Fraunhofer

FRAUNHOFER NETWORK “SCIENCE, ART AND DESIGN”

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FRAUNHOFER NETWORK “SCIENCE, ART AND DESIGN”

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FOREWORD

CHRISTIAN LANGFELD
HEAD OF DEPARTMENT "RESEARCH BUILDINGS" WITHIN THE FRAUNHOFER-GESELLSCHAFT

Buildings, and research buildings in particular, are always more than the representation of the specific fulfillment of tectonic and functional requirements of a real-world location at a given point in time. Rather, they also reflect the general technological and societal conditions governing their creation, whether intentionally or subconsciously.

Through the sheer number of projects set up for the construction of institute buildings within Fraunhofer, and through the funds expended, the German federal and state governments demonstrate their level of readiness and willingness to invest in research. In addition, the institutes intend that their buildings should not only provide the necessary shells for work processes, but also send signals to civil society and offer an inspiring, dignified work environment.

As a client, the Fraunhofer-Gesellschaft depends on the competence and commitment of its planning teams. For each new project, highly qualified and experienced external architects and engineers are hired according to their area of expertise.

Key concepts such as communication, transparency, flexibility and economic efficiency are continuously reprioritized and reinterpreted for each new project and subsequently implemented in the designs. Factors relating to ecology, sustainability and digitalization have also continued to gain importance, albeit in periodical surges.

Specific references to the surrounding environment and the special requirements of the buildings' users can result in highly individual building structures and facades.

However, most of the Fraunhofer institute buildings share a number of common features that make comparing them across decades attractive:

- Their combination of functional elements such as laboratories, technical centers and office areas
- The immensely high requirements of their technical building equipment
- The desire to have buildings express our trust that the future can be shaped through technology

We invite you on an exciting journey through research architecture realized by the Fraunhofer-Gesellschaft!

PREFACE

PROF. DR. HOLGER FALTER, DEAN OF THE DEPARTMENT OF DESIGN AT COBURG UNIVERSITY OF APPLIED SCIENCES

Buildings reflect societies and their cultures. Not only do they document the technological state of the art, but also the way in which the available resources are used. Composition and proportion, functionality, economic efficiency and longevity, under consideration of new developments and technological principles, have always been dominant design criteria. Resource and energy efficiency, on the other hand, as well as recyclability and flexibility in terms of work requirements and multifunctionality are aspects of sustainability that have joined the other criteria in the 21st century and are going to influence the construction and architecture sectors for an indeterminate time. Great architecture is created when all criteria are successfully balanced and intelligently integrated into the design process. Through society's aesthetic recognition, an edifice may even be elevated to a work of art.

The multitude of the aforementioned criteria, combined with the complex and specific requirements of research buildings, significantly increases the challenges involved in constructing them.

In an environment that has a profound influence on human perception, the aim of creating sustainable buildings and products calls for a design approach that elicits timeless acceptance from users and observers.

In order to plan research buildings that are long-lasting in terms of design and that also create a sense of identity, it is essential that we understand the processes of perception and meaning-making within the sensory experience and cognitive processing of stimuli.

This book describes new correlation systems established by Professor Michael Heinrich of the Department of Design at Coburg University of Applied Sciences. These correlation systems can be used to analyze design objects and constructed spaces on an interdisciplinary, scientific basis and evaluate them in terms of several different appropriateness criteria. In this way, the term "functionality" is expanded to include social, aesthetic and atmospheric environment factors that are crucial for human comfort, motivation and productivity, thus creating better opportunities to study these factors.

The following selection of Fraunhofer research facilities – with construction dates ranging from Fraunhofer's beginnings to the present – allows readers to classify the emotional and rational effects of these buildings for the first time.

“The intuitive mind is a sacred gift and the rational mind a faithful servant. We have created a society that honors the servant and has forgotten the gift.”

Albert Einstein

RESEARCH BUILDINGS AND HOW THEY ARE PERCEIVED

INTRODUCTION

Prof. Dr. Michael Heinrich, Coburg University of Applied Sciences

In a globalized, westernized world, scientific research is considered the crowning achievement of rational human endeavor. Since the early modern era at the latest, the person and activity of the scientist have ideally incarnated qualities such as the ability to think in abstract terms, logic, analytical precision and neutral observation, especially in the field of the natural sciences. Francis Bacon, René Descartes and countless other scientists and philosophers founded a form of rationalism during the Renaissance, Baroque and Enlightenment that was to become the preferred method of acquiring knowledge. Human sensory experience was separated from its subjective aspects of experience and interpretation, and completely appropriated as an instrument of empirical, objectifiable knowledge generation. Even today, rationalism is regarded as the anthropological guiding principle, and science, as its spearhead, is viewed as the motor of reason and progress and the promise of a bright future, in which the brilliance of the human mind utterly overcomes all the limitations of physical and biological nature. Although the hopes for salvation that were attached to science did suffer some disappointments and relativizations in the 20th century and even more so now in the 21st century, in many areas of public perception, it is still science alone that can heal and correct misdirections and aberrations, even of its own misuse.

Despite all claims to objectivity and rationality, science itself is by no means driven by reason alone. On the contrary: Rationality and intellectual brilliance only gain their direction and energy from the basic social, psychological and biological conditions and the emotions and motivations of people, be they individuals or groups. The extent to which unconscious emotional preconceptions and reactions control and influence rational decisions has been convincingly shown, for example, by the Nobel Prize winner Daniel Kahneman [1]. Affective-emotional dynamics are strongly linked to bodily states, but they are also in constant interplay with cognitive patterns of interpretation of other kinds. Indeed, many eminent researchers report their curiosity, passion for research and intuition as generators of their life’s work.
Albert Einstein even goes so far as to radically invert the relationship between intuition and rationality in a well-known remark that criticizes society and science: “The intuitive mind is a sacred gift and the rational mind a faithful servant. We have created a society that honors the servant and has forgotten the gift.”

Affect and emotion also play a key role within aesthetic experience [2]. Our expectations, attributions, hopes, memories, longings, needs and demands, together with their affective and emotional "charges", initially act as filters for the countless sensual stimuli in our environment: they automatically control our selective attention, match everything we perceive with existing memory content and generate embodied meanings that are most appropriate to and probable in the environmental context. This process gives rise to an interactive, aesthetic evaluation network that spans biologically anchored reactions, biographical influences, and patterns and attitudes learned from our sociocultural context. All in all, sensory perception and interpretation of the environment are our primary modes of accessing the world; their affective, emotional and motivational orientations determine all later, supposedly rational decisions, patterns of action and functional assignments.

The design of concepts, objects, spaces and architecture is nothing other than the control of these elementary processes of perception and interpretation. But before design invokes higher cognitive meaning and offers functional interactions as affordances, it creates an intuitively appealing atmosphere as a first overall impression. This impression not only determines whether we react to a part of the environment – for example, to a research building – with initial appetence or aversion, but also whether we feel comfortable with it in the long term or not. As recipients, we naturally also associate our impulses of attraction or repulsion with the person and the intention of the "sender" of the design, i. e., with the client that commissioned the architectural object or with its architect.

From this perspective, what potential does architectural design for research and science buildings offer? First of all, it can make complex, often very abstract issues – be it the ambitions and self-attributions of the institution, matters of disciplinary insight or attitudes about the relationship to the context – tangible to the senses. Scientific research, from its affective driving forces to its results, consists of multiform processes with countless facets and forms a highly complex bundle of phenomena. It is through our sensory experience that scientific research takes on a more concrete form, for example, in our encounters with scientists in real life and the media, or with places or instruments of scientific activity. Buildings of science that are home to such activities are particularly well suited in their overarching design quality as unifying carriers for the visual communication of the values that are to be read as "science".

The architectural design of science and research buildings, with its atmospheric and semantic potential, occupies a central position within a perception-oriented spectrum of functions. This potential decides – for example, through architectural branding – how the institution is publicly perceived and which core values are associated with it.

What instruments can now be used in architectural design in order for architecture to distinguish itself as a carrier of meaning? In addition to general form-giving qualities such as mass distribution, articulations, line progressions, alignments, rhythms, symmetries, groupings, self-similarities, iterative variations and the like, it is the dynamic field of order and complexity across different structural layers that provides the formal-aesthetic basis for higher cognitive classifications, e. g., for the broad field of analogies. In science buildings as much as any others, such analogies can take on different levels of semantic abstraction. On the concrete side of this scale of abstraction, replicas or re-creations mimetically repeat all the sensual qualities of a reference object and thus also adopt its meaning. In the case of the Academy of Athens (1856, Theophil Hansen) – as in countless other representative buildings of the 18th and 19th centuries – a classical portico refers in more or less exact detail to the temples of antiquity and lends all the sacral dignity of ancient tradition to the comparatively modern building.

On the abstract side of the scale, the reduction, typification and recontextualization of complex forms can produce an equally intense density of reference. For example, in the architectural design of the new Cottbus University Library (2004, Herzog/de Meuron), the color and bending behavior of paper and the structure of printed text form the semiotic foil for a very expressive, typifying reduction of architectural form. Paper and letter are used here pars pro toto as symbols for the complex world of a core academic institution, namely the library. Another, almost polar difference between the two examples is the temporal direction of reference: the Athenian Academy – just like countless other representative scientific buildings up to around 1910 – clothes its authority in formulas that refer to venerable traditions, thus emphasizing the preserving, archival aspect of science. The Cottbus University Library, on the other hand, transposes the topos "book" into an advanced, innovative world of materials and design that makes the creative potential of science and its experimental, empirical character tangible to the senses. Forerunners of this innovation-oriented form of scientific architectural semantics would be, for example, the reading rooms of the Bibliothèque Sainte-Geneviève or the Old Bibliothèque Nationale de France with their open cast-iron architecture, which was very new at the time of construction (Paris; Henri Labrouste, 1851 and 1868 respectively), or the Einstein Tower (Potsdam; Erich Mendelsohn, 1922).

