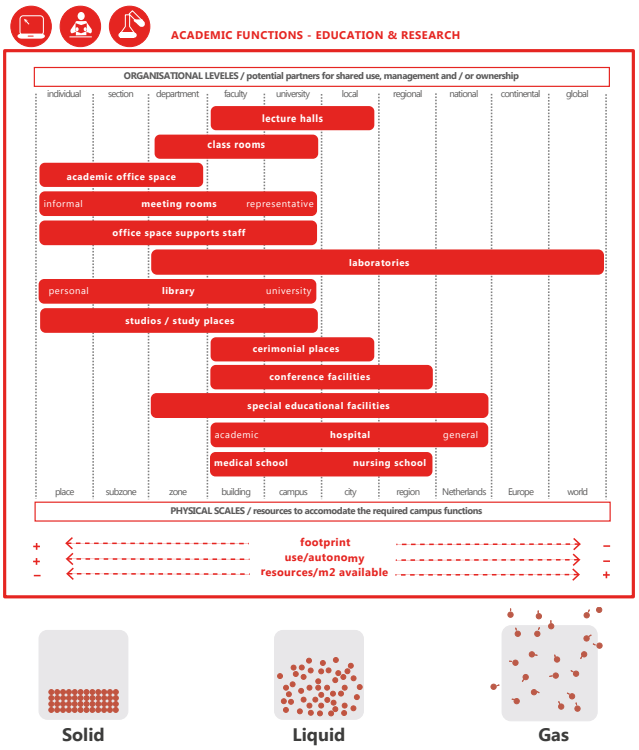


Figure 92: (in red) academic functions to share with different partners, on different level and scales from dissertation *Managing the univeristy campus* (Den Heijer 2011, adapted)

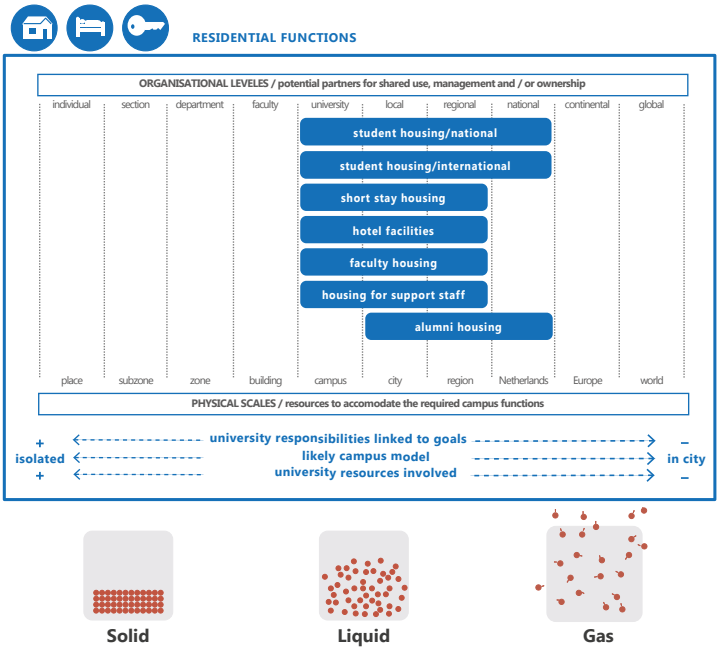


Figure 93: (in blue) residential functions to share with different partners, on different level and scales from dissertation *Managing the univeristy campus* (Den Heijer 2011, adapted)

