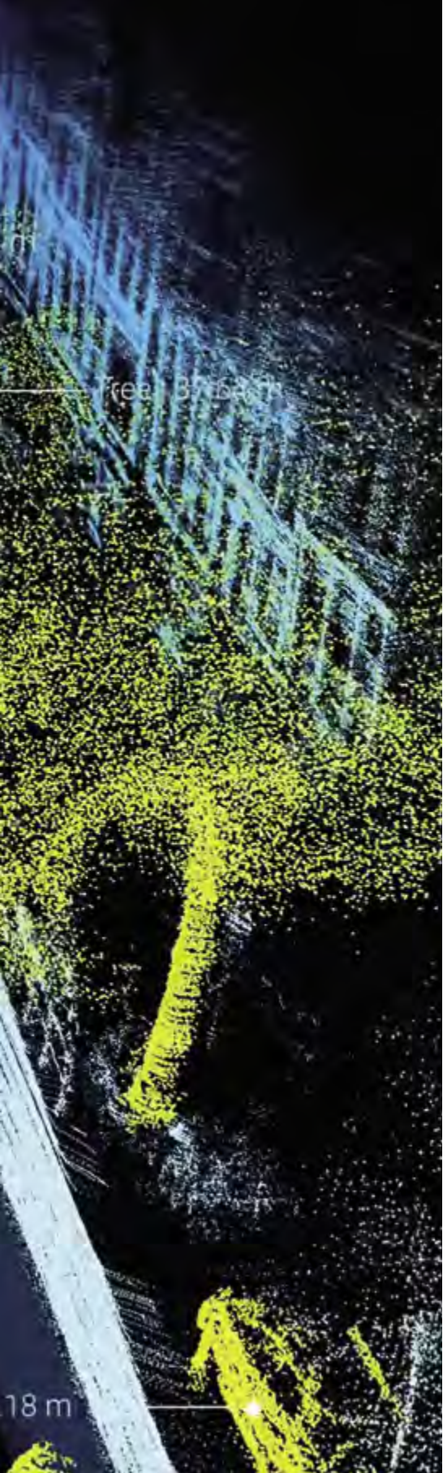
Annual Report 2018



Annual Report 2018

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Introduction

Cities truly need metropolitan solutions if they are to create more sustainable, resilient and just living environments. These solutions are made possible through the many advances in new technologies, research and design methods. But no stakeholder can achieve them alone – they require effective cooperation between knowledge institutes, companies, cities and citizens.

We aim to develop a deep understanding of the city and a true sense of the urban metabolism, and its infrastructural, logistical, participatory and co-creative components. More specifically, our research, innovation and educational activities focus on applied technology across themes such as energy, circularity, food, data, climate and mobility. A thorough understanding of all of these areas can then drive the design and integration of solutions that will meet metropolitan challenges and help create a more prosperous society.

Technology creates opportunity

AMS Institute was founded in 2014 by three institutions: Delft University of Technology (TU Delft), Wageningen University & Research (WUR) and Massachusetts Institute of Technology (MIT). We are an internationally-leading institute committed to fostering talent and education, as our engineers, designers, natural scientists and social scientists work together to develop and valorize integrated metropolitan solutions.

From the very beginning, AMS Institute's goal has been to advance technology within the ecosystem of the Amsterdam Metropolitan Area (AMA). To do this, we investigate new windows of opportunities in science, educate talent – and by extension create solutions with societal impact and business opportunities.

Amsterdam as a 'living lab'

The city of Amsterdam is therefore our living lab: a valuable context for experiments that aim to accelerate and advance the development of solutions that meet real challenges. Of course, meeting these challenges is just as important for an ever-increasing number of urbanized metropolitan areas across the globe.

This idea of a living lab – an 'in-between step' consisting of real-life research with multiple stakeholders – is crucial to achieving metropolitan solutions that will create real impact. Why? Because only solutions that can be adopted smoothly and swiftly by all involved parties can lead to truly improved living environments.

Driving innovation in three main ways

AMS Institute drives innovation in three main ways:

Research & Valorization: Our dedicated portfolio of over 100 projects and programs is developed and executed by interdisciplinary consortia of knowledge institutes and private companies, in cooperation with the City of Amsterdam and its citizen platforms.

Education: Our Master in Metropolitan Analysis, Design & Engineering (MSc MADE) targets and attracts top students from all over the world, and shapes the core of our educational program. This core is supported by a broad portfolio of educational activities for current and future urban professionals, including our innovative Massive Open Online Courses (MOOCs), summer schools and professional training activities.

Innovation: Our integrated set of Research & Valorization programs is set up to achieve a mission-oriented open innovation process. This process is distinguished by four different stages (each with its own set of activities):

- Researching
- Prototyping and validating
- Building and launching
- Starting and accelerating

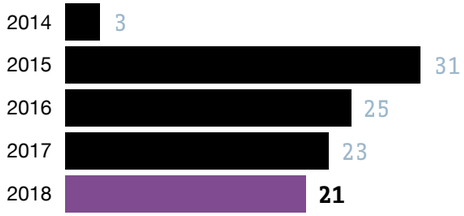
"Amsterdam is a small metropolis with great ambitions. Knowledge and innovation go hand in hand: gathering, reflecting on and researching knowledge form the context within which new applications can be developed, with the city as a 'living lab'. The City of Amsterdam believes that responsible capital invests in knowledge and innovation and continues to develop in this area. The partnership with AMS Institute helps us achieve this goal."

Ger Baron
CTO City of Amsterdam

Key Figures 2018

Research

Projects awarded



Total value of awarded projects

Average turnover projects

Number of running projects

Climate Resilient Cities **12**

Circularity in Urban Regions **13**

Metropolitan Food Systems **7**

Smart Urban Mobility **11**

Urban Data & Intelligence **13**

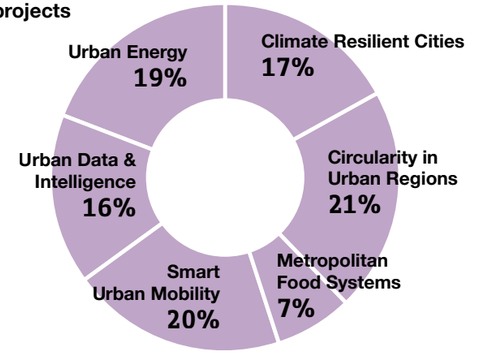
Urban Energy **18**

Overview accumulated research portfolio

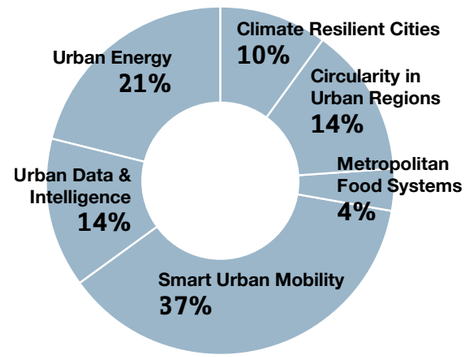
Total portfolio **103** projects

with a value of **€56M**

#projects



Budget % per research theme



Our MOOCs

8,500

New MOOC participants in 2018

(**45,000** total participants AMS MOOCs)

Press

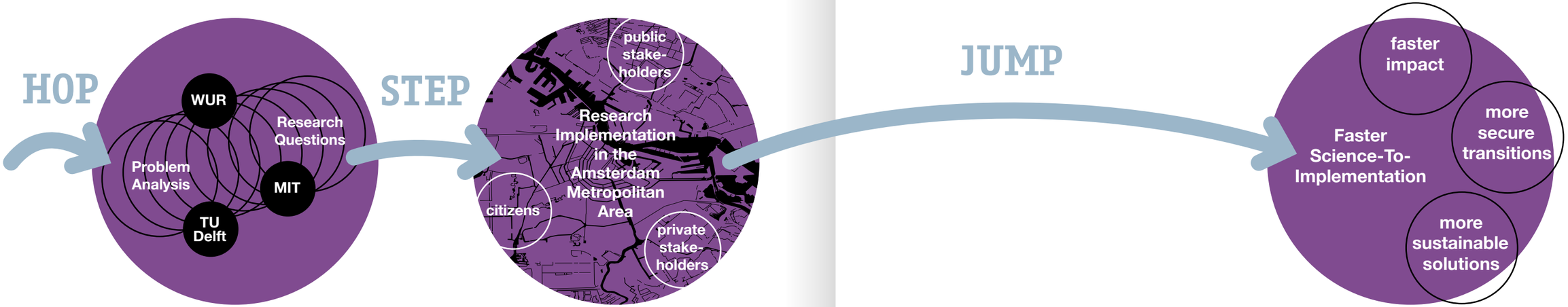
Total Media Value **€8.9M**

Social media

		Dec 2017	Dec 2018
Facebook	page likes	1,821	2,170
Twitter	followers	2,561	3,246
LinkedIn	followers	913	1,661
Instagram	followers	77	248

How we work

AMS Institute is positioned at the crossroads between fundamental science and the society-wide application of innovative solutions for metropolitan challenges. We bring together the brightest minds in the field. Our innovations have state-of-the-art research at their core. And we develop and test pilot projects and experiments throughout the city of Amsterdam together with local, national and international private and public partners, citizens and future users. AMS Institute works according to the Hop, Step and Jump approach.



Hop: We start by working with our key stakeholders and AMS partners to conduct a problem analysis of specific societal challenges in a metropolitan context. We use this analysis to create our research questions. Then we conduct our fundamental science activities, including modeling and laboratory research within conditioned environments. This takes place mainly at our three founding universities (TU Delft, WUR and MIT), where we use cutting-edge science to create solutions that can achieve true paradigm shifts.

Step: We then move on to the part of our research process where we implement and validate the outcomes of our research in real, living environments inside the Amsterdam Metropolitan Area (AMA). We do this in partially-conditioned settings, and we involve all public and private key stakeholders. This unique in-between step forms the basis of AMS Institute's goal: to generate solutions that truly address the well-known 'double complexity' of real life and urban environments.

Jump: Once we have validated an approach, we move on to the Jump phase: fast science-to-implementation trajectories with the goal of making a large impact quickly. Start-ups, industry partners and public authorities play a crucial role in this. We are committed to creating successful transitions to a more sustainable, just and resilient future in our increasingly urbanized and challenging world.

Directors' Report

We are delighted to have this opportunity to report on our key objectives. During the past year, we have continued to make significant progress in creating a positive impact on the life of our citizens through innovative metropolitan solutions. 2018 has proven to be a key year for our institute in a number of areas:

- **We moved to a new building in the up-and-coming innovation district of Marineterrein Amsterdam**
- **We began the second year of our MSc MADE program in September**
- **We scaled up our research portfolio and data science activities**

Our role in driving innovation to create urban solutions with impact

As an interdisciplinary knowledge institute, we identify and address issues raised by challenges such as rapid urbanization, climate change, and the introduction of IT innovations (such as artificial intelligence) across core societal domains within a metropolitan context. To do this, AMS Institute focuses on interdisciplinary research, education and innovation. This helps to ensure that the solutions we develop can be applied in ways that promote sustainability, resilience and justice.