As different as the two modes of reference in Athens and Cottbus may appear, they both make use of analogy as a generator of meaning and employ it as a semantic code across different levels of abstraction. In this way, they both refer equally to important, basic aspects of scientific development. For the user or observer of such semantically charged buildings, the current structural design and functional purpose is inevitably coupled with his or her experience and expectations and thus made emotionally significant.

From the great library of Alexandria, the alchemy laboratories and cabinets of curiosities of the princely courts, the collections of the great universal scholars of the Enlightenment, the programmatic science buildings of the Soviet Union and the USA during the Cold War, and the new, value-oriented corporate architecture of the headquarters and think tanks of major global players all the way up to Fraunhofer research buildings – the architectural self-presentation of science and research was and is anything but expendable icing on the cake.

Architectural-aesthetic communication is a core function that is highly effective at an emotional and sociocultural level, yet can be justified rationally. As we perceive our reality through the media to an ever-greater extent, architectural design inevitably becomes the most effective iconic reference to the identity, aspiration, self-concept and goals of the originating institution. Because it communicates sensually, spatially, atmospherically, socially and semiotically in equal measure, architecture determines attractiveness or disapproval. It documents the institution's claim to attention, acknowledgment and respect, and proclaims its sociopolitical significance and positioning in terms of brand image and identity to both the public and the institution's own research community.

The beginnings
Modern institute construction
Making intelligent use of existing structures

ARCHITECTURE BY FRAUNHOFER

Christian Langfeld, Fraunhofer-Gesellschaft

The buildings that have served as research spaces since 1949 are as heterogeneous as the topics pursued by the 76 institutes that currently make up the Fraunhofer-Gesellschaft. Their architectural language is as diverse as the institutes' research objectives and the decades in which they were built. If not for the signage, it would often be impossible to distinguish a Fraunhofer institute from a Max-Planck-Gesellschaft facility or any other large functional building.

But how do Fraunhofer research buildings affect clients, partners and visitors? Is it possible and meaningful to define characteristics that will make them recognizable at first glance? Or should each building reflect its own unique qualities, aspirations and appropriateness?

What are the features that make an excellent Fraunhofer building? Should these features be part of a branding scheme, or is the objective rather to display a responsible attitude towards society?

Each building is a functional, flexible and holistically designed tool for the research of today and the future. In addition, they serve as individual points of reference for researchers and nuanced signals to society. The most successful examples use collective resources intelligently and appropriately. They improve standards and make targeted use of technological highlights. By applying creative design approaches to find unique solutions for highly complex tasks in the construction of research facilities, it is possible to demonstrate how the future can become an attractive space for us and for the coming generations.

In recent years, many of the old Fraunhofer structures have been expanded and modernized. Keeping in mind how much the conditions for construction work have changed in the past few decades – especially in the case of publicly funded construction work – it is surprising how much the designs of older research buildings resemble those of new ones, and how comparatively modern the former remain today.

Legal guidelines, which always reflect societal values, have been a particular focus for refinement and diversification activities, thus changing both the processes and the culture surrounding planning and construction. Here is an overview of the individual subject areas concerned:

Public construction – a complex process

Design | In the early days of the German Federal Republic, the construction sector was characterized by a high level of craftsmanship displayed by both contractors and engineers. Architects often still thought of themselves as master builders, and thus as part of a construction team. The drafted and verbal instructions – composed, of course, with the help of rapidograph pens, drawing boards and mechanical typewriters – were limited to the basics and allowed considerable leeway for skilled craftsmen operating within the "generally approved practices of the trade".

Today, in contrast, it is necessary to provide high-precision CAD plans and digital tender documents, and to comply with deadlines, so that the quality of the construction work to be carried out is assured even without further communication.

Awarding of contracts | Rules for awarding contracts in the construction sector have existed in a relatively constant form since 1952. Initially, they focused mainly on how to place orders fairly and on general rules for cooperation at construction sites. Today, EU legislation provides a highly differentiated set of rules that balance the interests of all parties by mandating unrestricted access to the market, measures for corruption prevention and maximum cost predictability.

The regulations call for tenders with multiple lots, which generally means that at least 35 trades will be involved in the construction process, with some exceptional cases comprising up to 100 lots.

For a long time, planning services were commissioned at the discretion of the client in line with the set fee scale for architects and engineers, or an earlier form of that scale. These days, however, the European understanding of the objectivization and detailed differentiation of processes has led to the abolishment of obligatory compliance with the fee scale.

Today, planning teams are usually composed via a competitive EU-wide tendering process.

Construction | In the first decades of construction activities within the Fraunhofer-Gesellschaft, there was a strong desire to erect buildings more quickly and more cost-efficiently through standardization, prefabrication and industrialization. However, exclusively using serial design and prefabrication presents certain limits.

Today, unitization concepts are being revisited with a view to finding flexible solutions within approved standards using digital tools.

Current trends | Large-scale building projects that have attracted international attention are part of the reason why working conditions in the construction industry have been viewed much more critically of late. The Federal Government of Germany is supporting the strategic realignment of construction processes and culture through a range of different initiatives.

In the field of research facilities, two developments deserve special attention:

- BIM Building Information Modeling – the creation and use of "digital twins" during the construction process and operation of buildings are important elements of the digitalization strategy of the "Research Buildings" department. For this purpose, it relies on the expertise of Fraunhofer institutes that deal with construction-related topics.

- Variable construction and tendering processes, e.g., "partnering" – in the future, this standard construction process will be complemented by alternative models to a greater extent, depending on the buildings' purposes and specific constraints. For example, the integrated project management model, which is mainly focused on the collective success of all parties, will become more attractive for certain types of building projects.

The beginnings
Modern institute construction
Making intelligent use of existing structures

ARCHITECTURE BY FRAUNHOFER
BUILDINGS FOR APPLIED RESEARCH – THE BEGINNINGS

What should a perfect institute building look like? Now as in the past, little has changed in this regard. First and foremost, the building should be made available for pressing research tasks as quickly as possible. During the time in which it is used, it must be able to flexibly accommodate all requirements made by current research topics and allow the installation of new equipment while still being economical in terms of maintenance. The ideal image is a multi-functional platform – open for any modification, addition and reduction. In reality, this calls for rooms organized in a modular way, very high stories, support structures with a capacity to sustain high surface loads at maximum span, and ceilings without beams or girders.

Also, there should be additional space held in reserve, and in all cases, room for retrofitting technical equipment as well as expandable ducts for media transport. The routes between heavily used facilities should be as short as possible, while space for spontaneous professional exchange upon a coincidental meeting is very much desired. It is quite obvious that all these requirements are limited by the available funds and by the fact that they sometimes even contradict each other.

Therefore, each design process is also a question of determining the respective optimum to be created in a specific situation, a balance between reliance on standards and observation of individual requirements that needs to be struck over and over again.

Often, the rooms to be built are designed in such a way that they resemble high-precision research facilities themselves. Achieving this requires prototypical designs that do not rely on any sort of model. But even "standard" laboratories have a wide variety of forms that go far beyond the physical, chemical and medical-biological categories. The diverse Fraunhofer research landscape with its different focus points finds expression in its buildings.

While there may be one or two historic buildings that were heavily influenced by the respective tastes of their time and are now facing renovations or modernization work, each well-designed Fraunhofer building still projects the same image of dynamic research activity.

1

1 *The original administration building after its renovation.*

2 *Technical center for polymer engineering, built in Pfinztal in 2006.*

OVER 60 YEARS OF TRADITION IN CHEMICAL TECHNOLOGY

FROM BASIC FUNCTIONAL BUILDINGS TO A CUTTING-EDGE TECHNICAL CENTER

Fraunhofer Institute for Chemical Technology ICT

History | The Fraunhofer Institute for Chemical Propellants (later renamed the Institute for Chemical Technology) was founded in April 1959. The team, which had its origins in a research group at Technische Hochschule Karlsruhe (now KIT), initially moved into the buildings of an old stone quarry. In the early 1960s, the institute was relocated to a spacious compound on Hummelberg hill. The first buildings were ready for use in 1964 and others quickly followed.

Having focused exclusively on defense technology in its early years, the institute had to embrace civilian contract research after 1989. Fraunhofer ICT transferred its expertise to the civil industrial sector and, following the principles of dual use, developed new products and processes for both areas.

Architecture and utilization plan | As one of the first buildings on the grounds, a functional three-story office building was constructed for the institute administration. This building formed an L-shape with a two-story auditorium and two laboratory buildings, thus ensuring close proximity between the different sections and making it easy for users to find their way around the facility. Following changes to fire safety regulations, the laboratories were relocated to new buildings. The technical center for polymer engineering, built in 2006, received an award for "Exemplary Construction" from the Baden-Württemberg Chamber of Architects. The administration building was completely renovated in 2012. The compound's 60 buildings offer a total of approximately 30,000 m² of space for over 500 employees.

OVER 60 YEARS OF TRADITION IN CHEMICAL TECHNOLOGY

FROM BASIC FUNCTIONAL BUILDINGS TO A CUTTING-EDGE TECHNICAL CENTER

Fraunhofer Institute for Chemical Technology ICT

2

Architects | Staatliches Hochbauamt Karlsruhe (administration building); weinbrenner.single.arabzadeh.architektenwerkgemeinschaft, Nürtingen (technical center)

Years of construction | 1963 - 1965 (administration building); 2004 - 2006 (technical center)

Move-in date | May 1965 (administration building); September 2006 (technical center)

Last major renovation | 2012 renovation of the administration building

Funded by | BMVg (administration building), BMBF, State of Baden-Württemberg (technical center)

Awards | "Exemplary Construction" 2006, Baden-Württemberg Chamber of Architects

Profile of the institute | Fraunhofer ICT focuses on the scalability of processes and the transfer of research results from laboratory scale to pilot-plant scale and, in some cases, to pilot-level application. Its work spans five core competences, starting with "chemical processes", which refers to the ability to design and implement innovative, resource-saving chemical and technical processes. In the field of "polymer engineering", possible practical applications of technical plastics are investigated. The core competence "energy and drive systems" involves working on electrical energy storage devices for mobile and stationary systems. In addition, Fraunhofer ICT is the only German research institute that covers the entire development chain for propellants and high explosives.