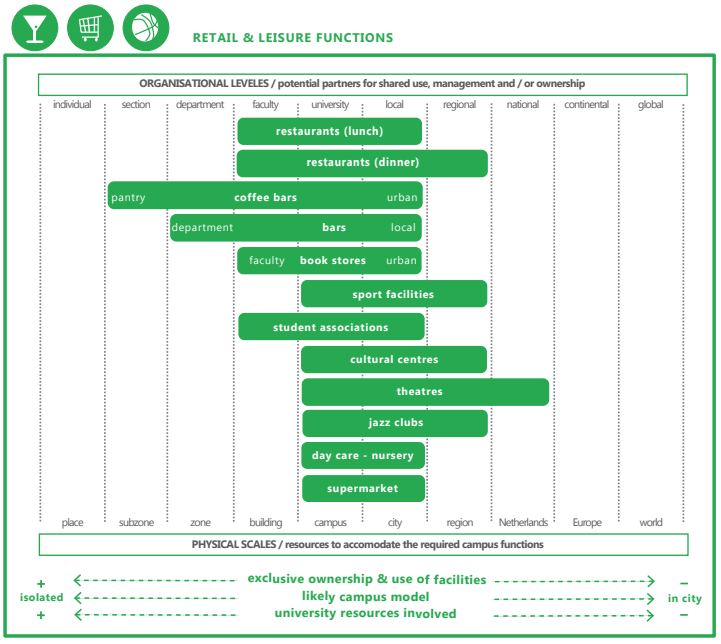
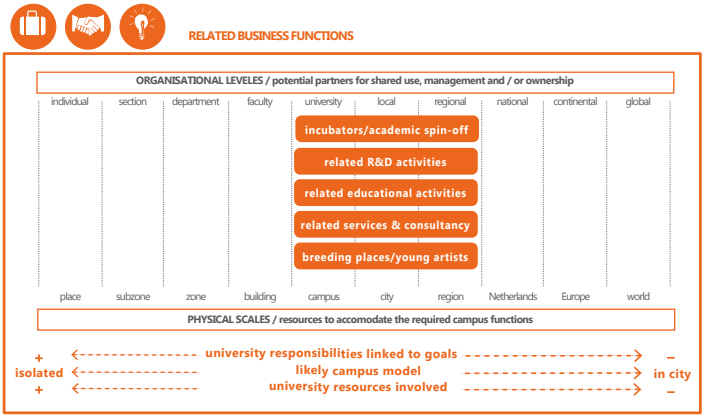


Figure 94: (in green) retail & leisure functions to share with different partners, on different level and scales from dissertation *Managing the univeristy campus* (Den Heijer 2011, adapted)



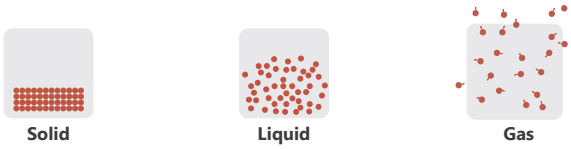
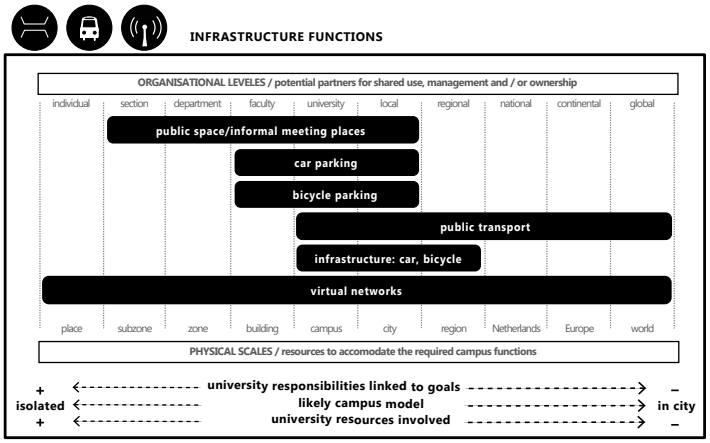


Figure 95: (in orange) related business functions to share with different partners, on different level and scales from dissertation *Managing the univeristy campus* (Den Heijer 2011, adapted)



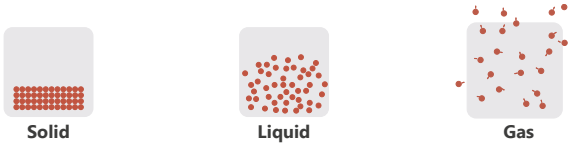


Figure 96: (in black) infrastructure functions to share with different partners, on different level and scales from dissertation *Managing the univeristy campus* (Den Heijer 2011, adapted)

Propositions about campus (management) of the future

This appendix includes the propositions that I have often used in presentations and publications (in chronological order). Each proposition is labeled with the chapter number in which it is directly or indirectly referred to. It ends with a short summary for the campus of the future.

ten propositions for dissertation (2011)

Propositions for PhD thesis Alexandra den Heijer "Managing the university campus – Information to support real estate decisions" (2011).