Whether we like it or not, our society is driven by an economic system that demands limitless growth. Accelerated by exponential technological advances, this means that a fifth of humanity enjoys materially prosperous and abundant lives. However, the vast majority of people still live in relative poverty.

At the same time, our sheer existence on this planet has disrupted the dynamic equilibrium of our climate and the natural world. We are seeing tremendous changes in our earth's biological, geological and hydrological processes. This environmental pressure will only increase as an increasing number of people start to experience material improvement in their lives. Our cities are changing too. The idea of an 'urban metabolism' can be used as a framework to model complex urban systems' material and energy flows – and to map a city's ecosystem.

At AMS Institute, our responsibility is to solve metropolitan issues in a methodological and innovative way. To achieve this, we introduce an essential component: the integration of both technical and social perspectives within an urban metabolism. The goal is then to achieve growth, produce (renewable) energy and eliminate waste as we improve the equity, sustainability and livability of our cities. Metropolitan challenges cannot be considered in isolation, and cooperation is key. Interaction with end users and stakeholders is therefore vital to creating solutions that work.

Research and Valorization

In 2018, we further anchored our focus and drive for excellence through innovation. We set our agenda, and achieved further involvement, visibility and gains for our key-stakeholders. As always, we started with Amsterdam and its citizens. But we are also committed to expanding our solutions to metropolitan areas across the globe.

AMS Institute's research portfolio is characterized by cross-fertilization between two areas: high-end engineering and information technology. This creates real-time sensing, strategies, tools and feedback loops that support all of the decisions we make.

In 2018 we re-designed our research activities around six core areas: Smart Urban Mobility, Urban Energy, Metropolitan Food Systems, Urban Data and Intelligence, Circularity in Urban Regions, and Climate Resilience. This re-design has brought more focus to our activities. It has also raised our profile and improved impact. At the end of 2018, our overall project portfolio consisted of 103 research projects, a wide variety of academic and public stakeholders, and over 150 private partners, representing a total value of €56M.

A strategic move to Marineterrein Amsterdam

At the end of 2018, AMS Institute relocated from our home base at the Royal Tropical Institute to the thriving and innovative Marineterrein area. This is a strategic move, and it will help us realize our ambitions. We began retrofitting the former military building into our new office in mid-2018 to create an inclusive environment and breeding ground for academics, public and private partners, and citizens. Here, all parties are able to come together to exchange, research, develop and test new approaches to the many challenges metropolitan areas are facing. Our new location – with a community that supports collaborative approaches and includes all relevant stakeholder groups – immediately proved itself. It has helped boost our activities to a next dimension…and this is only the beginning.

The board appoints Kenneth Heijns as new Managing Director

The first half of 2018 also saw the AMS board start a formal procedure to fill the position of Managing Director. This led to the appointment of Kenneth Heijns, who was already active as interim Managing Director. Heijns, along with Scientific Director Prof. dr. ir. Arjan van Timmeren, will now contribute fulltime to AMS Institute's upcoming and defining years. Our consolidation and the further exploration and development of our expertise and approach to excellence will take center stage during this period.

Living labs as test beds for innovation

We understand that new solutions are needed to secure the transition to sustainable, fair, and resilient cities. These solutions must be based on innovative, fundamental research, and many of the methods developed during the past decades have taken this approach. This has led to the increased importance of a living lab approach – an approach that has garnered a lot of attention and has gained traction among many innovation projects, scientific programs and municipal organizations. AMS Institute is now one of the leading international institutions when it comes to the expertise needed to set up and operate (urban) living labs to achieve meaningful results.

All living lab approaches have certain elements in common. They are aimed at urgent societal challenges. They address very complex issues. And they operate through iterative/learning approaches co-created in real-life with all stakeholders.

AMS Institute's urban living labs are characterized by innovation and learning. They include co-creation and a distribution of decision-making power. They move forward through iterative steps with built-in feedback loops. They involve all relevant participants, including public actors, private actors, users (civic society) and knowledge institutes. And they take place in a real-life context. In fact, we now actively use our new Marineterrein location as an in-situ site for innovation testing. This is a great step forward in terms of valorizing our research activities.

AMS Institute's book Urban Living Labs: *A Living Lab Was of Working* contains more information about setting up successful living labs. This book is available for download via our website.

Expanding our educational program and activities

2018 was also an important year for AMS Institute's educational program, as a second cohort of MSc MADE (Metropolitan Analysis, Design and Engineering) students joined the first cohort. The number of students of the 2018 cohort doubled compared to the year 2017 - when the program began – and we fully expect enrolment to continue to grow in 2019. Both groups demonstrate the qualities that fit AMS Institute: they are critical thinkers, with entrepreneurial interests, skills and initiatives, and an open-minded approach to finding effective solutions for metropolitan challenges. Our recent move has demanded a certain amount of flexibility from these students, but we are delighted to see that the new location is indeed reinforcing the tight bond between the program and AMS Institute. It also provides more than enough learning space for expected future growth.

As in previous years, we also organized a variety of successful summer schools in 2018. Special

mention goes to ‘Re-Learning Public Space’ and ‘Integrated Mobility Challenges in Future Metropolitan Areas’. These summer schools actively submerged participants into the city of Amsterdam to conduct field research on specific metropolitan challenges. The ‘Education’ chapter in this report contains more information.

The 2nd AMS MOOC (‘Co-creating Sustainable Cities’) had a 2nd run in 2018, while the 1st AMS MOOC (‘Sustainable Metropolitan Development’) had an automated pace rerun. This again resulted in thousands of new students, bringing total enrolment for these first two AMS MOOCs to more than 45,000 students from 178 different countries by the end of 2018. We have also started preparations for the AMSx3 MOOC (Nature-Based metropolitan Solutions) and the AMSx4 MOOC (Engineering Walking and Cycling Networks). The first runs of which will take place in 2019.

We also conducted two successful runs of the AMS Mid-City graduation studio. This resulted in a further amplification of the amazing series of models envisioned by the end of 2018 across ten parts of the city (and an overview model of the whole city), as well as their possible transitions in the coming three decades. Four of these models were exhibited in the Zuiderkerk in June/July, and six models will be exhibited in the first half of 2019 in our new AMS office.

Finally, we developed our first plans to set up professional education for urban professionals and partners in 2018. The first two programs were developed with our private partner AWECT, and focused on waste management for and in India. We also prepared a professional training program for urban professionals of the City of Amsterdam.

An urban data flow approach with globally-recognized results

In principle, all metropolitan solutions research depends on gathering and analyzing data across a wide variety of relevant spatial, environmental and social characteristics. Most of these characteristics concern urban flows and require data analytics, including big data.

Our data science team differentiates itself through a focus on:

- The spatial, social and temporal aspects of social urban data
- The socio-spatial dynamics of human activities, flows and interactions
- The integration of time-dependent and dynamic metropolitan datasets from multiple sources

This approach has resulted in achievements such as our Social Urban Data Lab, projects such as Social Glass, and the development and application of new and globally-recognized methodologies and tools. Within the City Simulation Lab we’ve set up a team to focus on Virtual Reality. This team supports research, education and communication as well as the development of the Participatory Urban Modelling (PUM) framework. From a data-stewardship perspective we consolidated the AMS DataHub processes and platform for migration to the FigShare platform, planned for 2019.

Communications and outreach

2018 was characterized by change and scaling up. This was also true for our communications team’s dissemination activities, which focused on AMS Institute’s positioning and brand improvement. This included:

- The positioning and involvement of AMS Institute’s Principle Investigators (PIs) and Research Fellows (RFs)
- Projects and project research leaders in societal and scientific debate
- Further support for the value created in education and research through peer-to-peer events

The approach resulted in a broad range of international publications across a wide variety of media, with an overall PR value of €8.9M. This confirms once again that while the outcomes of our activities are considered innovative, the institute itself is also seen as an example of institutional innovation.

Successful and recognized programs and in-house events

We continued our successful joint program with Pakhuis De Zwijger – called ‘Science for the City’ – in 2018. This program consists of six evening events focused on challenges in the Amsterdam metropolitan area, its citizens, and society as a whole. We also conducted a variety of in-house activities aimed at building and developing our network, including:

- An amazing Roboat demonstration and event in Marineterrein’s inner harbor
- A main stage TEDtalk on circularity at TEDxAmsterdam
- An invitation from King Willem-Alexander and the President of Singapore to present our innovations at Prodock Amsterdam

Strengthening international collaboration and partnerships

We strengthened our ongoing international collaborations in 2018. For instance, we further diversified our partnership with Paris through new Memorandums of Understanding (MoUs) with Paris Est and updated collaborations with Fabrique de la Cité. We also focused our efforts on preparing collaborations with Singapore and Vienna, which will become strong new partnerships in 2019.

In 2018, AMS Institute again hosted numerous delegations and representatives from national and

international governments, cities, and universities. This led to the formation of new connections and initiatives through projects, research and educational involvement with private companies, as well as partnerships and new relationships with multinationals and SMEs. Perhaps our most important activity in this area, however, was further strengthening Amsterdam's eco-system through collaborations on a program and project basis with Amsterdam-based businesses, universities, schools and institutes.

A future-oriented self-assessment

Overall, the year and its many changes proved to be both challenging and promising. AMS Institute also took a good look at itself: we conducted a self-assessment of all our activities to prepare for the 5-year evaluation of our first decade in action. This assessment – conducted in conjunction with an external consultant and based on internal and external interviews – concluded that AMS Institute has successfully delivered on the outcomes defined in our original vision and Final Contract. It also identified as-yet untapped potential as a basis for future growth.

Beyond horizons

While 2018 was another challenging and successful year, it also resulted in the consolidation of amazing content, which is something to be proud of. To our opinion - with the investment of our relocation - the year 2018 should be seen as a key year in a true first-stage scale-up towards a more structural institute. Our new location within the innovative and entrepreneurial environment of Marineterrein already promises to become a breeding ground in which partners from business, science, education and society can work jointly on innovative metropolitan solutions around the globe.

And while buildings and working environments are important, we understand that people are at the core of our success. At AMS Institute, we are proud of our dedicated team of bright women and men. Together, they work with hundreds of researchers and teachers from our three core academic partners (TU Delft, WUR and MIT), urban professionals from a variety of public and private partners, and our special and highly-appreciated ties with the City of Amsterdam. Their collaborative approach makes AMS Institute an amazing organization.

These people will drive the many new initiatives and successes that lie ahead of us. Together, we will take the important and necessary next steps in urban innovation as we find solutions to the challenges and complexity of our cities.

The overview presented in this introduction forms just a small part of what AMS Institute is. Continue reading to learn more about our impact and results. And we invite you to join us, as together we move beyond the horizon.

Arjan van Timmeren, *Scientific Director*
Kenneth Heijns, *Managing Director*

"The relocation of AMS Institute to Marineterrein Amsterdam will reinforce the area as an innovative environment for a range of challenges that involve learning, health, housing, mobility and water."