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1

1 *The main institute building in Karlsruhe.*

2 *The Rheinlandkaserne in Ettlingen.*

SPACE AND FUNCTIONALITY FOR A STEADILY GROWING INSTITUTE

OUTDOOR AREA OFFERS POSSIBILITIES FOR EXPANSION

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

History | Fraunhofer IOSB was founded in 2010 through the merger of the Fraunhofer Institute for Information and Data Processing IITB in Karlsruhe with the Ettlingen-based Research Institute for Optronics and Pattern Recognition (FOM) of the Research Association for Applied Natural Sciences (FGAN). FGAN-FOM traces its origins to the Gesellschaft zur Förderung der astrophysikalischen Forschung e. V. (1955) and IITB to the Institute of Vibration Research (1956). The Karlsruhe building and its expansion possibilities offered the answer to the demands of a steadily growing institute. It is complemented by the Rheinlandkaserne in Ettlingen, which was built in 1912 as a school for non-commissioned officers and is now a cultural monument due to its significance in terms of military history, architecture, science and local history.

Architecture and utilization plan | The Karlsruhe institute building currently consists of four wings arranged at right angles with a flat roof. It dates from 1974 and contains offices and the administration. Adjacent to the north wing is a two-story technical center with a high ceiling and a side wall that can be opened completely.

New buildings were added in the outer area of the grounds for a variety of research purposes. The SmartControlRoom is used for research into new technologies for human-machine interaction, a small container building supports local investigations with the help of drones, and the open ROBDEKON hall is dedicated to research into robot systems. The building's dark gray metal shell signals its highly technical use to the outside world.

SPACE AND FUNCTIONALITY FOR A STEADILY GROWING INSTITUTE

OUTDOOR AREA OFFERS POSSIBILITIES FOR EXPANSION

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

2

Years of construction | 1974 - 1976 (south and east wing); 1976 - 1977 (west wing); 1985 - 1986 (north wing)

Move-in date | 1976 (at the time as Institute for Information Processing in Engineering and Biology IITB)

Last major renovation | 2011

Integration into the Fraunhofer-Gesellschaft | 1967 – Institute of Vibration Research ISF (later IITB);
2009 – Research Association for Applied Natural Sciences (FGAN)

Funded by | BMBF, State of Baden-Württemberg

Profile of the institute | Fraunhofer IOSB specializes in the development of innovative visual systems and the related need to make the best possible use of sensors and sensor networks. The resulting data flows are processed and evaluated. The insights generated in this way can be used to complete the value chain, and can also serve as a basis for efficiently supporting humans in making sound decisions, improving processes and controlling autonomous systems in an intelligent way. The institute's research fields include AI engineering, digital twins, the industrial internet of things, information management and multi-sensor systems that provide support in environment perception and interaction.

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1 *The main building in Hannover, opened in 1981.*

2 *The new building of the Clinical Research Center Hannover (CRC Hannover).*

MORE SPACE FOR TRANSLATIONAL MEDICINE – IN THE PAST AND PRESENT

A CAMPUS WITH EARLY FUNCTIONAL BUILDINGS AND A PRESTIGIOUS NEW RESEARCH CENTER

Fraunhofer Institute for Toxicology and Experimental Medicine ITEM

History | The institute traces its origins to the Fraunhofer Institute of Toxicology and Aerosol Research ITA that was founded in Hannover in 1981 with the aim of elucidating correlations between the presence of airborne pollutants and their toxic effects on human beings. Due to the expansion of its research and service portfolio, the institute later changed its name to Fraunhofer Institute for Toxicology and Experimental Medicine ITEM. After only two years of construction, the main building was completed in the institute's year of foundation. Several extensions and new buildings followed, and in 2014, the Clinical Research Center Hannover was opened on the campus – the only medical research center of its kind in Germany for early-phase clinical trials of pharmaceuticals and medical products.

Architecture and utilization plan | The architecture of the early buildings is oriented toward research practice. Their layout was intended to provide sufficient space for preclinical trails in the technologically demanding field of inhalation toxicology. In 2000, a new building that had been specifically designed for clinical airway research was opened. It is connected to the main building by a glass corridor and includes facilities such as pollen exposure chambers for allergy research. The foundation for the CRC Hannover was laid in 2011. The impressive multilevel structure, which ranges from two to five stories, is located in the Medical Park and is jointly used by the neighboring institutions. In addition to 50 beds, the center has laboratories, treatment rooms and facilities for test persons, such as a cinema, a gym and a cafeteria.

MORE SPACE FOR TRANSLATIONAL MEDICINE – IN THE PAST AND PRESENT

A CAMPUS WITH EARLY FUNCTIONAL BUILDINGS AND A PRESTIGIOUS NEW RESEARCH CENTER

Fraunhofer Institute for Toxicology and Experimental Medicine ITEM

2

Architects | Walter Kleine, Hannover (main building); Nickl & Partner, Munich (CRC Hannover)

Years of construction | 1979 - 1981 (main building); 2011 - 2014 (CRC Hannover)

Move-in date | May 1981 (main building); June 2014 (CRC Hannover)

Last major renovation | 2010 - 2012 Renewal of the central cooling and ventilation control centers, renovation of the roof; 2020 renovation of the main building's lobby

Funded by | BMBF, State of Lower Saxony

Profile of the institute | Human health is at the center of Fraunhofer ITEM's R&D services. Its research focuses on potentially harmful airborne substances such as gases, aerosols, particles, fibers and nanomaterials, as well as on investigating and developing novel diagnostic and therapeutic approaches in the field of interstitial and allergic lung diseases. Fraunhofer ITEM also works in other areas, including the development and production of biopharmaceuticals, tumor therapy and translational medical engineering. In 2021, a new research field was launched that deals with the investigation and validation of new treatment models for cardiovascular diseases.

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LONG-STANDING INNOVATION POWERHOUSE FOR TELECOMMUNICATIONS

THE HEINRICH HERTZ INSTITUTE HIGH-RISE

Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI

1

1 *High-rise of the Heinrich Hertz Institute in Berlin.*

2 *Radome illuminated at nighttime.*

History | The Berlin-based research institute was founded in 1928 as "Heinrich-Hertz-Institut für Schwingungsforschung" (HHI for research on oscillations). Having been relocated several times, the institute moved into the new building at Einsteinufer in 1968. After becoming a limited liability company and changing its name to Heinrich Hertz Institute for Telecommunications in 1975, the institute shifted its research focus to telecommunications technologies. In 1998, a federal funding program by the new German government increased Fraunhofer's importance in the field of information and communication technologies. The HHI's aim of becoming a leading ICT institution made its integration into the Fraunhofer-Gesellschaft in 2003 an attractive solution.

Architecture and utilization plan | After the institute had been temporarily relocated to a site owned by TU Berlin, planning for the new building started in the late 1950s. The 15-story high-rise is divided into a north wing and a south wing. Offices and conference rooms can be found on every floor. A radome installed on the roof has become Fraunhofer HHI's trademark. Since 2020, the sphere has been illuminated with various different colors at nighttime.

To create space for the Integrated Optics working group formed in 1979, the adjacent low-rise building was used as a laboratory. In 1988, the new central technical laboratory was connected to the main building.

LONG-STANDING INNOVATION POWERHOUSE FOR TELECOMMUNICATIONS

THE HEINRICH HERTZ INSTITUTE HIGH-RISE

Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI

2

Architect | Carl-Heinz Schwennicke (main building)

Years of construction | 1964 - 1968

Move-in date | May 1968

Last major renovation | 2009 - 2015 office renovations

Integration into the Fraunhofer-Gesellschaft | 2003

Funded by | BMBF, State of Berlin

Profile of the institute | Fraunhofer HHI's work covers the whole spectrum of digital infrastructure – from fundamental research to the development of prototypes and solutions. With interdisciplinary approaches becoming more and more important, the institute increasingly works in cross-departmental projects focusing on artificial intelligence, medical applications, 5G and sensor technology, and applications in the field of security. Fraunhofer HHI is a world leader in the development of mobile and optical communication networks and systems, as well as data processing and video signal coding. Further research topics include signal processing and system optimization in the area of mobile broadband systems and the development of fiber-optic measuring systems.

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1 *South gable with main entrance at the Dresden site.*

2 *Technical center from the year 2013.*

INTEGRATION OF THE EAST GERMAN RESEARCH INSTITUTES

ACADEMY OF SCIENCES OF THE GDR

Fraunhofer Institute for Transportation and Infrastructure Systems IVI

History | Fraunhofer IVI emerged from one of Germany's oldest research facilities for control engineering. The building was opened in 1961, and initially served as home to the Institute for Control Engineering of the German Academy of Sciences (later Academy of Sciences of the GDR). As a branch of Fraunhofer IITB (now IOSB), the institute was integrated into the Fraunhofer-Gesellschaft in 1992 and renamed the Fraunhofer Institute for Transportation and Infrastructure Systems in 1999. As Fraunhofer IVI became an independent institute and began to grow, it became necessary to completely modernize the building and create additional working space and shelters and test facilities for experimental vehicles. This led to the expansion of the institute's infrastructure to include a technical center and a test track in 2013.

Architecture and utilization plan | The institute building consists of two wings of differing heights, arranged at right angles and covered with uniform textured plaster. It was designed in accordance with the workplace safety regulations in force at that time, as well as the technological needs of the research facility. Menzel-L precast concrete ceilings were used in the office areas, which was typical for the time. Cast-in-place concrete was used for the staircases and their ceilings, as well as the ceilings between large rooms (conference room and library). A technical center built in 2013 adjoins the east wing and includes a vehicle hall as well as an outdoor test track. The building is designed as a homogeneous metal structure, with its roof and facade forming a single unit, thereby emphasizing its technical character.