1. Each university goal can be frustrated by the physical campus. (B3)

2. Campus management is improved as real estate decisions are explained with more concrete data to policy makers, controllers, users and technical managers, referring to key performance indicators. (A2)

3. The campus of the future is a city. (B1)

4. The innovative and flexible knowledge economy can bring new life to obsolete industrial heritage buildings. (B4)

5. Considering the added value of the university for the knowledge economy, the Ministry of Economic Affairs, Agriculture and Innovation should contribute substantially to the public funding of Dutch universities, next to the Ministry of Education, Culture & Science. (B3)

6. It takes a crisis – for example a fire – to change the academic workplace. (B4)

7. The campus will benefit from pop-up retail* and leisure. (B4)
   *Pop-up retail, also known as pop-up stores, pop-stores (US) or pop-up shops (UK), is the trend of opening short-term sales spaces (Wikipedia 2010). Examples for the campus are temporary outlet stores, karaoke bars, multi-cultural restaurants, sandy beaches and ice-skating facilities with drinks and food.

8. Alumni should be considered important stakeholders whose substantial financial contributions to the campus will benefit both the university and alumni themselves. (B3)

9. The virtual campus is less sustainable than the reduction of m^2 on campus might suggest. (B2)

10. A new building is not appropriate for a national historical museum. (B3)

The previous ten propositions have also been translated in multiple languages (see https://managingtheuniversitycampus.nl/about-the-book/10-propositions/)

ten propositions in position paper (2017)

11. Science is much too interesting to make a choice for a specific field. (Preface, C1)

12. Design and management are both complex, due to the integration of many different aspects. (B3)

13. I consider it my challenge is to simplify the decision-making process about the built environment (for students and professionals), but not by excluding key variables. (C4)

14. The strength of a university – and the innovation power – is in the combination of scientific disciplines: unusual cross-overs should be stimulated and introverted tendencies – in education and research – should be avoided. (B4, C2)

15. When I encounter something or someone new, I am more focused on the common denominator than on the difference. (B3)

16. The added value of a manager (and leader) is preferably like a catalyst, not like an emulsifier. (B3, C1)

17. The physical state of the campus is (and will be) a combination of solid, liquid and gas. (B2)

18. The university – especially a university of technology – should also protect people from technology. (B4)

19. Organisations and individuals need to find a healthy balance between being (self-) critical and being proud of strengths and legacy. (B3)

20. I will most likely study the campus for the rest of my life. (Acknowledgments)

additional propositions

21. To share or not to be. (B3)

22. Silence is the new scarcity. (B3)

23. The city as campus is more resource-efficient than the campus as city. (B1)

24. The campus of the future is more dependent on the flexibility of people than the flexibility of buildings. (B4)

25. Practise what you preach, also on campus. (C2)

26. The connector in campus management deservers more respect. (B3)

27. "There is no campus B" (B3)

28. "Ask not what your university can do for you, ask what you can do for your university" (original quote inaugural speech JFK, 1961: "ask not what your country can do for you, ask what you can do for your country") (C4)