Liesbeth Jansen
Director Bureau Marineterrein

AMS Institute: designing solutions for urban challenges

Engaging and developing the latest technology and science with research, experiments and projects in the city of Amsterdam, AMS Institute takes on the challenges posed by our rapidly urbanizing world. The institute wants to develop a deep understanding of the city – sense the city – to design solutions for its challenges, and integrate these into the city of Amsterdam.

The institute's three core pillars

Urban Energy

Design integrated innovations that help establish sustainable and resilient energy systems, for example synergies between energy transition and urban (re-)development.

Kattenburgerstraat 7
Marineterrein Amsterdam

Collaboration

AMS Institute is an ambitious institute at the forefront of innovation, and works closely with industry, government, academia and the citizens of Amsterdam.

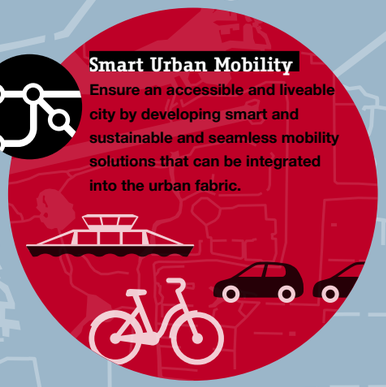
Our activities result in:

- Knowledge
- Start-ups
- Talent
- Solutions
- Spin-outs
- Impact

Focus on Six Urban Challenges

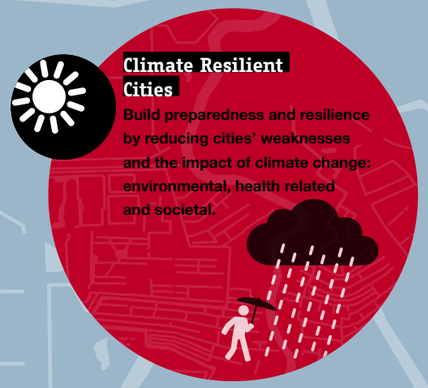
Smart Urban Mobility

Ensure an accessible and liveable city by developing smart and sustainable and seamless mobility solutions that can be integrated into the urban fabric.



Climate Resilient Cities

Build preparedness and resilience by reducing cities' weaknesses and the impact of climate change: environmental, health related and societal.



Metropolitan Food Systems

Create inspiring scenarios to make food systems more sustainable and future-proof, by focusing on core elements such as: economic development, health, mobility and regional attractiveness.

Amsterdam as a Living Lab

What makes AMS Institute unique is that we valorize our research through practice, using the city of Amsterdam as a living lab: a valuable context for experiments that helps develop and test advanced solutions for challenges in urbanized metropolitan areas around the globe.

Urban Data & Intelligence

Mobilize new analytical tools to better use urban (big) data and improve city life, while strengthening and safeguarding the democratic values of citizens and society.

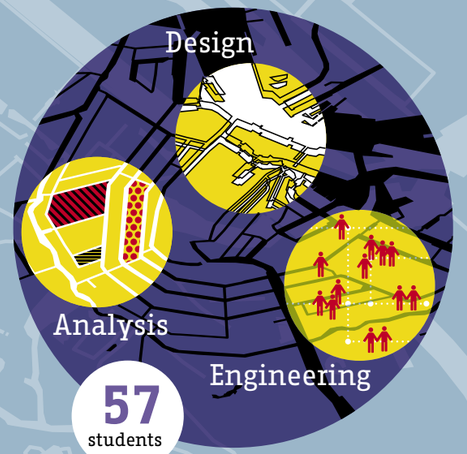
The solutions we develop can be used for cities worldwide

MSc MADE

A joint master's program offered by Delft University of Technology and Wageningen University & Research, using the city of Amsterdam as a case study and living lab via AMS Institute.

Circularity in Urban Regions

Re-design resource flows that drive urban activities, whilst establishing integral sustainable urban ecosystems, supported by a new, resilient economic model.



57 students

Education

Creating an ideal environment to foster skills and development

AMS Institute continued to develop its educational activities in 2018. As always, our approach was geared towards changing cities for the better. The living lab concept played a central role here, as we used an iterative, co-creative process with cities to reinforce the openness and abilities needed to deal with change.

The generation and dissemination of knowledge is essential to developing a deep understanding of – and sustainable solutions for – our cities of today and tomorrow. Using Amsterdam as a living lab, our educational activities are aimed at current and future professionals. Our goal is to create an ideal environment that will foster the research, design and innovation skills essential for sustainable, resilient and just cities.

The Metropolitan Analysis, Design and Engineering master program (MSc MADE)

The Metropolitan Analysis, Design & Engineering master program (MSc MADE) forms the core of AMS Institute's educational activities. MSc MADE brings multidisciplinary teams of students together in Amsterdam to address questions such as:

- How can we keep our cities connected?
- How can urban environments safeguard their vitality?
- How can we create truly circular cities?

This two-year master program is a combination of in-situ and online education. It provides students with thorough training in academic skills and project work, while simultaneously connecting them to AMS Institute's research portfolio and our network of business and societal partners.

Educating future Metropolitan Engineers

In January 2018, the first cohort of 18 MADE students continued their journeys towards becoming Amsterdam Metropolitan Engineers. Between January and the summer, they followed continuation courses on data and entrepreneurship. They also followed a three-month process to define and proceed along their individual tracks at TU Delft and Wageningen University & Research. Most also attended AMS Institute's elective and combined international seminar on "Smart Water and Mobility in Sydney's CBD" at the UTS in Sydney. Upon their return to Amsterdam, all students engaged in the Metropolitan Solutions course in a collective effort to employ their newly developed knowledge and skills for the benefit of a specific Amsterdam issue: the future mobility of Marineterrein Amsterdam.

A wide range of backgrounds and nationalities

In September, 39 new students started their MADE trajectories. This second cohort of MADE students comes from a wide range of disciplinary (engineering) backgrounds and 21 different educational institutions. Together, cohorts 1 and 2 are comprised of 12 different nationalities. This group of students has started to look for ways to engage with the city of Amsterdam and AMS Institute's research and activities. For example, they contributed to the Roboat project and presented their knowledge clips at Pakhuis de Zwijger. Our second year MADE students (the first cohort) have already started working on their living lab and thesis research.

Living lab and thesis

Our students use their living lab and thesis work to engage with real-life challenges in the Amsterdam Metropolitan Area. For their thesis, students formulate their own research questions around an identified challenge, guided by at least two academics from Wageningen University & Research and/or Delft

University of Technology. Thesis topics cover a wide range of subjects, from social practices such as ‘mobility as a service’, ‘energy streams in built environments’, and ‘urban solid waste management’, to more methodological areas such as ‘innovative technical and participation platforms’ or ‘inclusive city’ related challenges.

These living labs also help students work in groups to set up development trajectories for actual (and practical) solutions. They conduct their activities in collaboration with AMS partners from the Amsterdam eco-system to co-create metropolitan solutions that enhance sustainability in the Amsterdam region. Solutions vary – from protocols to apps to physical structures – and apply to a diverse range of areas. For instance, some students are working in *Zuid-Oost* to find solutions for street waste, while others are working with the DGTL music festival to develop a more flexible lighting structure.

A wide variety of educational activities

Our other educational activities include summer schools, lecture series, professional training and Massive Open Online Courses (MOOCs). Our overall aim is to provide innovative education to help deliver interdisciplinary engineers the theoretical basis and practical skills they need to tackle complex metropolitan challenges.

Massive Open Online Courses (MOOCs)

Over 45,000 students from 178 countries have participated in our online courses. 2018 saw the third iteration of our MOOC ‘Sustainable Urban Development: Discover Advanced Metropolitan Solutions’. Successful completion of this course is a prerequisite for admission to the MSc MADE. In 2018, we re-ran the MOOC ‘Co-Creating Sustainable Cities’ course that we launched in 2017. We also kick-started the development of two new MOOC initiatives: ‘Nature-Based metropolitan Solutions’ and ‘Engineering Walking and Cycling networks’. We plan to launch both in 2019.
As their name implies, these courses are open to anyone with internet access and an interest in metropolitan solutions. They are also free of charge. Participants often include cross-disciplinary academics and professionals in urban development with a desire to expand their knowledge. AMS Institute’s educational activities have also stirred global interest, and the MOOCs have played a significant role in raising our international profile.

The MADE IT! student association

MADE IT! Is now an official MSc MADE student association registered at the Chamber of Commerce, with AMS Institute as its home. This association aims to strengthen the academic community. They have organized a variety of extra-curricular events, ranging from a Christmas dinner for all students to a study trip to Paris during the summer break.

Summer schools with an interdisciplinary approach

Our 2018 summer schools used interdisciplinary approaches to contribute to the knowledge of (international) urban engineers. Two highlights in this area were:

AESOP Summer School: Re-Learning Public Space (28-30 June 2018): A group of 40 participants traced the stories behind contemporary appropriations of public space in Amsterdam. These participants included international urban researchers, planners, communication experts, geographers, architects, policy makers and active citizens. Together, they identified dilemmas and formulated research questions by interacting with local inhabitants. They also designed an alternative city guide inspired by a set of broad but timely themes related to co-creation, self-sufficiency, informality and tourism.

AMS Summer School: Integrated Mobility Challenges in Future Metropolitan Areas (21-28 August 2018): Following 'Making the Metropolis' in 2017, this year's summer school turned towards the 'Stations of the Future' research project. The intensive course was organized by AMS Institute, TU Delft and DIMI, in collaboration with the ARENA architectural research network, University of Paris-Est and the City of Amsterdam. It extended the debate among 50 international young professionals, academics and master students by looking at an important rail-metro node in the Amsterdam metropolitan area: Sloterdijk Station. The station was approached in terms of its role as a crucial hub for mobility and exchange. The goal was to contribute to sustainable urban growth in our Haven-Stad living lab. The summer school resulted in four different interdisciplinary plans for the station area. Each follows a different scenario to make stations future-proof intermodal hubs.

We also organized a PhD summer school on 'Interpretive Policy, Analysis, Conflict and Sustainable Futures' between 9-13 July, 2018.

Urban Data Science

Data is the catalyst needed to make the vision of intelligent cities a reality in a transparent and evidence-based way. Urban data and urban data science methods are therefore an essential link – they enable the transformation of data into a valuable resource for solutions supporting intelligent cities.

This data-driven approach applies to any solution in which interactions between data streams and their interpretation lead to increased understanding and new discoveries about city life. In other words, they help guide the decisions that transform metropolitan areas.

In-house competences and infrastructure

Our Urban Data Science team develops the in-house competences and infrastructure required to conduct data-driven experiments and studies on urban challenges. They also manage the resulting digital assets, such as data and software. More specifically, AMS Institute designs and develops novel computational methods and tools for the *acquisition*, *integration*, *visualization*, and *exploratory analysis* of time-varying, dynamic and large urban datasets. This work contributes to an increased understanding of the metropolitan challenges we address. The team also actively supports AMS partners with off-the-shelf technological and methodological solutions and contributes to AMS research and education-related topics.