INTEGRATION OF THE EAST GERMAN RESEARCH INSTITUTES

ACADEMY OF SCIENCES OF THE GDR

Fraunhofer Institute for Transportation and Infrastructure Systems IVI

2

Architects | Prof. Schaarschmidt design institute, TU Dresden (main building); Kilian Architekten, Dresden (technical center) and LandschaftsArchitektur Petzold, Dresden (test track)

Years of construction | 1958 - 1960 (main building); 2012 - 2013 (technical center and test track)

Move-in date | January 1961 as institute for control engineering of the German Academy of Sciences

Last major renovation | 2022 - 2023

Integration into the Fraunhofer-Gesellschaft | 1992

Funded by | BMBF, Free State of Saxony (technical center and test track)

Profile of the institute | The institute's transport-related research work ranges from the intelligent planning, coordination and management of mobility to the development of innovative charging technologies and projects focused on investigating autonomous systems, especially in heavy goods transportation and agriculture. Special attention is devoted to security-related topics, particularly the areas of civil hazard prevention, functional safety of vehicle technologies, developments in the fields of vehicle and road safety, and accident research. The Fraunhofer Application Center "Connected Mobility and Infrastructure" in Ingolstadt was established in 2019 and focuses on automated and cooperative driving.

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Director |
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1 *View from above – machine hall with surrounding office wing at the Berlin site.*

2 *View of the building ensemble from the Spree.*

AN IMPRESSIVE BLEND OF THEORY AND PRACTICE

PRODUCTION TECHNOLOGY CENTER

Fraunhofer Institute for Production Systems and Design Technology IPK

History | The Production Technology Center (PTZ) is home to Fraunhofer IPK and TU Berlin's Institute for Machine Tools and Factory Management IWF. Its concept of combining basic and applied research has a long-standing tradition, dating back to 1904. At that time, Georg Schlesinger, IWF's first professor, promoted dialog between science and industry by various means, including establishing the first test field for production research in Germany. Professor Günter Spur, who became head of the IWF in 1965, later developed the idea of a Berlin-based institute for production engineering – an institution for applied research, aimed at transferring scientific results into industrial application. This led to the conception of Fraunhofer IPK, which was founded in 1976 as branch of the Stuttgart-based Fraunhofer IPA, and became an independent institute in 1979.

Architecture and utilization plan | In 1986, the two collaborating institutes moved into a shared building. The aim of the architectural plan was to disrupt common habits in university and industrial construction, in which spaces for theoretical work had traditionally been separated from areas of practical application. The PTZ was intended to act as a role model in this field by innovatively linking offices, workshops and the test field. As a result, the building was designed in the form of a circle: a round, self-supporting machine hall in the center surrounded by an office wing. In 2011, the Application Center for Microproduction Technology was added under Professor Eckart Uhlmann – a cutting-edge laboratory building for the production of very small parts. The PTZ is jointly owned by TU Berlin and the Fraunhofer-Gesellschaft.

AN IMPRESSIVE BLEND OF THEORY AND PRACTICE

PRODUCTION TECHNOLOGY CENTER

Fraunhofer Institute for Production Systems and Design Technology IPK

2

Architects | Fesel + Bayerer with Hekker and Ostertag, Berlin (main building); Bayerer, Berlin (laboratory)

Years of construction | 1983 - 1986 (main building); 2008 - 2011 (laboratory)

Move-in date | November 1986 (main building); November 2011 (laboratory)

Last major renovation | 2018 - 2022 modernization of the seminar and event rooms

Funded by | BMBF, State of Berlin

Awards | Deutscher Architekturpreis and European Steel Design Award, 1987

Profile of the institute | Fraunhofer IPK offers technologies with a strong digital focus for the entire spectrum of industrial tasks – from production management, product development and manufacturing to maintenance of capital goods. In addition, the institute transfers production technology solutions to application areas outside of industry, such as transport, security, and medicine. Accordingly, Fraunhofer IPK is structured in the divisions Corporate Management, Virtual Product Creation, Production Systems, Joining and Coating Technology, and Automation Technology. Close collaboration between the divisions means that holistic system solutions can be offered.

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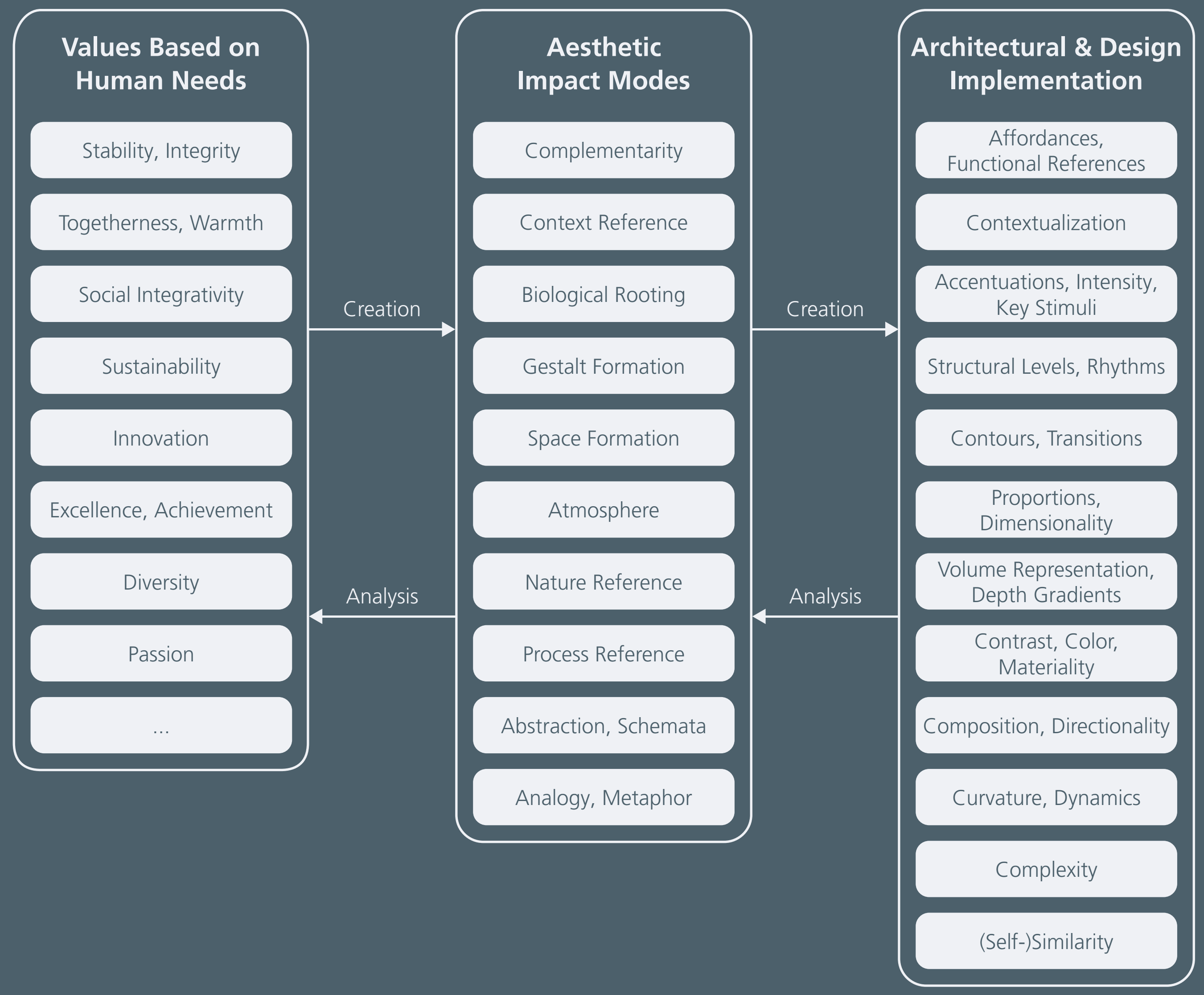
Prof. Dr. Dr. Eckart Uhlmann

Correlation Model of Value, Impact, Architecture and Design

Prof. Dr. Michael Heinrich, 2020



RESEARCH BUILDINGS AND HOW THEY ARE PERCEIVED

ASSESSMENT CRITERIA

Our built environment documents the sociocultural practices and conceptions of man and the ideals of our individual and collective lives and their transformations over the course of history. The criteria and patterns used to evaluate architectural quality are also always inseparably linked to the changing developments of human culture and society. Yet from a comprehensive scientific perspective, they must inevitably incorporate a whole series of anthropological constants that control perception and attribution of meaning. In architecture, to this day, programmatic leading figures – like Corbusier – tend to function as focal points of the dominant zeitgeist currents and have left deep media footprints through their work. Now, however, the development of empirical psychology and biology up to and including the neurosciences is opening up ever wider scope for scientific substantiation of architectural experience and design.

The correlation model of value, impact, architecture and design that is used here follows the systemic approach of a metadisciplinary aesthetics [3], and incorporates various traditional disciplinary categorizations and discourses of aesthetic experience with a view to synthesizing them within a larger context that takes into account the current state of neuroscientific knowledge [4]. The countless attempts to describe and model the complexity of aesthetic experience – and thus a large area of consciousness itself – range from the discourse on beauty and the sublime in the 18th century to the theories of empathy and Gestalt psychology, the Offenbach design theory approach, postmodernism, the discourse on atmosphere and the neuroaesthetics of the 21st century. Many of these observations and conclusions are also accessible to everyday perception and show a wide range of metadisciplinary similarities. Nevertheless, models of aesthetic perception and the evolution of meaning-making have necessarily remained incomplete to the very extent that they have failed to take note of aesthetically relevant developments in other scientific fields; blind spots of this nature with respect to various branches of psychology or cognitive neurosciences, including their novel neuroimaging procedures, can still be detected not only in fields such as cultural studies and the humanities, but also in design and architecture. Now, however, thanks to a metadisciplinary combination of current findings and process models [5], the possibilities of transcending outdated anthropological premises and tradition-based lines of reasoning are greater than ever before.

Despite many similarities in the human processing structures of aesthetic experience, there are many differences in the way individuals and groups with different sociocultural backgrounds interpret and evaluate sensory perceptions. In order to clarify this contradiction, it is useful to start by very clearly dividing the broad field of aesthetic experience into three different areas of influence [6].