29. Sharing should often be interpreted as 'time-sharing' (B2)

30. It takes a village to raise a child and it takes a "university community" to manage a campus. (B3, C2)

31. Public real estate is extra-large. (A2)

32. The campus induces relationships for life. (Acknowledgments)

Campus of the future summary

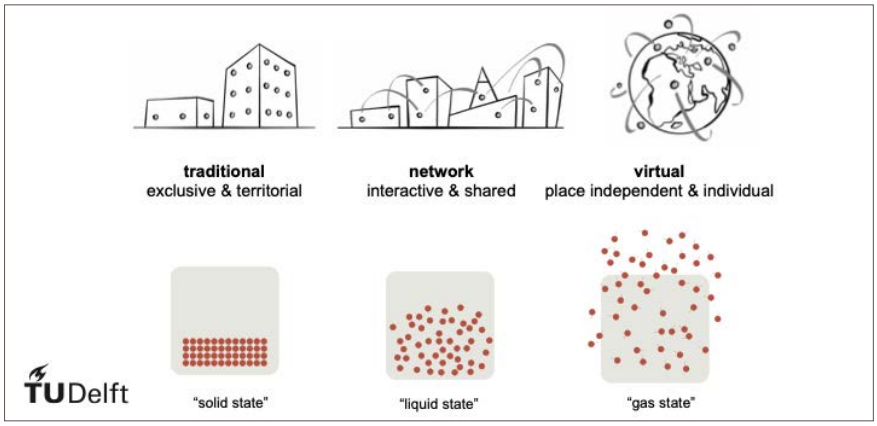
text source: adapted from blog post www.mnagingtheuniversitycampus.nl, also used as a basis for EUA column in 2020: https://eua.eu/resources/expert-voices/185:the-sound-of-silence-universities-need-to-facilitate-places-to-focus.html

At the beginning of the 21st century many thought that bricks would be replaced by clicks on campus. However, the universities' estate managers had a different story to tell. Indeed, there were more clicks to facilitate, but not to replace the bricks. The virtual campus would emerge, but the physical campus would stay.

This is good news for universities that cherished their heritage - like Cambridge, Amsterdam and Delft, among many European universities - but there are challenges to improve utilization rates of expensive spaces (offices, lecture halls, laboratories) that are also often vacant. Strategic choices need to be made to preserve the traditional values, to accommodate the network organisations that universities have become and to support the mobile community that needs a home base to return to.

The future state of the campus will be a combination of:

- "solid", resembling the traditional campus, representing the fixed structures and (need for) territory on campus
- "liquid", facilitating the network campus, representing the multiple connections on campus and more (resource-efficient) shared spaces
- "gas", representing the openness of the campus and the flexibility and possibility to work and study anywhere



Trends are international competition, identity, inclusiveness, social engagement, re-embracing heritage and the use of big data about utilization of space (for smart campus tools). Urgencies are the growing scarcity of financial and energy resources as well as the responsibility that universities take for the well-being of their students and staff. However, sustainability goals cause a shift from demand-driven to supply-driven. Additionally, there are three balances to consider for the future campus: between silence (solitude) and buzz (community), between quality and quantity, between online and offline.

(photo AdH)

Acknowledgements

(source photos: Marcel Bilow and Alexandra den Heijer)

Next to being the object of study, the campus has mattered to me personally for more than thirty years. I have considered the university my second family and the campus my second home. I want to express my gratitude to whom I cherish and met on campus, in general and by mentioning some people specifically.

First of all, I want to thank all (former) members of TU Delft's Campus Research Team, for their contribution - directly or indirectly - to my inaugural speech and to this book. A special thanks to Monique Arkesteijn, Flavia Curvelo Magdaniel, Bart Valks, Mark van Huystee and Ruben Vos (see photos on the left) for their unique contributions to the content, the graphic design or the publication process. Monique provided valuable support and content advice, while she was also finishing her dissertation. Bart collected TU Delft campus data and made animations of the transition in 25 years and the utilization of space, for the inaugural speech. For the book's cover and graphic design, the basis was already available from the previous book series, designed by Flavia (and started in 2011, for my dissertation "Managing the university campus"). Illustrator Mark was essential in the visualization of the storyline for both the inaugural speech and this book. Our collective, creative sessions were campus memories that I cherish. Ruben played a crucial role in the book's editing process, after research assistant Saskia Gribling helped me with the inaugural speech and foundation of the book.