The AMS Data Infrastructure and Stewardship team

The information and data collected during the research projects we support is often very valuable to researchers, students, citizens, governmental parties and companies in metropolitan areas around the world. The AMS Data Infrastructure and Stewardship team supports and promotes the FAIR *Guiding Principles for scientific data management and stewardship*, with the ultimate goal of improving the Findability, Accessibility, Interoperability, and Reuse of digital assets. In 2018, we consolidated the AMS DataHub processes and platform for migration to the FigShare platform planned for 2019. The goal is to achieve full interoperability between the research data management platforms run by our founding institutions and partners (such as the Amsterdam Data Portal, and the 4TU.Centre for Research Data).

The Social Urban Data Lab (SUDL)

The Social Urban Data Lab (SUDL) develops technology for the integration and exploratory analysis of heterogeneous and dynamic geo-social urban data. Our work enables data-driven urban analytics, planning, decision-making, transport and social science research. SUDL activities and contributions are disseminated through education and training, targeted to both academic and professional communities. The SUDL team also supports and promotes the FACT *Guiding Principles for responsible data science*, with the ultimate goal of improving the Fairness, Accuracy, Confidentiality, and Transparency of computational solutions.

SocialGlass – a software ecosystem platform used as a service system for Social Urban Data – is the SUDL's flagship project. In 2018, we used SocialGlass across a variety of projects and experiments to address metropolitan challenges as diverse as crowd management, energy transition, and safety and security. Our ambition for 2019 is to develop and field-test human-enhanced conversational agents for urban data. This will help engage all Amsterdam citizens in democratic and inclusive decision-making processes.

The City Simulation Lab (CSL)

The City Simulation Lab (CSL) provides researchers and students with a set of simulation techniques and tools to explore a city's use-patterns. In 2018, our City Simulation Lab contributed a *CitySimulator* framework and toolkit to enable researchers and students to easily assemble and analyze behavioral-based simulations of spatial-temporal processes. It uses both formal and informal sources to explore and simulate the city's use-patterns. These patterns are related to issues such as the movement of people and vehicles, the flow of materials entering and leaving the city, the consumption and production of energy, and so on. The toolkit has already been put into practice within the context of several research activities centered on the issue of crowdedness and tourist flow in Amsterdam.

The Internet of Things (IoT) Lab

The Internet of Things (IoT) Lab was set up in 2018, with the goal of developing Internet of Things technology to help create privacy-aware and energy-efficient social urban data. The IoT Lab team envisions a future in which all Amsterdam stakeholders, administrators and citizens will be able to exploit privacy-aware, intelligent, and energy-efficient IoT and big data technologies to better understand their city. The IoT Lab developed the LuxSenz platform – a visual light communication (VLC) infrastructure for future low-energy, short-range visual communication. This LuxSenz platform was featured at the Innovation Expo 2018.

The Data Visualization Lab

The Data Visualization Lab was set up in 2018, with the goal of developing technology for the visualization and sense-making of social urban data. The team has contributed to several initiatives directly linked to Amsterdam's metropolitan challenges. These initiatives include the first public presentation of the MX3D Smart Bridge during the Dutch Design Week in Eindhoven, and the Evidence-based Food System design project. The team also collaborated closely with the City of Amsterdam's DataLab for the *Drukteradar* project to monitor and predict crowdedness levels in the city. They have also designed and prototyped a new Virtual and Augmented reality platform for immersive and interactive data visualization. This platform's first demonstration combined CBS data about individual neighborhoods with 360° imagery of those neighborhoods.

Research & Valorization

Climate Resilient Cities

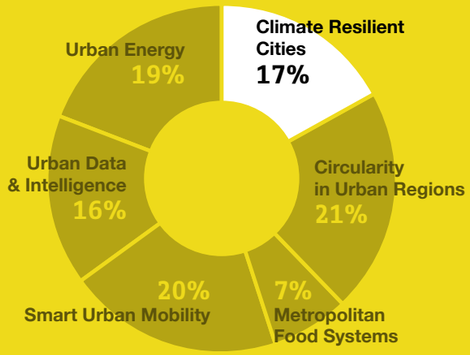
Becoming climate-proof by 2050

Heavier rainfall and storms, higher temperatures, rising sea levels, drought and other climate change consequences all present challenges to the quality of city life. As a result, cities across the globe need to prepare for the impact of climate change on urban life. Amsterdam is aware of this, and is committed to becoming as climate-proof as possible by 2050.

The Climate Resilient Cities research program evaluates the functioning, adaptation and resilience of climate systems. The entire urban air-water-soil-green system is analyzed, to map rainfall, temperature and wind turbulence in and around Amsterdam. We then use this information to create a climate adaptation planning approach that carefully designs and assesses interventions such as greening and the sustainable (re)design and maintenance of the city's infrastructure.

Total research portfolio

(in #projects)



REALCOOL

Surging heat levels in the summer of 2018 emphasized the need for solutions that effectively cool cities during heat waves. Our REALCOOL project explores a series of prototypes to design small urban water bodies (such as ponds and canals) that can lower temperatures on hot days. This research demonstrates that we can reduce perceived temperatures by approximately 10°C through a combination of shading, water vaporization, and ventilation around water areas. We released the first prototypes in the summer of 2018. The REALCOOL research team also produced animated scenes of the design prototypes for cooler urban water environments.

Project lead: AMS PI Prof. Sanda Lenzholzer (Wageningen University & Research)
Partners: Hogeschool van Amsterdam, Wageningen University & Research, Lenné3D, OKRA, de Urbanisten, TAUW, City of Amsterdam, 's-Hertogenbosch, Enschede, Utrecht and Hoogeveen and the RIVM.
Total budget: €417K
Duration: 2 years

Green Health Check

Greenery can greatly improve the quality of life in urban environments. Green Health Check developed a tool to map out the spatial challenges, opportunities and benefits of city greenery. This innovative tool helps planners, designers and developers optimize the use of greenery for a healthier and more pleasant city. More specifically, the currently-available tool maps the health effects of different types of greenery and even quantifies the economic value of greenery in the city.

Project lead: Robert Snep (Wageningen University & Research)
Partners: Ministry of Economic Affairs (Topsectoren), Wageningen University & Research, Permavoid Drain Solutions, MetaDecor BV, Soontiëns landscaping, RoyalFloraHolland, De Groene Stad, GGD Amsterdam & DRO Amsterdam
Total budget: €422K
Duration: 2 years

Amsterdam Atmospheric Monitoring Supersite (AAMS)

Amsterdam faces a number of challenges related to the quality of its urban environment. The Amsterdam Atmospheric Monitoring Supersite (AAMS) has expanded Amsterdam's meteorological network through 30 weather stations that monitor a wide range of variables. The AAMS's goal is to increase our understanding of local weather, climate and air to help improve local hydrology, air quality, and citizens' health.

Lead research: AMS PI Prof. Bert Holtslag (Wageningen University & Research)
Partners: Wageningen University & Research, eScience
Total budget: €1.5M
Duration: 4 years

"We want to improve the resiliency of the city by finding fiercely attractive solutions to our urgent challenges. Therefore, we work in triple-helix collaborations with knowledge partners like AMS Institute and business partners. Together with AMS Institute, we take the initiative and integrate the principles of resilience thinking into the city's processes, encourage new kinds of cross-sectoral collaboration and support bottom-up initiatives by communities."

Sacha Stolp

Senior Strategic Advisor City of Amsterdam, department of Engineering

Circularity in Urban Regions

Becoming fully circular by 2050

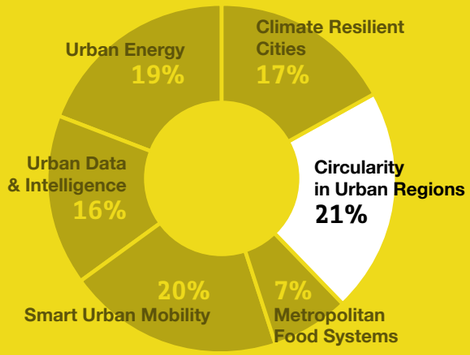
Cities around the world now realize the importance of switching from a linear 'make, waste, dispose' model towards a circular model. This means that we need to rethink and redesign the resource flows – such as building materials, water, food and energy – that drive our urban activities, based on reuse (or eventually recycling) of existing resources. The goal is to move away from a 'disposal' mindset as we reduce, reuse, refurbish and recycle as many resources as possible. Amsterdam has committed to becoming circular by the year 2050.

Re-designing resource flows

Circularity in Urban Regions focuses on re-designing the resource flows that drive urban activities while at the same time establishing integrated and sustainable urban ecosystems supported by a new, resilient and circular economic model. We work towards achieving this goal in three main ways: we support the science of resource flow physics, we develop innovative design methods and tools, and we collaborate with governments and industry partners to work on innovation in governance structures.

Total research portfolio

(in #projects)



Converting Wastewater into Composites (WASCOM)

The Converting Wastewater into Composites (WASCOM) project aims to produce high-value, lightweight composite material from urban waste water. Composite materials such as carbon and glass consist of fibers and a glue. However, sustainable and less energy intensive replacements for these composites can be found in wastewater treatment plants. For example, bacteria that clean the water tend to stick together in granules and can serve as a sort of bacterial glue. Wastewater is also full of toilet paper, which is made from cellulose fibers. Together, the bacterial ‘glue’ and cellulose fibers can form a renewable composite material for urban use made entirely from urban waste.

Project lead: AMS PI Prof. Mark van Loosdrecht (TU Delft)
Partners: TU Delft, Chaincraft, NPSP, Waternet
Total budget: €70K
Project duration: 2 years

Resource Management in Peri-urban Areas (REPAiR): going beyond urban metabolism

Cities need to shift towards a more circular economy if they are to achieve sustainable and inclusive growth. Resource Management in Peri-urban Areas (REPAiR) helps local and regional authorities reduce waste flows in peri-urban areas. The project is developing and implementing a geo-design decision support environment (GDSE) in living labs across six European metropolitan areas, including the Amsterdam Metropolitan Area as its lead case. It promotes the use of waste as a resource by helping cities create integrated, place-based spatial development strategies.

Project lead: Prof. Arjan van Timmeren (AMS Institute, TU Delft)
Partners: Delta, GeoCol, Municipality of Haarlemmermeer, City of Amsterdam, Ghent University, DiARC UNINA, Naples Federico II, HafenCity University Hamburg, Institute for Regional Studies CERS of HAS, MTA KRTK, Institute of Geography and Spatial Organization Polish Academy of Sciences, Europe Joint Research Centre (JRC), BIOKOM Nonprofit Ltd, Gertz Gutsche Rümenapp Stadtentwicklung und Mobilität GbR, OVAM - Public Waste Agency of Flanders, Campania Regional Authority, Pheno horizon, Bauer Umwelt GmbH, IVAGO Flandres, Stadtreinigung Hamburg.
Total budget: €5.1M
Duration: 4 years

REHAB: Developing circular renovation solutions for late post-war habitats

Amsterdam will need to renovate a part of its housing stock in the years to come if it is to realize its circularity and sustainability goals. This concerns 28% of Dutch housing (built in the 1980’s). However, this area still lacks evidence-based knowledge about how to reconcile the added requirement of circular renovation within this already complex renovation challenge. The REHAB project develops and tests integral circular solutions in this area. Results so far include circular design assessment methods and strategies, circular renovation elements such as roofs, facades and demonstration cases.