The field of "biology" contains culture-independent anthropological constants of aesthetic experience, e. g., key stimuli/natal trigger mechanisms, functions of gestalt formation and the intuitive, initial evaluations of "atmospheric" perception. These predispositions are either biologically and physiologically anchored in the embodied individual or they consist of behavioral tendencies that proceed from the individual's basic genetic structure as an evolutionary inheritance [7].

The field of "culture" contains culture-dependent semi-variables, namely socioculturally induced, often predictable cultural patterns in the form of aesthetically encoded sign systems. These semiotic aspects of aesthetic perception and interpretation include languages or conceptual systems and schemata as well as symbols or other objects that serve as some form of reference. It should be noted that the cultural or semiotic level of aesthetic perception encodes all kinds of socially relevant forms of self-representation and communication, including the identification signs of social belonging and the attributive divisions of social and individual spaces [8].

Finally, the area of "biography" is composed of an immense network of biographically conditioned attitudes, motivations, influences, mental paradigms, reaction patterns and perceptual habits that shape our individual aesthetic preferences [9]. In this context, various dimensions of the individual personality may well have some biological manifestation, for example, through the balance profile of neurotransmitters involved in the regulation of emotions. This third area of influencing factors represents the most individualized part of the perceptual continuum and should be taken into account when dealing with individuals or target groups with very strong commonalities in their biographical influences.

All three areas of aesthetic perception – biology, culture and biography – are thus always jointly involved in the interpretation of sensory stimuli, reinforcing or inhibiting each other in multiple feedback loops.

Based on this three-level model, a semiotic-sociological perspective gives most weight to the communicative character of architecture and incorporates the syntax (formal contexts and grammars), semantics (meaning) and pragmatics (application contexts and objectives) of architectural language. A psychological and biological perspective with a neuroscientific dimension reflects human need and value profiles and systematizes the processing mechanisms of multisensory and visual perception and gestalt formation, affective-emotional evaluation, and cognitive interpretation of any aesthetic experience – in our case, the experience of architecture. A systems-theoretical view focuses on the dialectic of order and complexity and of wholes and partial forms and their coherence, organization and relation to each other. When taken together, all these perspectives condense into an overall philosophical-anthropological view of aesthetic experience, that is, into a series of both principal and complementary aesthetic modes of action, which, in mutual conditionality, open up the many facets of the complex continuum of aesthetic experience. These aspects of impact can be read both as questions and as scientifically founded tendencies of aesthetic experience and thus as measurement criteria; they mediate between the concrete, sensual reality of architectural appearance and the profiles of values and needs that need to be taken into account, articulated or answered by architecture. The common basis of all these measurement criteria consists of three facets: the various disciplines' basic relevant literature on the field of aesthetics; a wealth of empirical studies from psychology, biology and neuroscience and the insights derived from them; and expanded or newly developed models of aesthetic experience based on psychology, neuroscience and cognitive science [10].

If it is simplified and correlated to our topic of research buildings, the system of science-based aesthetic impact modes can also be described as the operative core of an aesthetic-communicative transmitter-medium-receiver model that goes far beyond classical architectural semantics.

Let us first examine the sender side of this correlation model of value, impact, architecture and design by asking which values, self-concepts and messages are to be conveyed while also comprehensively addressing the required function (in our case, the values of science in general and of the concerned research institution in particular)? What role has the sender envisaged for the recipient and what physical or social behavior is the recipient to be invited to engage in? What need profile does the sender want to address in the recipient? What functional requirements are to be met? What emotions or analogies are to be created? The answers to these questions form the aesthetic requirement profile – for example, for a research building – regardless of whether the form of architecture in question already exists or has yet to be created.

The recipient's side is represented by the impact modes of aesthetic experience, which describe their sensory perception and cognitive interpretation structure. To which psychological, biological and neurological process structures of sensual perception, interpretation and aesthetic-emotional evaluation are the sender and their architectural input actually referring? What sociocultural patterns of classification and influence is the sender likely to find in their target group? Which individual biographical patterns of interpretation must be taken into account? Which situational need profiles should be met? The more these aesthetic modes of impact are addressed in a comprehensive, interdisciplinary manner, the more target-oriented architectural design communication can become.

Finally, the medium of aesthetic communication must be examined. Which formal properties characterize the design of the architecture or are to be implemented in the design? Are the sender's messages coded for the receiver and their specific aesthetic experience in such a way that the most fluid and low-threshold readability is probable?

In cases where an existing form of architecture is analyzed, this results in a comprehensive, complex critique that includes possible optimizations. The yardstick for measuring the quality of an object would then be the extent to which the ascertainable design qualities of the architectural structure fit the value profile and the needs of the target group, if the complex processing apparatus of aesthetic impact modes described above is taken as a basis. When it comes to the design of new architecture, on the other hand, the ideal result is a design concept that semiotically reflects the purpose of the building, that is psychologically grounded, formally coherent and founded on the value and need profile, and can be translated via the aesthetic modes of impact into any number of combinations of design qualities.

The beginnings
Modern institute construction
Making intelligent use of existing structures

ARCHITECTURE BY FRAUNHOFER
IDENTITY AND SUSTAINABILITY – MODERN INSTITUTE CONSTRUCTION TODAY

More than any previous era, our present age makes diverse and very high demands on modern institute buildings. In addition to the aforementioned requirements, which remain valid, the following topics have become increasingly vital:

CO_2-neutrality – not only must building operation have as little impact on the climate as possible, but construction processes also require a small CO_2 footprint.

Digitalization – the aim here is to transfer the advantages of the systematic utilization of software solutions and databases into construction and operation processes.

Sustainability – choosing holistic planning approaches that consider a building's entire life cycle up to and including complete recyclability.

Resilience – it is important to guarantee the reliable usability of buildings and their technical infrastructure despite extremely high complexity levels and a wide range of flexible, individualized usage profiles.

Acceptance by society – buildings must send signals and make their presence known, but it is also necessary that they show a willingness to subtly integrate themselves into the context of civil society.

New Work – new working models should be supported and high standards should be met when it comes to providing inspiring and attractive workscapes.

Pioneering roles – in order to support future-oriented solutions, it is important to take responsibility for the use of pioneering technologies.

Given that the rate of technological advancement in relation to very complex research buildings is high and continually increasing, it is reasonable to expect that it will be impossible to consolidate and codify global standards for their construction. Instead, it seems more likely that constantly developing, highly diverse solutions will continue to exist in the future.

Perhaps these buildings will follow a similar road to that of individualized medicine and become highly modular and rely on the support of digital technology. They will help us implement better solutions more quickly, while simultaneously meeting individual demands.

With these facts in mind, we continue to expect intelligent and exciting Fraunhofer buildings in the future!

1

1 *Striking high-rise building of the Fraunhofer headquarters in Munich.*

2 *Open space concept for both concentration and communication.*

TRANSPARENCY AND OPENNESS – THE HEADQUARTERS' GUIDING PRINCIPLES

FRAUNHOFER-HAUS

Fraunhofer Headquarters

Architecture and utilization plan | The Fraunhofer-Haus is home to the Executive Board and the headquarters. It has space for 500 employees and consists of three buildings: one high-rise, one longitudinal and one low-rise building. Together with the Fraunhofer EMFT building, the construction forms a quiet, green courtyard. A largely open space concept supports communication and collaboration within and between the departments. This design was inspired by the archetype of the monastery – monastic cells provide room for concentration and the cloister is a place for communication. The generous use of glass and filigree-metal balustrades create an atmosphere of openness. The structure allows for flexibility in reacting to the development of future, innovative office concepts without having to interfere with the building fabric.

Ecological features | Several Fraunhofer institutes contributed their own concepts and solutions to the realization of the building's distinctive technical features. Fraunhofer ISE in Freiburg developed a matrix for the control of the shutters, enabling natural ventilation of rooms and integrating sunshade. Researchers at Fraunhofer IAO in Stuttgart gave their expert advice regarding office organization and a sustainable office model. Support in planning the room acoustics was provided by Fraunhofer IBP in Stuttgart, and the computer-assisted integrated facility management system was developed in cooperation with Fraunhofer IITB in Karlsruhe and Fraunhofer IVI in Dresden. Fraunhofer IFF in Magdeburg designed a cleaning robot to clean the building facade.

TRANSPARENCY AND OPENNESS – THE HEADQUARTERS' GUIDING PRINCIPLES

FRAUNHOFER-HAUS

Fraunhofer Headquarters

2

Architects | HENN Architekten, Munich

Years of construction | 2000 - 2003

Move-in date | May 2003

Funded by | BMBF, Free State of Bavaria

Profile of the Fraunhofer-Gesellschaft |
The Fraunhofer-Gesellschaft is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, it is helping shape our society and our future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,000 employees, predominantly scientists and engineers, work with an annual research budget of €2.9 billion. Fraunhofer generates €2.5 billion of this from contract research.

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RECYCLABLE SHELL FOR THE CRYOBANK

BIOMEDICAL ENGINEERING WITH A "TALKING" FACADE

Fraunhofer Institute for Biomedical Engineering IBMT

1

1 *Extension building with "cell membrane" at the Sulzbach site.*

2 *View into the hall for cryostorage tanks.*

Architecture and utilization plan | The motivation for altering and extending the existing buildings was to fulfill functional tasks, while also providing viable future prospects for the institute. Due to its heterogeneous appearance as far as urban planning is concerned, the surrounding industrial zone hardly shows any sign of design purpose. An independent solution thus seemed reasonable. At the interface between the building and its extension, a large entrance with a reception area offers space for presentations and exhibitions. The clear development plan provides a structure for the hall, dividing it into flexible and modular elements. Three sheltered inner courtyards were added to allow for a more flexible design of the adjacent areas. The building is home to the cryobank, a unique collection of living organisms that preserves knowledge about nature.

Ecological features | During the conversion of the former storage hall, ceiling plates were removed without any considerable construction interventions, creating open inner courtyards. The extension building has a connecting route which is covered by a membrane – a screen made of ethylene-tetrafluoroethylene (ETFE) foil. ETFE foil is 100 percent recyclable and as a technical material, it supports the "cradle-to-cradle" strategy for sustainability and is beneficial for life cycle assessments. The shape of the three-layer screen is derived from the appearance of the cryostorage tanks. It acts as a mediator between their round geometries and the cubic industrial architecture. The design and material choice of the ETFE screen makes the facade talk – the "cell membrane" symbolizes the work of the institute.