After the distribution of the 2021 version of this book, I was happy to receive feedback from students, academic peers and campus experts from practice, also on the many presentations that I based on the books content. A special thanks to Hiral Patel and Suvi Nenonen for their peer reviews. Years later, researcher Sanjana John helped me with the final changes, processing the feedback towards the official publication. For the guidance of the last publication steps, I am also grateful to Just de Leeuwe and his TU Delft OPEN Publishing team.

Secondly, I am grateful to TU Delft's Executive Board and the Faculty of Architecture (and the Built Environment) for the academic opportunities and challenges, providing a living lab for campus decision making. I treasure my position in the department of Management in the Built Environment (MBE), but also my link with the department of Architectural Engineering + Technology, where I always feel welcome. I look forward to more opportunities for collaboration within the faculty. Special thanks to TU Delft's department of Campus Real Estate and Facilities Management (CREFM) and the thirteen other campus departments of Dutch universities. You have been our research partners for decades.

Thirdly, I am thankful to be part of an inspiring university community, with students and colleagues and all the staff that support us on a daily basis. Without them we would not be able to perform. Especially, the friends-for-life that I met when I studied, the professors I worked for as a student, my supervisors and promotors. They all brought me food for thought and we stayed in touch ever since. It demonstrates that the campus is crucial in building scientific, professional and personal networks.

Last but not least, I feel blessed with dear friends and our large 'modern family'. This patchwork family with so many children gives me a good impression of the students of the future. You enrich my life. But most grateful I am for the love of my life, my husband, who I met on campus. This is the ultimate reason why the campus matters to me and evidence, which supports my final proposition of this book: "the campus induces relationships for life".

About the author

Alexandra den Heijer, MSc PhD is full professor (chair Public Real Estate) at the Faculty of Architecture and the Built Environment, Delft University of Technology (TU Delft). She has a background in Architecture (BSc) and Management in the Built Environment (MSc), both obtained at TU Delft. Her specialisation is planning, design and management of university campuses and buildings. She focuses on generating management information for (public) real estate decisions, which was also the subject of her PhD thesis "Managing the university campus" (2011).

In the past decades, she has developed models and theories that help universities to design and implement their campus strategies and that contribute to knowledge cities. She has explored international references and has written many reports, articles and papers on the university and campus of the future, trends and changing concepts and campus strategies. University campuses are examples of built environments that support public goals and have a large impact on society. By managing these buildings – often heritage on iconic locations - universities as large property users/owners need to set an example to society and have a responsibility to implement policies with effective and efficient use of financial resources, resulting in meaningful, functional, affordable and sustainable built environments.

Professor Den Heijer has always combined her career in academia with projects in (public) practice, including the Central Government Real Estate Agency and DUWO Student Housing (as member of their supervisory board from 2009 to 2016). She has also frequently been part of boards, committees, think tanks and juries, about the future of the built environment, (university) cities or campuses in particular. She operates in an extensive network of national and international campus management experts – both in academia and in practice. She is proud of the widespread use of her dissertation (2011) and her international reputation as campus expert. She has also used TU Delft's campus as a living lab, for instance by playing a leading role in the making of BK city – accommodating the Faculty of Architecture in a large heritage building after the fire that destroyed their 1970s building – and sharing the lessons with universities worldwide.

Alexandra den Heijer leads TU Delft's Campus Research Team with PhD students, postdoc researchers and other university staff members – consisting of a core team at TU Delft and guest researchers and professors in a network of researchers and campus experts in practice.

For more (links to) scientific publications, international lectures, presentations and projects:

- TU Delft page - chair Public Real Estate - https://www.tudelft.nl/en/architecture-and-the-built-environment/about-the-faculty/departments/management-in-the-built-environment/organisation/research-groups/public-real-estate
- TU Delft - personal page (link to publications): https://www.tudelft.nl/en/staff/a.c.denheijer
- Google Scholar: https://scholar.google.nl/citations?user=lGruFr8AAAAJ&hl=nl
- LinkedIn profile: https://www.linkedin.com/in/alexandra-den-heijer-85109b5/

Abstract / *Korte samenvatting*

University campuses, hospitals, schools, and city halls are just some examples of built environments that support public goals and have a large impact on society. Managing these buildings – often heritage on iconic locations – is a challenging task for organisations that often already struggle with decreasing public funding. They need to set an example to society and have a responsibility to implement public policies, resulting in meaningful, functional, affordable, and sustainable built environments.