Project lead: AMS PI Prof. Vincent Gruis (TU Delft)
Partners: Ymere, Dura Vermeer Bouw, Heyma BV, Eigen Haard, Wonion
Total budget: €600K
Project duration: 4 years

"REPAiR's interactive geo-design tool shows what activities and stakeholders are connected to what waste. It also allows city authorities to select the right enabling context for certain solutions. They can see where certain implementations should be located to have the largest impact, and how flows are affected by a certain policy or planning decision."

Tamara Streefland
Sustainability Consultant Metabolic

Circular solutions in the royal spotlight

A state visit from Singapore

Her Excellency Madam Halimah Yacob, President of the Republic of Singapore, visited the Netherlands for a state visit on 21-22 November 2018 at the invitation of His Majesty the King. The visit was an affirmation of the close ties between the Netherlands and Singapore, and an excellent opportunity to broaden and deepen bilateral cooperation – especially in the realm of commerce and innovation. The event was hosted at Prodock, an innovation hub for start-up companies, and was attended by King Willem-Alexander, President Halimah, her husband Mr. Mohamad, Mr. Masagos Zulkifli (Singapore's Minister for the Environment and Water Resources), other members of Singapore's government and business community, Sigrid Kaag (the Dutch Minister for Foreign Trade and Development Cooperation) and Femke Halsema (the Mayor of Amsterdam).

Innovations of AMS Institute and Waternet on display

AMS Institute and Waternet were invited to share their innovations during this visit, and the delegation was invited to Prodock's workshop area where Waternet, AMS Institute and a selection of start-ups from Prodock presented their solutions for urban challenges in the area of circular economy and resource recovery. It was a great opportunity to share our expertise and enthusiasm for these topics with this very special audience.

An MoU on environmental collaboration

Mayor Halsema and Ministers from both Singapore and the Netherlands signed an MoU to enhance collaboration on environmental and water management. This will facilitate knowledge exchange and enhance mutual expertise and capabilities in four areas: integrated water resource management, circular economy, climate change, and pollution prevention and control. As a frontrunner in the area of resource recovery, water and waste management, the Netherlands will continue to work closely with Singapore in exploring circular economy concepts – a collaboration that took its first steps in December 2017 with the signing of the ReCirc PIB covenant.

First stop: Print your city from recycled plastic waste

A huge amount of plastic waste is generated by cities every day. In fact, it is estimated that plastics represent about 25% of the total volume of domestic waste in Amsterdam. Foteini Setaki, the founder of the AMS start-up The New Raw, therefore asked herself the following question: 'What if we could reduce this waste stream of discarded materials by recycling household plastics waste and transforming them into valuable products by using 3D-printing?'

It became a personal mission, as Setaki and her team examined and assessed local plastic waste streams to define their utilization patterns and recycling potential in terms of printing material. Foteini spoke with so much passion about the project that King Willem-Alexander could not resist rocking on The New Raw's XXX Bench.

Second stop: Alleviating pressure in Amsterdam's congested inner-city

Arjan van Timmeren, AMS Institute's Scientific Director, explained how the city of Amsterdam offers an ideal environment for expanding its current infrastructure through the deployment of autonomous vessels. This alleviates pressure in the relatively small but busy city center, and restores the historic purpose of Amsterdam's canals: to provide access to the inner city. Roboat – a collaboration between AMS Institute and Massachusetts Institute of Technology (MIT) – is the first research project of its kind in which high-accuracy autonomous navigation

algorithms are deployed on boats to move through the complex urban dynamics of a city like Amsterdam.

Roboat researches five areas of application/ use cases:

1 household waste collection in the inner city,
2 the autonomous transport of people in the city of Amsterdam,
3 the distribution of food/goods within the city center,
4 self-assembling water-infrastructures (such as temporary bridges), and
5 options for the automated sensing of water quality and other urban and environmental variables (in close collaboration with Waternet).

The results of this project can be applied across the globe in other water-rich cities, which represent 70% of populated urban areas and 80% of GDP. Madam President Halimah Yacob and His Majesty the King were invited to experience our canals of the future through Augmented Reality (AR) at the pop-up Roboat exhibition.

Third stop: Research on converting wastewater streams into composites

Waste streams are efficiently recycled and upcycled in a circular society. According to Peter Mooij, Research Fellow at AMS Institute, this also holds true for waste streams from wastewater treatment plants. Unfortunately, it is still common practice in the Netherlands to digest or incinerate these streams.

But this will change – combining cellulose fibers from toilet paper and a class of biopolymers known as alginate-like exopolysaccharides (ALE, a sort of glue) can yield a high-value lightweight bio-composite material. This material can in turn be applied in the transport and building sectors. The project to produce this bio-composite is called WASCOM, a collaboration between TU Delft, ChainCraft, NPSP, Waternet and AMS Institute. The topic of water management and water solutions is close to King Willem-Alexander's heart, and Mooij's presentation resulted in a lively interaction.

It was a privilege to present these innovations to this special audience. We look forward to future collaborations with Singapore, and other cities worldwide, on the topic of urban innovation, circular economy and integrated water and waste management.

Urban Energy

Eliminating natural gas and reducing CO2 emissions

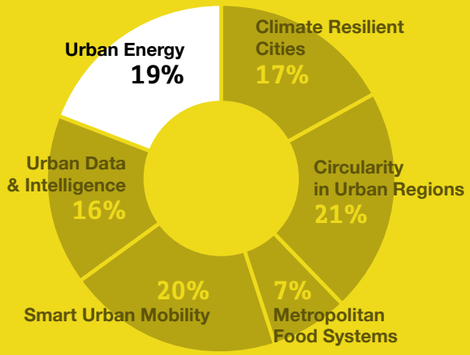
Amsterdam wants to eliminate the use of natural gas by 2040, as stated in the new coalition agreement of the Municipality of Amsterdam presented in 2018. This presents a big challenge when it comes to existing building stock, and will require difficult interventions in current structures. The city also wants to reduce CO2 emissions by 55% by 2030, and by 95% by 2050. This will require a major transformation of the current energy system.

A 'smart infrastructure' approach

The Urban Energy program therefore focuses on the following question: What is the best way to ensure a sustainable, affordable and reliable energy system for the Amsterdam region? The answer includes smart infrastructures that help the energy transition while also dealing with increased variability in consumption, storage and production on multiple scales. The program contributes to accelerating Amsterdam's urban energy transition by starting new and relevant energy projects and sharing the latest insights from current ones.

Total research portfolio

(in #projects)



DC Smart Grids

Amsterdam's current AC (alternating current) distribution grids are under pressure – they have almost reached their designated capacity. Unfortunately, it is difficult and extremely costly to change this infrastructure. The DC Smart grids project therefore explores opportunities for DC (direct current) distribution grids, which can achieve up to 60% extra capacity in the existing infrastructure. DC grids can also reduce operational costs and improve efficiency.

Project lead: AMS PI Prof. Pavol Bauer (TUDelft)
Partners: TU Delft, Alliander
Budget: 1.0M
Duration: 4 years

StoRE

Energy transition presents both technical and social challenges. StoRE contributes to the design of socially robust and sustainable storage models and services for the use of renewable energy on a household level. The study looked at the social and behavioral effects of using solar panels for home energy storage. Results demonstrated that participants developed an 'active' relationship to energy usage after installing solar panels. However, this relationship was disrupted through the Virtual Power Plant, due to process management and fundamental features of the technology.

Project lead: Prof. Gert Spaargaren (Wageningen University & Reseach)
Partners: Wageningen University & Research, Alliander, NeoSmart
Total budget: 746K
Duration: 1.5 years

Aquifer Thermal Energy Storage (ATES)

Aquifer Thermal Energy Storage (ATES) systems use the space beneath buildings to store warm and cold thermal energy. This helps to manage building temperatures sustainably without using energy from the grid, and represents a significant potential for energy reduction. However, energy systems that are geographically close to each other can influence performance. The project explores ways for neighboring ATES systems to organize themselves by communicating and coordinating with each other, using Museumplein as one of the test sites.

Project lead: Tamas Keviczky (TU Delft)
Partners: TU Delft, Priva BV, DWA, Tauw BV, Waternet, KWR Watercycle Research Institute, Province of Noord-Holland, DWA, Van Gogh Museum
Total budget: 921K
Duration: 3 years

“AMS Institute adds unique value to the Amsterdam Region by bridging societal needs with academic research and innovation. As the region is transitioning to new energy systems and solutions, quality insights with regards to new infrastructures, governance models, citizen participation and usage of data are crucial. The collaborative DNA of AMS Institute helps put these insights directly into practice, something we often experience in the collaboration between partners of Amsterdam Smart City.”

Leonie van den Beuken
Program Director, Amsterdam Smart City

Smart Urban Mobility

Greater pressure on urban mobility

The number of people visiting, living and working in Amsterdam's metropolitan area continues to rise. Inevitably, this means that issues of congestion, crowded streets, the misalignment of public transport supply and demand, and air pollution are placing greater pressure on the city. Given competing demands for the use of public space and their impact on livability and accessibility, Amsterdam – like large urbanized areas all over the world – is urgently seeking innovative solutions for sustainable, reliable and inclusive mobility.

Better insight into mobility flows and transport infrastructure

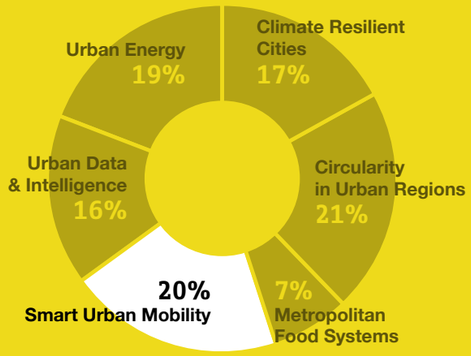
The Smart Urban Mobility program explores the feasibility and impact of concepts such as user-driven Mobility as a Service (MaaS), autonomous driving, and Intelligent Transport Systems (ITS) on the city. The program also focuses on better understanding active mode travelling (i.e. cycling and walking) by fusing advanced mobility and sensor data sources and analytics. The goal is to develop tools and solutions that will improve the (re)design of public spaces and the better use of existing transport infrastructures.

"The city of Amsterdam is growing fast. The upcoming decade will present many challenges that we must meet to facilitate this growth in a smart, efficient, and intelligent way. We challenge AMS Institute to facilitate this growth by creating scientific, smart and sustainable solutions for handling crowds and traffic. Not only on a regular basis, but also during big events such as EUR02020 and SAIL2020. It's a learning by doing approach. Each challenge needs to make us smarter, step by step. AMS Institute can develop the solutions: it's an ideal combination for the coming years!"