RECYCLABLE SHELL FOR THE CRYOBANK

BIOMEDICAL ENGINEERING WITH A "TALKING" FACADE

Fraunhofer Institute for Biomedical Engineering IBMT

2

Architects | hammeskrause architekten bda, Stuttgart

Years of construction | 2011 - 2014

Move-in date | March 2014

Funded by | BMBF, State of Saarland, European Regional Development Fund (ERDF)

Awards | Industriebaupreis in the category "Building", 2018

Profile of the institute | Fraunhofer IBMT primarily works as a technology developer and device manufacturer and offers individual R&D solutions in the areas of biomedical/medical engineering, medical (molecular and cellular) biotechnology, biohybrid technology, bioprocessing and bioanalytics, cryo(bio)technology and nano(bio)technology, ultrasound technology, biomedical microsystems, neuroprosthetics and implants, health information systems, theranostics, (mobile) laboratory technology, and laboratory automation including in-line/on-line process control. For more than ten years, the institute has been working in the field of stem cell research and hosting extensive cell line stocks in industrial and clinically structured biobanks for low-temperature storage of valuable samples.

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1

1 *Office-laboratory wing of ZELUBA® at the Braunschweig site.*

2 *View of the testing hall.*

FOCUS ON SUSTAINABILITY – WOOD AS A SOLUTION-DRIVEN BUILDING MATERIAL FOR THE FUTURE

CENTER FOR LIGHT AND ENVIRONMENTALLY-FRIENDLY STRUCTURES ZELUBA®

Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI

Architecture and utilization plan | A research building as a timber structure – that was the task faced by the designers of the "Center for Light and Environmentally-Friendly Structures ZELUBA®." In a joint venture, DGI Bauwerk and schneider+schumacher planned a building that consists of three structures. In addition to the one-story testing hall with a seismic simulator, it was necessary to design laboratories – decoupled from the dynamic equipment. The foyer and the office wing are accessible via a one-story structure. This connecting structure, built as a three-dimensional reinforced-concrete system, facilitates the necessary fire separation. It is also the building's communicative center, hosting the reception and the seminar room.

Ecological features | For several years, Fraunhofer WKI and TU Braunschweig have been jointly working on the development of modular, hybrid construction systems for light, environmentally friendly structures. Corresponding to the research at ZELUBA®, the focus during the planning phase was on the utilization of renewable resources in combination with conventional materials. Wood – being light and environmentally friendly – was the material of choice for the hybrid timber structure. The advantages of wood, steel and precast concrete elements have been combined.

FOCUS ON SUSTAINABILITY – WOOD AS A SOLUTION-DRIVEN BUILDING MATERIAL FOR THE FUTURE

CENTER FOR LIGHT AND ENVIRONMENTALLY-FRIENDLY STRUCTURES ZELUBA®

Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI

2

Architects | Arge ZeLuBa: DGI Bauwerk, Berlin; schneider+schumacher, Frankfurt am Main

Years of construction | 2017 - 2021

Move-in date | June 2021

Funded by | BMBF, State of Lower Saxony

Profile of the institute | Fraunhofer WKI develops new materials and technologies from wood and other lignocellulosic plants, supporting the industry through the development of new products, adhesives, biomaterials and coatings, measurement techniques, quality assurance programs and certifications, emission measurements, and training. ZELUBA® focuses on the development of new materials and components based on renewable resources, e. g., classical timber structural elements, connections, fire coatings, wood-concrete composite materials, and textile-reinforced materials and components. The equipment includes environmental atomic force microscopy (AFM) and dynamic mechanical thermal analysis (DMTA), as well as other material testing laboratories combining nano-, meso- and full-scale experimental capabilities with analytical methods.

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Center for Light and Environmentally-Friendly Structures

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1 *Entrance area of the research campus at the Waischenfeld site.*

2 *Buildings inspired by the Franconian village structure.*

A PLACE TO WORK, NETWORK AND MEET IN RURAL TRANQUILITY

FRAUNHOFER RESEARCH CAMPUS

Fraunhofer Institute for Integrated Circuits IIS

Architecture and utilization plan | The research campus in Waischenfeld is a location for retreats and conferences. It is open to Fraunhofer and university employees, groups from public and non-profit institutions, and clubs and associations from scientific backgrounds. Located in a tranquil rural area, the campus facilitates both focused work and team building and networking activities. Offices, laboratories and seminar rooms with a floor space of approximately 600 m² provide a creative atmosphere for concentrating and working effectively. The complex holds conference rooms of various capacities, individual office spaces as well as 47 single rooms for overnight accommodation. Thanks to its modular building plan, the campus can be used by both smaller and larger groups.

Specific regional features | The research campus is located near the small spa town of Waischenfeld, which is home to 3,000 inhabitants. The choice of wood as one of the primary building materials has allowed the campus to integrate unobtrusively into its surroundings in the heart of Franconian Switzerland. The exterior of the research campus is finished with timber cladding and fits in carefully with the landscape and the townscape of Waischenfeld. Four buildings are assembled around the central one-story entrance and reception area. Design and material choices are oriented toward the fragmented village structure of Franconian Switzerland. The construction method is based on the timber framing tradition that is typical for the area. Large windows create a sense of closeness to nature, connecting the indoors with the outdoors.

A PLACE TO WORK, NETWORK AND MEET IN RURAL TRANQUILITY

FRAUNHOFER RESEARCH CAMPUS

Fraunhofer Institute for Integrated Circuits IIS

2

Architects | Barkow Leibinger, Berlin

Years of construction | 2012 - 2014

Move-in date | July 2014

Funded by | BMBF, Free State of Bavaria, European Regional Development Fund (ERDF)

Profile of the institute | The Fraunhofer Institute for Integrated Circuits IIS, headquartered in Erlangen, Germany, conducts world-class research on microelectronic and IT system solutions and services. Today, it is the largest institute of the Fraunhofer-Gesellschaft. Research at Fraunhofer IIS revolves around two guiding topics: cognitive sensor technologies and audio and media technologies.

More than 1,100 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985, the institute now has 14 locations in ten cities: Erlangen (headquarters), Nuremberg, Fürth, Dresden, Ilmenau, Bamberg, Waischenfeld, Würzburg, Deggendorf and Passau.

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RESEARCH FACILITY AND INNOVATION PLATFORM UNDER ONE ROOF

CENTER FOR VIRTUAL ENGINEERING ZVE

Fraunhofer Institute for Industrial Engineering IAO

Architecture and utilization plan | The Center for Virtual Engineering ZVE with its floor space of more than 3,200 m^2 and its ultramodern architecture brings laboratories, demonstration spaces and offices together. In the "House of Knowledge Work", researchers develop and test virtual reality technologies, innovative new work environments and tomorrow's solutions in the fields of urban living and e-mobility. Large, connected workspaces allow for visual contact. They facilitate productivity, effectiveness and creativity and offer space for carrying out elaborate tests directly at the workplace. The design intention was to create a work environment that maximizes the speed at which information and knowledge are exchanged. The structure supports identification and affiliation in an increasingly multi-local working environment.

Ecological features | For its innovations in the fields of energy efficiency and sustainability, the ZVE was awarded the "DGNB certificate in Gold". The heart of its energy model is a geothermal plant for extracting renewable energy from the ground below. The model also includes a tank for the sprinkler system that is used to store waste heat energy coming from the computer rooms and high-performance projectors. A heat exchanger and thermally activated ceilings for cooling and base-load heating enable steady heat distribution. The innovative building automation system controls heating and cooling, air ventilation and lighting. An energy measurement and monitoring system analyzes the effects of these features. This working environment implements measures from the "Green Office" concept developed at the institute.

1 *View of the "House of Knowledge Work" in Stuttgart.*

2 *Demonstrator for ultramodern working environments.*

RESEARCH FACILITY AND INNOVATION PLATFORM UNDER ONE ROOF

CENTER FOR VIRTUAL ENGINEERING ZVE

Fraunhofer Institute for Industrial Engineering IAO

2

Architects | Ermel Horinek Weber ASPLAN Architekten BDA, Kaiserslautern; UNStudio van Berkel & Bos, Amsterdam

Years of construction | 2009 - 2012

Move-in date | June 2012

Funded by | BMBF, Baden-Württemberg Foundation

Awards | DGNB Platinum certificate for particularly sustainable construction, 2008; ImmobilienAward, Immobilienwirtschaft Stuttgart e. V., 2013; Hugo-Häring-Auszeichnung, Bund Deutscher Architekten BDA, Baden-Württemberg, 2014

Profile of the institute | The institute's research work is based on the principle that in times of global competition, economic success primarily depends on the effective application of new technological potential. Innovative, human-centric work organization models are used to systematically optimize the interaction between humans, organizations and technology. Economic success, the interests of the employees and the impact on society are given equal consideration.

By closely cooperating with the Institute of Human Factors and Technology Management (IAT) at the University of Stuttgart, Fraunhofer IAO connects basic research, application-oriented science and economic practice.

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apl. Prof. Dr. Anette Weisbecker (Deputy Director)
Dr. Florian Herrmann (Deputy Director)

1

1 *Fraunhofer IMTE building at the Lübeck site.*

2 *Atrium with view into the foyer.*

MARITIME THEME CONNECTING ARCHITECTURE, REGION AND RESEARCH

CORE TOPICS MARINE AND CELLULAR BIOTECHNOLOGY AS DESIGN BASIS

Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE

Architecture and utilization plan | During the planning stage of the new building on the Lübeck University campus, it was necessary to combine the research focus and the specific regional features with the architectural design. The designers intended to harmoniously merge marine and cellular biotechnology – which were core topics at the time – into one building. All laboratories for investigations into cellular biology are located on the upper two floors surrounding the open inner courtyard, whereas the areas relating to marine biotechnology are grouped together on the lower floors. This lower area consists of a simulation center for maritime technology with a unique research facility for integrated multitrophic aquaculture systems as well as equipment for simulating various conditions at sea, such as surf, wave movements and deep-sea pressure.