With the campus as her specialisation, Alexandra den Heijer uses the university as an example to illustrate what changed in 25 years time, which management matters set the current context and how research can support decision makers. With her Campus Research Team she has built a network with academics and practitioners and will continue to develop methods and tools. Examples are comprehensive databases with recent projects and smart tools that empower the users of buildings to find the best workplace, based on real-time (big) data about utilization of space. The mission is not only to support campus decision makers, but (public) real estate managers in general.

Inaugural speech November 13, 2019
(photos by Hans Krüse 2019)

Universiteitscampussen, ziekenhuizen, scholen en stadhuizen zijn voorbeelden van gebouwen die publieke doelen ondersteunen en een grote impact hebben de samenleving. Het managen deze gebouwen - vaak erfgoed op beeldbepalende locaties - is een uitdaging voor organisaties die vaak al worstelen met afnemende publieke budgetten. Ze moeten het goede voorbeeld geven aan de samenleving en hebben een verantwoordelijkheid om publiek beleid te implementeren, resulterend in betekenisvolle, functionele, betaalbare en duurzame gebouwen.

Met de campus als haar specialisatie gebruikt Alexandra den Heijer de universiteit als voorbeeld om te illustreren wat er in 25 jaar tijd veranderd is - zowel binnen de universiteit als op de campus - voor welke uitdagingen managers staan en hoe onderzoek hun beslissingen kan ondersteunen. Met haar Campus Research Team heeft zij een netwerk gevormd, met een groot aantal Europese universiteiten en wetenschappers die zich eveneens op de campus focussen, en zal zij doorgaan met het ontwikkelen van beslissingsondersteunende methoden en instrumenten. Voorbeelden zijn databases met recente projecten en "smart tools" die de gebruikers helpen in hun zoektocht naar een passende studieplek of vergaderruimte, gebaseerd op de daadwerkelijke beschikbaarheid (gemeten via sensors) en gebruikspatronen. De missie is om niet alleen beslissers over de campus daarmee te ondersteunen, maar (publieke) vastgoedmanagers in het algemeen.

Colophon

Campus of the future | Managing a matter of solid, liquid and gas

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No conflict of interest to disclose.

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This book is based on the inaugural address "Campus matters", given by prof. dr. ir. Alexandra C. den Heijer at the occasion of her installation on Wednesday November 13, 2019, as professor of Public Real Estate. This inaugural lecture is publicly available on TU Delft's Collegerama. The author applies data from previous (campus) research projects and cites a range of publications, which are explicitly mentioned on the pages 30 and 33 in part A of this book.

History of the book:
The first printed version of this book was distributed in 2021, available only for designated education, research and practice networks. In the next years, the content of the book was presented to many universities, providing feedback on the content and confirming that the "solid, liquid, gas" metaphor - as expressed in the subtitle of this book - helped decision makers in their consideration about the future of their campuses.

Peer Review:
This book has been peer reviewed. The peer review was open. The Author and the Publisher would like to thank the reviewers (dr. Suvi Nenonen from University of Helsinki, Finland and dr. Hiral Patel from Cardiff University, Wales) for their time and effort.

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The campus of the future is a combination of solid, liquid and gas. This metaphor from physics refers to three states of matter, resembling the traditional, network and virtual university. The virtual campus emerged, but the physical campus has stayed and changed. Alexandra den Heijer is full professor Public Real Estate and wrote this book as the extended version of her inaugural speech, introducing her vision on real estate decision making and strategies for the future, based on her research of the past decades. While she focuses on universities and campuses, the future models and themes in this book also apply to many other (public) organisations and their built environments.

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