Daniël van Motman
Expert Advisor Traffic Management, City of Amsterdam

Total research portfolio

(in #projects)



Noord/Zuidlijn Impact Study

The Noord/Zuid Metro line started its operation during the summer of 2018. This study examined the impact of this large-scale new infrastructure on the Amsterdam Metropolitan Area. It provided researchers with a unique opportunity to explore effects on mobility patterns and behavior, socio-economic and spatial aspects, and on quality of life. The results will help decision-making for future large-scale mobility interventions in metropolitan areas.

Project lead: Niels van Oort (TU Delft)
Partners: City of Amsterdam, Vervoerregio Amsterdam, University of Amsterdam, VU University, Centrum Wiskunde & Informatica
Total budget: €1.9M
Duration: 4 years

Urban Mobility Observatory (UMO)

Understanding and managing rapid developments in urban transport calls for new types of observations. The Urban Mobility Observatory (UMO) collects, integrates and stores multi-modal traffic, transport, and mobility data from a variety of existing and new measurement tools, such as cameras, mobile phones and surveys. The results will help professionals better understand, predict and facilitate multimodal mobility in metropolitan areas like Amsterdam.

Project lead: Winnie Daamen (TU Delft)
Partners: Universiteit Twente, TU Eindhoven, CWI, Universiteit Utrecht, Vrije Universiteit, Rijksuniversiteit Groningen
Total budget: €3.25M
Duration: 5 years

CriticalMaaS

New and innovative modes of transport and digitization mean that urban mobility solutions must now offer more flexibility and an on-demand approach. Mobility as a Service (MaaS) is currently one of the most relevant concepts for supporting seamless door-to-door transport, and affects research areas such as travel behavior, interactions and supply and demand. CriticalMaaS researches the development of network, operations and behavioral concepts, theories and models for the emergence of Mobility as a Service in Amsterdam.

Project lead: Oded Cats (TU Delft)
Partners: GVB, Transdev, Metropool Regio Amsterdam (MRA), Kennisinstituut voor Mobiliteitsbeleid (KiM)
Total budget: €1.4M
Duration: 5 years

"On-demand transport is both an opportunity and a threat to urban mobility and public transport in particular. New transport solutions can complement existing options, but can't fully substitute them due to the geometrical and economical properties of transport service systems. We need to create the best conditions for an integrated transport planning and management system."

Oded Cats
Associate Professor TU Delft

Roboat Ahoy!

Testing the first autonomous boat prototypes in Amsterdam

Roboat – a research program focusing on autonomous vessels – concluded its second year of research by demonstrating the first Roboat prototypes at Marineterrein Amsterdam on October 5th. The program is a collaboration between MIT and AMS Institute, and has achieved important results in terms of full boat autonomy, including a latching system that links and docks individual vessels. In 2018 also various use cases have been explored, e.g. in the fields of waste logistics and food distribution.

Principal Investigators Carlo Ratti, Dennis Frenchman and Andrew Whittle joined the broader Roboat MIT research team to showcase their year-two results. Over one hundred people interested in the project gathered to see Roboat's progress, and research outcomes and future possibilities were discussed in industry and government focused workshops. The 2018 research results also received extensive national and international PR exposure with a total value of 3.8M Euro.

Using sensors and algorithms to safely navigate canals

Depending on its specific assignment, each Roboat is able to determine an optimal A to B route through Amsterdam's canals. To do so, it considers water traffic, incorporates canal and bridge characteristics such as width and height, and also evaluates possible obstacles. The team currently develops 1:4 scale model prototypes to accelerate testing and development.

The position of the vessel is determined with the help of Laser Image Detection and Ranging (LIDAR), supplemented by camera imaging and GPS sensors. When a Roboat encounters an object in the water, it can assess its distance and decide whether it is stationary or moving. It then determines the best way to avoid the obstacle as it continues along its optimal route. This motion planner ability is AI-based and self-learning, making it possible to adapt future execution based on past experience. It uses algorithms to learn to recognize the behavior of different types of objects and their dynamics on the water. The more hours Roboat operates on the canals, the better the estimates become.

A unique opportunity

"What is unique about the autonomous techniques we apply in Roboat is that the control system is challenged by Amsterdam's dynamic urban environment," says Carlo Ratti, Director of the MIT Senseable City Lab and

Principal Investigator at AMS Institute. “By applying Roboat in a city like Amsterdam, with busy canals, we have a great opportunity to improve the control system for autonomous navigation in urban environments. This is something that has not been shown before in other projects for autonomous vessels”.

Fine-tuning maneuverability and latching

Roboats can latch to each other and dock individually or groupwise, therefore set up temporary infrastructures such as bridges and platforms, or to function as push and tugboats. The second year of research further developed this mechanism by incorporating GPS for maneuvering, LIDAR for local positioning, and cameras to provide visual indication for the latching mechanism. This is the last step before the mechanism is activated to link the vessels to each other or dock them to the quay.

Autonomous coordination of linked platforms

Roboat’s autonomy and control system is designed in such a way that the system can control several vessels connected to each other. The algorithms for this purpose were developed in the second research year. These algorithms allow the Roboat units to intelligently interact and collaborate, as they link together to form a single organism that can navigate and move in a coordinated way.

Real-time water quality measurements

Part of the Roboat project has involved the development and testing of new sensors. These sensors continuously measure water quality while the autonomous vessels move throughout the city. The resulting data provides much better insight (higher resolution and larger time lapses) into the quality of surface water and water flows, which in turn contributes to urban water management and the related health risks for Amsterdam’s inhabitants. The team is now collaborating with Waternet to explore ways in which the new sensors can complement their current water quality measurements at fixed locations and in Waternet’s manned boats.

Creating a better balance in Amsterdam’s city center

A quarter of Amsterdam’s surface area consists of water. Expanding the current infrastructure with the deployment of autonomous vessels can alleviate pressure on the relatively small but busy city center, e.g. by reducing the amount of traffic on the streets.

Roboats also enhance the city’s aesthetics. For instance, the underground waste containers used throughout the city are unsuitable for the fragile quays of the canals. As a result, much of the city’s household waste is still dumped at the curbs of these canals. This tarnishes the view, takes up space and attracts rodents. However, if residents start placing their household waste into a series of 48 floating containers – at the same distance from their homes as the current system with underground containers – Roboats can collect the waste and bring it autonomously to a waste processing platform. The result? A single vessel that can collect waste from 1100 households flexibly and quietly, without taking up valuable street space.

Refining applications

Part of the team’s research explores Roboats’ ability to contribute to its innovative character and added value for the city and its inhabitants. For instance, Roboat units could be used for food distribution and temporary floating markets or other amenities in the IJburg and the Haven-Stad area.

In 2019, activities will focus on areas such as increasing Roboat navigation and autonomy prototype models to a 1:2 scale. The increased vessel size will introduce different dynamics and navigation behavior, requiring refinements in technology and design.

"Making a robot boat that can navigate through the canals is not actually that complicated in itself. It becomes interesting when you consider the potential applications: collecting domestic waste, carrying construction materials and solving other transport and mobility problems".

Udo Kock
Alderman City of Amsterdam

Urban Data & Intelligence

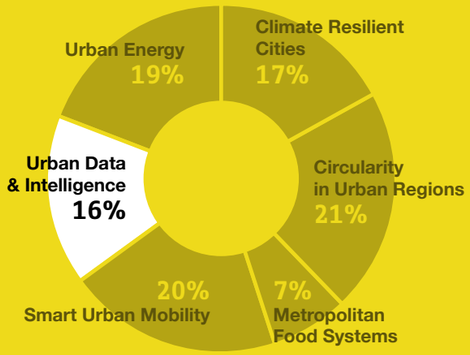
Positive impact on city inhabitants

Digital tools and technologies are increasingly important for the fabric of our urban infrastructure. Examples include big data analytics, distributed sensor networks, artificial intelligence and robotics. When used in a smart way, these technologies can help solve metropolitan challenges, thereby potentially improving quality of life, positively impacting sustainability and leveraging citizen engagement.

Urban Data & Intelligence researches, develops and integrates advanced and novel IT and data science technologies. Besides that, ways to safeguard societal values, such as autonomy, privacy, transparency, inclusiveness and empowerment are researched and developed as well.

Total research portfolio

(in #projects)



Catalyst

The rise of the smart city has introduced a seemingly endless array of possibilities. But it has also brought uncertainties, dilemmas and concerns about how technology will affect urban life. All parties in society should be involved in this discussion, but it is not always easy to effectively engage citizens in this area. For instance, the usual procedure for setting up debates and discussions often fail to include so-called ‘hard-to-reach’ groups. The Catalyst project developed and tested three novel discussion formats with the goal of involving these groups in new ways and enabling them to articulate their opinions about smart city developments.

Project lead: Frank Kupper (VU Amsterdam)
Partners: TU Delft, NEMO Science Museum, Societal Interface Lab (SIL) coalition (Waag Society, Pakhuis de Zwijger, Innovation Exchange Amsterdam, VU, Startup Amsterdam, AMS Institute)
Total budget: €134K
Duration: 1 year

Bridging Data in the Built Environment (BRIDE)

The Bridging Data in the Built Environment (BRIDE) project explores the role of smart public infrastructure in making and re-making public space. The MX3D 3D printed steel bridge developed during one of our previous projects – embedded with Internet-of-Things (IoT) sensors – will soon be placed in the center of Amsterdam. The data this bridge collects will help provide insights into how people make use of the bridge. The project will also explore how the bridge could interact with users through activities such as changing lights or using projections. This will help us design data-informed intelligent objects that are responsive to the activities in the city.

Project lead: Prof. Peter-Paul Verbeek (University of Twente), AMS PI Prof. Gerd Kortuem (TU Delft)
Partners: TU Delft and MX3D
Total budget: €476K
Duration: 4 years

“Smart city technology is all around us. However, not everyone is part of the discussion on how this technology should be designed. Through Catalyst, we develop working methods to involve all Amsterdammers, both in the city and in NEMO.”

Giovanni Stijnen
Senior Program Manager, Nemo

Metropolitan Food Systems

Flevo Campus garners attention

In 2018, the Metropolitan Food System program focused on the eastern part of the Amsterdam Metropolitan Area: Almere and its surroundings. Here, the program is developing a Living Lab setting called Flevo Campus to valorize our research in practice – in terms of governance as well as in business opportunities. The activities in Almere recently inspired the Amsterdam Metropolitan Area's dialogue in formulating the city's Food Vision and the programming of emerging MRA-initiatives such as *Voedsel Verbindt*.

Emphasis on a regionally-oriented food system

In 2018 the Flevo Campus partners jointly took the initiative to re-design the program through a series of short explorative studies. These studies focused on three aspects of the food system: urban food production, local-to-local food distribution, and the urban consumer diet. Particular emphasis was put on the various ways of producing urban food through a more regionally-oriented urban food system.