Specific regional features | The building rests on a massive sandstone plinth, creating associations with the steep coastlines that can be found all across the north of the country. The structure on top is enclosed by vertical, diagonally folded, lightweight lesenes. Due to the exceptionally high levels of micaceous iron oxide in the green coating, the facade displays a shimmering play of light and shadow, recalling maritime themes such as coastal plant life or reflections on the water. Only native coastal plant species were chosen for the outdoor green areas. The indoor color scheme imitates various maritime landscapes, with a different landscape reflected on each individual floor. The open inner courtyard with its Mediterranean design and the adjacent library create quiet zones for a focused work atmosphere.

MARITIME THEME CONNECTING ARCHITECTURE, REGION AND RESEARCH

CORE TOPICS MARINE AND CELLULAR BIOTECHNOLOGY AS DESIGN BASIS

Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE

2

Architects | Thomas Müller Ivan Reimann Gesellschaft von Architekten mbH, Berlin

Years of construction | 2013 - 2015

Move-in date | April 2015

Funded by | BMBF, State of Schleswig-Holstein, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer IMTE focuses on the integrated development of medical devices for diagnostic and therapeutic applications. Thanks to its expertise in biosensor technology, cell technology and mechatronics and its focus on interdisciplinary cross-sectional topics such as additive manufacturing and artificial intelligence, the research institution offers a unique service portfolio for the medical device industry. Fraunhofer IMTE also dedicates its efforts to research questions in the fields of cellular and aquatic technologies, particularly the development of aquaculture components, but also of food technology processes, as well as projects in the areas of bioeconomy and biodiversity.

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Prof. Dr. Philipp Rostalski
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1

1 *Institute building at the Dresden site.*

2 *View of the technical center.*

COMMUNICATION SPACE FOR THE PRODUCTION OF THE FUTURE

INNER COURTYARD OFFERS ROOM FOR DIALOG

Fraunhofer Institute for Machine Tools and Forming Technology IWU

Architecture and utilization plan | The facility was completed in 2005. It consists of a three-story office building and a laboratory building with a workshop that form the borders of a spacious inner courtyard, thus creating an open communication space for employees that can also be used for events. Movable orange benches on rails offer flexibility in using the courtyard, and in combination with the flower beds, they provide a contrast to the shades of gray in the building facades. The adjacent reception hall provides another space for communication. After the enlargement of the laboratory building in 2011, the office wing was expanded from 2019 to 2021. It is now equipped with two additional workshops, including a technical center for additive manufacturing, workspaces for employees and a rooftop terrace.

Ecological features | Owing to the natural lighting and ventilation in all the office spaces, additional air conditioning was not necessary. Weather-proof and burglar-proof night-time cooling elements naturally reduce the room temperatures, especially in the morning hours at the start of work. Furthermore, solid ceilings in the offices function as a separate, thermally activated storage mass.

On the whole, the design stands out due to its longevity and sustainability, as it offers numerous options for adaptations to future changes.

COMMUNICATION SPACE FOR THE PRODUCTION OF THE FUTURE

INNER COURTYARD OFFERS ROOM FOR DIALOG

Fraunhofer Institute for Machine Tools and Forming Technology IWU

2

Architects | Beeg Geiselbrecht Lemke Architekten GmbH, Munich (1st and 2nd construction stages); Beeg Lemke Architekten GmbH, Munich (3rd construction stage)

Years of construction |
2001 - 2005 (1st construction stage);
2010 - 2011 (2nd construction stage);
2019 - 2021 (3rd construction stage)

Move-in dates |
December 2005 (1st construction stage);
September 2011 (2nd construction stage);
June 2021 (3rd construction stage)

Funded by | BMBF, Free State of Saxony (1st and 3rd construction stages); BMBF, Free State of Saxony, European Fund for Regional Development (EFRD) (2nd construction stage)

Profile of the institute | Headquartered in Chemnitz, Fraunhofer IWU is a driver for research and development innovations in production engineering. The institute focuses on components and processes, technologies and methods, and complex machine systems – the entire factory. As the leading institute for resource-efficient manufacturing in the Fraunhofer-Gesellschaft, its main focus lies on the development of efficient technologies and intelligent production plants for manufacturing chassis and powertrain components as well as optimization of the associated forming and cutting processes. At its Dresden site, Fraunhofer IWU develops solutions in the areas of adaptronics and acoustics, additive manufacturing, mechanical joining technologies and medical engineering.

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SOLUTIONS WITH LIGHT

EXTENSION BUILDING WITH INTELLIGENT FACADE

Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Architecture and utilization plan | In 2012, the Fraunhofer IOF institute building on the Beutenberg Campus in Jena was extended by a V-shaped annex. The design of the floor plan and the bent, blue glazed facade reflect a high degree of dynamics and variability, which symbolizes the institute's research work in the field of optics and photonics. With the extension, the institute's floor space has grown by 2,000 m², meaning that its employees now have more than 7,000 m² of office and laboratory space. In the new laboratories, the researchers are creating solutions with light for key future areas such as energy and the environment, information, and production. High-end optics for outer-space systems as well as fiber lasers for material processing are developed here.

Ecological features | In accordance with Fraunhofer IOF's research focus, innovative artificial lighting solutions have been included in the design. Energy-efficient LED lights in the building provide for optimal illumination. The consistent use of LED technology has kept the building's energy requirements to a low level.

In addition, intelligent sensors use automated movable elements to protect the facade from intense environmental impact, thus actively increasing the building's life span. The facade is partly illuminated, which emphasizes the institute's role as a leading light in its field.

1 *Institute building with extension at the Jena site.*

2 *Illuminated facade.*

SOLUTIONS WITH LIGHT

EXTENSION BUILDING WITH INTELLIGENT FACADE

Fraunhofer Institute for Applied Optics and Precision Engineering IOF

2

Architects | Kohl Fromme Architekten, Duisburg (extension building)

Years of construction | 2009 - 2012 (extension building)

Move-in date | October 2012 (extension building)

Funded by | BMBF, Free State of Thuringia, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer IOF conducts applied research in the area of photonics and develops optical systems for controlling light – from its generation and manipulation to its application.
The institute's focus is on micro- and nanotechnologies, fiber laser systems, quantum optics and optical technologies for human-machine interaction. It also develops optical solutions for the key future areas of information, energy, health and the environment. In this context, "Green Photonics" – the creation of sustainable solutions with light for the future – is of high importance. Mirror systems for satellite-based, optical instruments make an active contribution to environmental protection.

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1 *Institute building with large glass facade at the Kaiserslautern site.*

2 *Looking into the Innovation Lab.*

SPACE FOR DIGITAL INNOVATIONS
GREEN ATRIA WITH A SUSTAINABLE ENERGY MODEL

Fraunhofer Institute for Experimental Software Engineering IESE

Architecture and utilization plan | Fraunhofer IESE's appearance is characterized by the interplay of the office wing's perforated, light sand-lime brick facade and the large glass facades of the atria. The cubic staircases at the gable ends of the building provide additional emphasis. The four-story building consists of three wings connected by glazed inner courtyards with integrated "meeting blocks". All shared facilities, including the cafeteria, the seminar area and the auditorium, are joined by a two-story central block, which simultaneously constitutes the connecting element to the neighboring Fraunhofer ITWM. One of the most remarkable features is the Innovation Lab, which has unique, movable elements, such as write-on desks that turn into whiteboards, and an elaborate lighting system to help establish an exciting atmosphere of creativity.

Ecological features | In designing the institute building, the architects dedicated special attention to a sustainable energy model. Fresh air is blown into the building via underground ventilation ducts. Geothermal collectors allow for cooling by approximately 4 °C in the summertime, as well as appropriate heating in the wintertime. The buildings are heated by cogeneration (CHP) units that form an energy network together with absorption chillers. During the heating season, the overflowing indoor air from the adjacent office wings is used for heating the atria. The waste heat from the computer rooms is also used for this purpose. The roof surfaces of the institute building have been extensively greened and used as a space for photovoltaic systems.

SPACE FOR DIGITAL INNOVATIONS

GREEN ATRIA WITH A SUSTAINABLE ENERGY MODEL

Fraunhofer Institute for Experimental Software Engineering IESE

2

Architects | Ermel Horinek Weber ASPLAN Architekten BDA, Kaiserslautern

Years of construction | 2003 - 2005

Move-in date | December 2005

Funded by | BMBF, State of Rhineland-Palatine, European Regional Development Fund (ERDF)

Awards | "Lernorte, die begeistern", awarded for the Innovation Lab by Fraunhofer Academy, 2020

Profile of the institute | Fraunhofer IESE has been one of the leading research institutes in the area of software and systems engineering as well as innovation engineering for over 25 years. The institute develops innovative solutions for the design of dependable digital ecosystems, thus accelerating the economic and social benefits for its customers. Fraunhofer IESE provides support in mastering challenges in the areas of "Automotive & Mobility", "Production", "Digital Business", "Smart City & Smart Region", "Smart Farming" and "Digital Healthcare". In over 2,000 customer projects, cutting-edge research has been transferred into sustainable business practices and innovative products. Currently, the institute is focusing on the topics of "Digital Ecosystems", "Digital Twin/Virtual Engineering", "Dependable AI" and "System Modernization".

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STRIKING HOME FOR SMART SYSTEMS

BUILDING COMPLEX WITH A HIGH-TECH APPEAL FOR DEVELOPMENTS IN NANOTECHNOLOGIES

Fraunhofer Institute for Electronic Nano Systems ENAS

Architecture and utilization plan | At nighttime, the Fraunhofer ENAS main building with its highly visible LED lines seems like a lighthouse in the Chemnitz Smart Systems Campus. Inside the four-story building, offices and laboratories are arranged around a central accessible atrium. Together with three loggias, this atrium adds natural daylight and creates a pleasant work atmosphere. The multilayered facade with its metal screen symbolizes the high-tech nature of nanotechnologies, referring to the institute's core research competence.

The extension building was opened in 2018, creating additional office space. The design elements were chosen so as to refer to the main building and ensure that the two buildings were recognizably architecturally related.