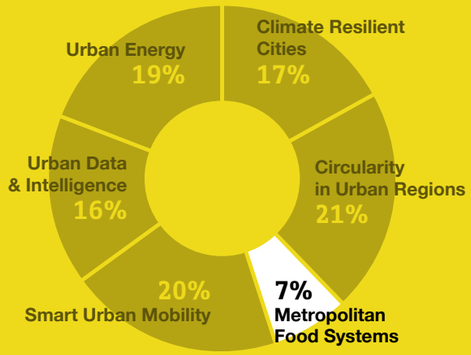
“It is the challenge of our era to find the balance between local and international, between small scale and large scale, and all gradations in between”.

Prof. Louise Fresco

President of the Executive Board, Wageningen University & Research

Total research portfolio

(in #projects)



Commercial urban food production

Cities across the globe now face rapid urbanization and growth. This has resulted in the rise of the concept of Urban Farming: producing food within the boundaries of the city. For instance, innovations such as vertical farming work well in cities were food prices are high and energy costs are low. But what about a new city like Almere? This project investigates sound vertical farming business models that are applicable around the world. The results will help make decisions about how best to invest in new urban farming enterprises.

Project lead: Jan-Willem van der Schans (Wageningen University & Research)
Partners: Flevo Campus, Wageningen University & Research
Budget: 65K
Duration: 6 months

Urban Food Park design

The connection between the landscape of cities, their citizens and the production of food is fading. The Food Park on the edge of Almere is geared towards restoring this connection. Its design involves farm-cooperation (sharing a closed resource cycle and equipment), a short supply chain, and the interaction and participation of Almere's citizens. Inspired by programs such as the Parco Agricolo Sud Milano, the Food Park is an exploration of one of the possible scenarios for urban farming concepts and healthy business models.

Project lead: Prof. Adriaan Geuze (Wageningen University & Research)
Partners: Flevo Campus, Wageningen University & Research
Budget: 65K
Duration: 6 months

The Prosumer: food-producing citizens

An increasing number of consumers are becoming more interested in the origin of the food they eat each day. Some are starting to produce food themselves – at home, in an allotment garden, or as a member of an urban food corporation. However, it is not yet clear what the role and impact of these 'prosumers' will be on our urban food systems. Research on the motives and needs of citizens (whether they require technical assistance or farmer expertise, etc.) and an overview of product innovations will help industries and municipalities understand perspectives and further stimulate this trend.

Project lead: Jan-Eelco Jansma (Wageningen University & Research)
Partners: Flevo Campus, Wageningen University & Research
Budget: 65K
Duration: 6 months

“If we want to feed the city in a healthy and green way, we have to think about vital suburbs – a place where an exchange between farmers and citizens is possible.”

Prof. Adriaan Geuze
Wageningen University & Research

Impact and outreach

Aside from our ongoing programs, AMS Institute also conducted a variety of other activities in 2018. Each of these activities had its own particular impact on the city of Amsterdam and beyond.

January 2018

'Under Pressure: Water and the City' book launch – January 24
Climate change is becoming increasingly visible and urgent each day, including the topic of water. The book *Under Pressure: Water and the City*, written by AMS Institute's RF Laurence Henriquez and Scientific Director Arjan van Timmeren, maps the relationship between water and civilization in the past, present, and future.

February

Science for the City #8: The Autonomous City – February 5
Our urban spaces are becoming more 'smart' and sensored than ever before. AMS Institute's Principal Investigator Carlo Ratti took the stage at Pakhuis de Zwijger to discuss the future of our increasingly smart urban spaces.

Living Urban Office – January 29
As more people become 'knowledge work nomads', questions regarding the purpose and nature of offices arise. This mini-symposium at our office demonstrated a selection of interactive prototypes from TU Delft students.

March

Re-run of MOOC I – February 6
We launched the third successful re-run of our MOOC 'Sustainable Urban Development: Discover Advanced Metropolitan Solutions'. In the first two rounds, more than 28,500 participants from 174 countries followed the MOOC.

International MSc MADE student visit – February 6-13
Our MSc MADE students travelled to Sydney for an international study visit connected to an elective course with an interdisciplinary course on water and smart mobility. They teamed up with students from TU Delft and Sydney University of Technology.

Stations of the Future: Paris – March 15-16
To celebrate our two-year collaboration with Fabrique de la Cité, we organized a seminar on stations as important connection hubs for cities. The seminar involved close collaboration between the Embassy of the Netherlands in Paris, Atelier Néerlandais, TU Delft (DIMI) and La Fabrique de la Cité.

Announcing our relocation to Marineterrein Amsterdam – March 29
AMS Institute has grown steadily in recent years, and it was time to take a next step in our development: a relocation to a new office in the heart of Amsterdam's upcoming innovation district. This new location will help us realize new partnerships and provides ample space to test, design and implement new innovations in our mission to create sustainable, resilient and just cities.

April

May

June

Science for the City #9: Food Proof Cities – May 8
The number of inhabitants in Amsterdam will reach 1 million during the next decade, and the number of mouths that need to be fed will rise accordingly. Together with researchers from the HvA, we discussed how political decisions will impact Amsterdam's food logistics, and which innovative solutions can help make the city food-proof.

AMS Summer Event at Hotel Arena – June 6
The 2018 annual summer event celebrated our fourth anniversary with staff, researchers, partners and stakeholders. We started with an exclusive pre-event to provide a broad outline of our educational program and discuss the profile of the future urban professional.

WeMakeThe.City – June 20-24
This five-day event celebrated urban living while addressing important urban issues in Amsterdam's metropolitan region. The main topic was: How can we make our cities better? We contributed to this amazing stage show with presentations, workshops and panel discussions on topics such as food security, mobility and logistics, water and waste management, health and wellbeing.

Launch of the MSc MADE video – June 14
The first year of the MSc MADE is a wrap. Our introduction video – created together with TU Delft – highlights the most important features of this new innovative master program.

Partnership Amsterdam Smart City – June 21
We share a wide array of competencies with Amsterdam Smart City. To celebrate this fact, we signed an official partnership with ASC to contribute to the open collective for positive city change. Topics of interest include the circular economy, digitalization, mobility, and energy.

Kick-off to design a new website – July
Together with Fabrique, we started preparations for a new website that better reflects the institute's ambitions. The website also tells our story in a way that suits our innovative spirit.

Introduction of www.roboat.org – August 10
We have partnered with MIT to launch a new Roboat website. The website showcases the project's technical details, use cases, data visualizations, videos, research publications, news and events.

July

August

Green House Challenge Finale in Wageningen – August 28
Together with Wageningen University and Research, we organized a student challenge to design the ultimate urban greenhouse in the former "Bijlmerbajes" prison in Amsterdam. The ideas generated are also intended to encourage citizens to actively engage with the sustainable production and consumption of healthy food.

First step in moving to Marineterrein – September 3
AMS Institute's staff and researchers moved to a temporary location at Marineterrein.

MSc MADE student introduction day – September 3
AMS Institute opened the new academic year by welcoming the second cohort of forty new students from over nine countries into the MSc MADE program.

September

Academic Appointment for Arjan van Nieuwenhuijzen – September 6
MSc PhD Arjen van Nieuwenhuijzen, Chief Technology Officer Renewable Energy, Water and Resources at Witteveen+Bos Consulting Engineers, was appointed as the first industry-based Principal Investigator at AMS Institute as of 1 September 2018.

The appointments of Kenneth Heijns & Ron Maziers – September 25
The AMS Board formally appointed Kenneth Heijns as Managing Director, and appointed Ron Mazier, Director Corporate Strategy & Accounts at Wageningen University & Research, as a member of the board. Both appointments are effective as of September 2018.

Roboat Demo & Opening Expo – October 5
To wrap up Roboat's second year of research, we demonstrated the first autonomous Roboat prototypes at Marineterrein Amsterdam harbor area and officially opened the Roboat Expo in our new building.

Disruptive Innovation Festival – November 6-23
During this online festival, we partnered with Metabolic to broadcast our own DIF Film on the link between smart and circular, and we unpacked what the terms 'smart' and 'circular' mean for the cities of the future.

Smart City Expo World Congress Barcelona – November 11-14
During the Smart City Expo World Congress in Barcelona, Scientific Director Arjan van Timmeren and Metabolic Strategy Consultant Tamara Streefland presented the REPAiR project in the Holland Pavilion.

AMS staff and students move into the new building at Marineterrein Amsterdam – December 1
AMS Institute staff, students and researchers have excitedly moved into our new building at Marineterrein. We are all looking forward to the new possibilities and collaborations these fresh surroundings present.

October

November

December

AMS projects showcased during the Dutch Design Week – October
AMS Institute participated in two projects for the Dutch Design week: 1) we presented design prototypes for cooling urban environments as part of REALCOOL (Really Cooling Water Bodies in Cities), and 2) we unveiled the MX3D 3D printed steel bridge.

State Visit at Prodock – November 21
Her Excellency Madam Halimah Yacob, President of the Republic of Singapore, visited the Netherlands for a state visit on 21-22 November 2018 at the invitation of His Majesty the King. AMS Institute and Waternet were invited to share their innovations. The event was hosted at Prodock, and was attended by King Willem-Alexander, Minister Kaag and mayor Femke Halsema.

Arjan van Timmeren on stage during TEDxAmsterdam – November 29
Our society already consumes almost two times the planet's capacity to naturally replenish resources. How will we make ends meet? Global ecological overshoot is a wake-up call for immediate action to change the course of societies' metabolism. Scientific Director Arjan van Timmeren was invited to give a TEDtalk during the 10th edition of TEDxAmsterdam on how we should look at cities and their dynamic relationships with surrounding environments.

Science for the City #11: Today's Challenges of Amsterdam – December 12
MSc MADE students produce knowledge clips for their Metropolitan Challenges course. During this event at Pakhuis de Zwijger, they showed and discussed two of these videos with the audience: one on 'Floating Cities' and the other one on 'Disneyfication'.

Circular collaboration: turning waste into energy

Cities are increasingly working towards contributing to a circular society, in which the goal is to reuse resources rather than dispose of them. Nevertheless, for the time being there are still resources that can't be re-used, and must be disposed of. In many areas of the world, this means that waste ends up in landfills – a process that strongly impacts the emission of greenhouse gases.

Amsterdam Waste Environmental Consultancy & Technology (AWECT) is an Amsterdam Energy Company (AEB) spin-out that uses new technology to create a better purpose for non-recyclable residue waste. In other words, they help transform waste into energy.

AWECT was founded at the end of 2017 and started their activities from AMS Institute's office. The organization has grown since then. They now have their own office on the Keizersgracht thanks to the growth, but they still work in close collaboration with AMS Institute.

Exemplary waste management in Amsterdam

Amsterdam has a long history of waste management. The city's approach really came into its own in the 1990's and through the turn of the century, as it integrated waste water and urban planning. More specifically, they used highly-efficient waste-to-energy technology to design and build a waste water treatment plant in the port of Amsterdam. This method of creating beautiful industrial symbiosis – and a successful eco-system – can serve as an example for cities all over the world. Indeed, it is a technology worth sharing, as it cuts down greenhouse gas emissions and provides a valuable alternative for landfill waste disposal.

A shared focus

AMS Institute and AWECT collaborated on a variety of international projects in 2018. These projects and activities in the area of circular economy help cities transition from a linear model to a circular model of resource management. "This helps to create livable and sustainable cities," says Sietse Agema, Chief Technology Officer at AWECT. "As a start-up, we immediately felt at home in such a family with a shared focus."

In 2018, AWECT tapped into AMS Institute's expertise for Masterplanning studies in Maharashtra and Manilla, a collaboration between AMS Institute, Waternet, the City of Amsterdam (waste and planning) and AWECT. "We used an integrated approach to help governments set goals for waste management as they explore and implement more circular approaches," adds Agema. "In these approaches, technology is used as a means and a goal unto itself."

Bringing business and science together

The collaborative efforts are about bridging the world of scientists and the real world of living labs, which tend to behave slightly differently than scientific labs. "For example, what we see in India is that they really want to move towards better and controlled waste management systems and a circular economy," says Agema. "However, they want to enhance their abilities in the area of data collection and interpretation, to help them monitor the results of their policies more effectively. This is where a scientific partner is valuable. They can help governments set up these kinds of monitoring plans to measure effects. A joint effort that combines our expertise helps us successfully contribute to a more circular society, and 2019 already has a bright outlook for possible collaborations."

Urban intelligence and integrated metropolitan solutions for sustainable growth

Moving from linear to circular

Humanity is exerting tremendous pressure on the earth's biological, geological and hydrological systems, which is already leading to a scarcity of resources such as water, energy and food. This 'global ecological overshoot' is increasingly seen as a wake-up call for immediate action. Since our society already consumes almost two times the planet's capacity to naturally replenish resources, one of the most promising actions is to change our 'societal metabolism' from linear to circular.

Cities' ecological footprints are too high

Cities can be seen as the engines of modern civilization, exemplified by dynamic relationships with one another and the surrounding environment. But clearly, their ecological footprint has become too high. Many cities are now looking for ways to alter their current infrastructures in ways that will meet current needs without compromising the security and prosperity of future generations.

Current frameworks don't always ensure accountability

This can be a daunting challenge. The pervasiveness, complexity, and scale of metropolitan systems is growing. However, the frameworks presently governing metropolitan solutions don't always ensure accountability. As a result, the search for meaningful and integrated metropolitan solutions that can be tested and implemented rapidly – including basic safeguards of responsibility, liability, and due process – is becoming increasingly urgent.

Smart Cities for sustainable growth

AMS Institute researches and develops metropolitan solutions that include new concepts of integrated urban intelligence to achieve sustainable growth. This leads to what often is framed as a Smart City. These cities are said to integrate and sort data gathered from a variety of sensors, enabling citizens and enterprises to apply new IT in a variety of areas. They can economize time, improve individual mobility, facilitate access to information and services, save energy and resources, and adapt to change.

At AMS Institute, we emphasize the creation of social, political and economic infrastructures as vital components that will support the growth of intelligent use. So it is not necessarily smart cities what AMS Institutes aim at, but smart use(rs), and smart citizens. This as we strongly belief that fair and sustainable transformations will include *distributive components* relating to

anticipated and realized distribution of social, economic and environmental outcomes. They will also include procedural elements relating to who is involved in the decision-making process. By encouraging all stakeholders to participate in urban decision-making processes, the approach helps to ensure lasting efficiency, equity, sustainability and quality of life for the citizens and users of metropolitan areas.

Big data is strikingly important

IT can now guide current and future urban professionals via the use of algorithmic software. This software analyzes 'big data' obtained for instance from sensors deployed throughout the urban environment. The integration of this software to the domain of urban engineering is strikingly important among today's professionals: it is considered to be the next key urban infrastructure paradigm that will make our cities more responsive, agile and resilient in the face of the many crises facing them. AMS Institute is committed to helping cities achieve these goals.

The Complexity Theories of Cities

AMS Institute's focus addresses this directly, basing its approach on systems thinking to urbanism, codified as *Complexity Theories of Cities (CTC)*, evolving in the last two decades. Complexity Theory of Cities sees cities as multilevel systems of several interconnected subsystems such as buildings, blocks, networks of streams and transport, and social structures. Because of the multiplicity of subsystems involved, the interactions among several dynamic agents and their *nestedness*, the boundaries of cities as complex systems are fuzzy. These interacting components can also change their roles over time in unpredictable ways.

Beside the assessment of cities as complex systems' unfamiliarity, AMS Institute's CTC based approach recognizes benefits entailed in their complexity: firstly, a complex urban system produces perceptual richness and offers more functional capacity. Furthermore, in a complex environment synergies arise, creating an added value, which is more than the sum of the parts. Within this context, metropolitan regions can be described by the conceptual framework of panarchy and the concept of the urban metabolism; the former concerns a concept that explains the evolving nature of complex adaptive systems: the duality of stability and change in which complex systems of people and nature are dynamically organized and structured across scales of space and time. The latter, urban metabolism, shows the scope of focus, and is a framework for modeling complex urban systems' material and energy flows as if the city were an ecosystem. AMS Institute introduces the essential component of integration of both technical as well as social perspective within this urban metabolism, as it addresses it as 'the sum total of the technical and socio-economical processes that occur in cities, resulting in growth, production of (renewable) energy, and elimination of waste, for the improvement of equity, sustainability and livability'.

Scientific Advisory Committee

The AMS Scientific Advisory Committee (SAC) is a formal body that advises the AMS Board on scientific strategy, including the R&V themes and the overall R&V portfolio. In 2018, the SAC was made up of the following members:

- Prof. Michael Batty, Professor of Planning at University College London, Chair of the Centre for Advanced Spatial Analysis (CASA)
- Rob Mudde, Vice-Rector Magnificus, Delft University of Technology
- Cécile Maisonneuve, President of La Fabrique de la Cité
- Prof. Arthur Mol, Rector Magnificus and Vice President of Wageningen University & Research
- Prof. Dean Sarkis, Dean of MIT's School of Architecture and Planning

Board Report

AMS Institutes' board was founded on August 26, 2014 and is registered with the Amsterdam Chamber of Commerce (KVK 854305610). It consists of four representatives – two each from our founding partners Delft University of Technology and Wageningen University & Research.

In 2018, the composition of the AMS Board was as follows:

- Paul Althuis, Delft University of Technology
- Prof. Huub Rijnaarts, Wageningen University & Research
- Prof. Peter Russell, chairman, Delft University of Technology
- Bram de Vos, Wageningen University & Research until August 2018
- Ron Mazier, Wageningen University & Research as of August 2018

The board was initially supported by Kenneth Heijns, and from 1 November 2018 by Executive Secretary Saskia Faas.

The board met nine times in 2018 to discuss and steer the general development and long-term strategy of AMS Institute. During these meetings, the board made decisions on a broad range of topics, including:

- The 2017 Annual Report, the 2018 Quarterly Reports, and the 2019 Budget and Annual Plan.
- New projects and programs in 2018 and the extension of existing ones, including BRIDE, CATALYST, The Circular Kitchen (CIK), ENLARGE, M-NEX, Participatory Value Evaluation, WASCOM, Urban Pulse II, Stimulus Flevo Campus, Re-StORe, LUO2 (Living Urban Office Seeds), HS4AMS, Roboat, Circular Productive Cities, Eat your City, REHAB, Urban Mobility Observatory, Cinderela, and CriticalMaaS@AMS. The overall R&V portfolio reached a grand total of 103 projects with a total value of more than €56M.
- The rental agreement and renovation plan for building 027W at Marineterrein Amsterdam and the related housing budget, as well as a lease agreement with EIT Climate-KIC.
- The appointment process for new and re-appointed Principal Investigators. Arjan van Nieuwenhuijzen, Chief Technology Officer Renewable Energy, Water and Resources at Witteveen+Bos Consulting Engineers, was appointed the first industry-based Principal Investigator.
- A self-assessment of the institute in preparation for the 5-year evaluation of AMS Institute in 2019/2020.

In Q3 2018, the AMS Board agreed to a two-year extension of Prof. Van Timmeren's appointment as Scientific Director and the appointment of Kenneth Heijns as Managing Director.

References

On the cover:
Laserscape: A view of the Amsterdam canals from a Roboat perspective with the use of LIDAR – Laser Imaging Detection and Ranging. This sensor technique allows Roboat to autonomously navigate through the canals, detect objects and enables the vessel to respond accordingly.
Image by MIT/AMS Institute

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Summer School 2018 – Integrated Mobility Challenges in Future Metropolitan Areas
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View on the AMS Institute office at Marineterrein Amsterdam
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Summer School 2018,
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Roboat VR Workshop by MIT
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AMS Internet of Things Lab – LuxSenz
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Cyclists after heavy rainfall
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Summer School 2018, Station Sloterdijk
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Crowded IJ River during SAIL
Photo SAIL

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Bike garage
Photo free of copyrights

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Bike garage
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Roboat 1:4 prototype
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Roboat 1:4 prototype at Marineterrein Amsterdam
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MX3D Bridge at Dutch Design Week 2018
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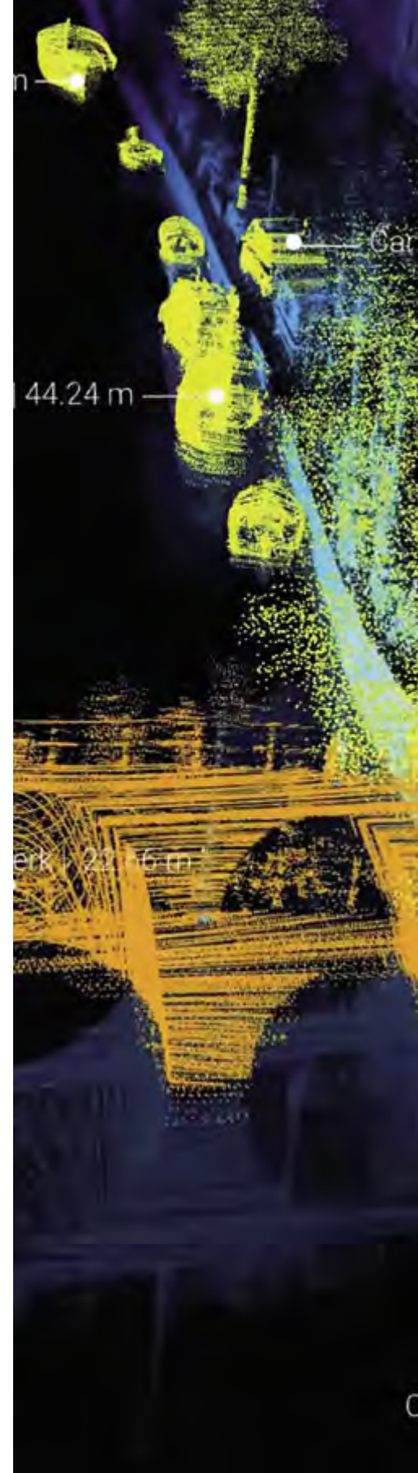


Car | 127.58 m
Dude Kerk | 47.81 m
Bike
Light | 31.56 m
Light | 20.18 m
Others | 13.19 m