Ecological features | Energy consumption in the main building has been kept at very low levels by means of a combination of an air-to-ground heat exchanger, a well system that uses groundwater for temperature control, emergency cooling, cooling water and the ultra-pure water system, and a highly efficient chiller.

Both buildings have highly effective technical equipment and deconstructible, recyclable facades. Owing to these technical features, both structures fall well below the requirements of the Energy Conservation Ordinance (EnEV) – a German regulation that stipulates the minimum requirements regarding energy consumption in new and renovated buildings.

1 *Main building and extension building on the Chemnitz Smart Systems Campus.*

2 *LED facade lighting inspired by conductive paths.*

STRIKING HOME FOR SMART SYSTEMS

BUILDING COMPLEX WITH A HIGH-TECH APPEAL FOR DEVELOPMENTS IN NANOTECHNOLOGIES

Fraunhofer Institute for Electronic Nano Systems ENAS

2

Architects | Nickl & Partner, Munich (main building); DEWAN FRIEDENBERGER ARCHITEKTEN GmbH, Munich (extension building)

Years of construction | 2006 - 2009 (main building); 2016 - 2018 (extension building)

Move-in date | June 2009 main building; November 2018 extension building

Funded by | BMBF, Free State of Saxony, European Regional Development Fund (ERDF) (main building); BMBF, Free State of Saxony (extension building)

Profile of the institute | Fraunhofer ENAS is an expert development partner in the field of smart systems and the integration of those systems into various applications. Its focus is on the challenge of combining microsensors, nanosensors, actuator systems and electronic components with communication interfaces and a self-sustaining energy supply to form smart systems. With its work, the institute supports the internet of things and increasing digitalization. For its clients' benefit, and in cooperation with them, Fraunhofer ENAS develops individual components and the technologies needed to produce them, as well as system concepts and systems integration technologies. It also actively promotes technology transfer.

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LANDMARK FOR EXCELLENT RESEARCH IN CERAMIC TECHNOLOGIES

UNITING DESIGN AND RESEARCH TOPICS IN A BUILDING FACADE THAT CREATES A SENSE OF IDENTITY

Fraunhofer Institute for Ceramic Technologies and Systems IKTS

Architecture and utilization plan | The integration of the "Hermsdorf Institute for Technical Ceramics" into the Fraunhofer-Gesellschaft in 2010 kicked off dynamic developments at the Thuringia location. These developments are reflected in "Technikum III", a two-story building which was opened in May 2014. Its parallelogram shape is the distinguishing feature of both its exterior appearance and the inner arrangement of its rooms. In roughly 2,800 m² of floor space, the Technikum contains two-story laboratories and test stands, workshops, offices, conference rooms and a cleanroom. The structure connects the existing buildings and represents the institute's activities through its unique outer appearance. The white, shiny ceramic facade acts as a connecting element that alludes to the research topics that Fraunhofer IKTS explores.

Ecological features | In a nod to the research on oxide ceramic and optoceramic materials and systems conducted at the site, delicate horizontal belts of light, fine-pored ceramics were used for the facade, thus creating a sense of identity. The material's extremely high levels of durability and longevity have a positive impact on the building's primary energy consumption.

In the interests of achieving a climate-friendly, socially responsible form of construction that enables economic efficiency and maximum flexibility while keeping operating costs to a minimum, the institute building was created with the option of adding up to two identical modules.

1 *New "Technikum III" at the Hermsdorf site.*

2 *Ceramic facade combines design with research topics.*

LANDMARK FOR EXCELLENT RESEARCH IN CERAMIC TECHNOLOGIES

UNITING DESIGN AND RESEARCH TOPICS IN A BUILDING FACADE THAT CREATES A SENSE OF IDENTITY

Fraunhofer Institute for Ceramic Technologies and Systems IKTS

2

Architects | Gewers Pudewill, Berlin

Years of construction | 2012 - 2013

Move-in date | December 2013

Funded by | BMBF, Free State of Thuringia, European Regional Development Fund (ERDF)

Awards | Thüringer Staatspreis für Architektur und Städtebau, 2014; Winner ICONIC Awards, 2015; Special Mention German Design Award, 2017

Profile of the institute | Fraunhofer IKTS conducts applied research on high-performance ceramics. As a research and technology service provider, the institute develops advanced high-performance ceramic materials, industrial manufacturing processes, and prototype components and systems, using complete production lines that extend right up to the pilot-plant scale.

At their Hermsdorf site, Fraunhofer IKTS focuses on four strategic research fields: membrane development, oxide ceramics, functional ceramics for sensor and actuator applications, and battery development for stationary and mobile storage systems.

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1 *Entrance area of Fraunhofer IWM at the Freiburg site.*

2 *View of the new building's green inner courtyard.*

INTELLIGENT NETWORKS

NEW ANNEX JOINING DIVERSE EXISTING STRUCTURES INTO A UNITED WHOLE

Fraunhofer Institute for Mechanics of Materials IWM

Architecture and utilization plan | The theme of the Fraunhofer IWM annex is "networking". The architectural feat that has been accomplished here involved adding two wings in order to connect existing buildings with different designs into a united whole – both visually and in terms of engineering. The spacious reception hall, which allows a smooth transition to the exhibition and event areas as well as the cafeteria, creates a fully accessible entrance at the bend in the street. Its understated materials, surfaces and colors bring the core values of the institute into focus: research on mechanics for materials. The expansion also brought the addition of a laboratory for testing large-scale samples, more room for the workshop and quick crash tests, better delivery options and more offices. The interior connection creates a network of existing and new buildings.

Ecological features | In the course of the extension process, Fraunhofer IWM opted for a completely fossil-fuel-free heating system, using only waste heat from the cooling of experimental setups, the machines in the workshop and the air conditioning. The idea of using materials and resources sustainably – one of the core motivations for the research work carried out at the institute – is reflected in the sparing use of materials within the new wings of the building.

The biodiverse greenery outside provides break areas for the staff within close proximity of their workspaces, while additionally enabling complete drainage of the property.

INTELLIGENT NETWORKS

NEW ANNEX JOINING DIVERSE EXISTING STRUCTURES INTO A UNITED WHOLE

Fraunhofer Institute for Mechanics of Materials IWM

2

Architects | Auer Weber and Associates, Stuttgart, Munich (sub-architect: Architektengruppe F70, Freiburg)

Years of construction | 2017 - 2021

Move-in date | June 2021

Funded by | BMBF, State of Baden-Württemberg

Profile of the institute | Fraunhofer IWM characterizes and assesses properties of materials, components and production processes with the aim of making them smarter, safer and more sustainable. As a "one-stop shop" for application-oriented experiments and multiscale computer simulations, the institute develops solutions in the fields of component safety and lightweight construction, tribology and optimization of manufacturing processes, and assessment of materials and concepts for increased longevity. The digitalization of materials engineering, materials in contact with hydrogen, and quantum technologies are strategic topics for the future at Fraunhofer IWM. It has excellent contacts for its applied research work, as it is a member of various large project consortia with industry partners, research organizations and universities.

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Director |
Prof. Dr. Peter Gumbsch

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1 *New Technical Center III at the Würzburg site.*

2 *View into the foyer.*

AESTHETICS AND RESEARCH HAND IN HAND

TECHNICAL CENTER WITH UNIQUE SIGNATURE

Fraunhofer Institute for Silicate Research ISC

Architecture and utilization plan | With this new building, the Fraunhofer ISC campus is gaining an additional floor space of 2,500 m², which include features such as laboratories and technical areas. Starting from a compact building block at the east end of the grounds, the structure develops westwards with an open, five-story layout. West of the building's curved section, the first and second upper floors are cantilevered in order to accommodate rooms with more depth. A steel structure bridge connects the technical center with the existing buildings, enabling barrier-free access to all parts of the building. With its irregular triangle-shaped grounds, the structure anticipates the bent course of the road, creating a spacious forecourt in front of the new main entrance of Fraunhofer ISC.

Ecological features | The facade is broken up by protruding cantilevers that provide sun and weather protection for the interior and exterior spaces below, as well as for the entrance area. Flexible photovoltaic modules have been integrated in the curved glass – the energy produced here supports the operation of the charging infrastructure for electric cars in front of the building. Solar panels on the roof generate thermal energy that is used to operate absorption chillers for air conditioning in the offices and laboratories. The tube collectors are equipped with anti-reflective coatings that were partly developed by the institute itself. These coatings allow for an increased annual output of up to 8 percent. The structure was one of Germany's first large research buildings to be awarded the preliminary bronze certificate of the German Sustainable Building Council (DGNB).

AESTHETICS AND RESEARCH HAND IN HAND

TECHNICAL CENTER WITH UNIQUE SIGNATURE

Fraunhofer Institute for Silicate Research ISC

2

Architects | ZAHA HADID ARCHITECTS Ltd., London, Hamburg

Years of construction | 2010 - 2013

Move-in date | September 2013

Funded by | BMBF, Free State of Bavaria, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer ISC conducts research and development on innovative materials and technologies for sustainable products. The institute focuses on energy and battery technologies, climate and the environment, biomedicine, bioeconomy and digitalization.

With its various locations and centers, Fraunhofer ISC combines first-rate expertise in materials science with long-standing experience in materials processing, industrial application and the upscaling of production and process technologies to pilot scale, as well as in materials analysis and characterization.

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1 *New building at the Darmstadt site with facade made of brass bond sheets.*

2 *View into the test laboratory.*

THE COMMUNICATIVE CHAMELEON

TRANSFER CENTER FOR SMART STRUCTURES

Fraunhofer Institute for Structural Durability and System Reliability LBF

Architecture and utilization plan | The architects reduced the complex field of smart structures to two core topics: "action" and "reaction". To reflect this, the unique brass facade appears to change color as the light conditions vary – the building "reacts" to its environment.
The surface is perforated by an irregular pattern of square-shaped openings, giving the simple structure a filigree texture and spatial depth. The interior design focuses on the topics of optimal communication and knowledge exchange. Thanks to its open spatial structure and glass walls, and the smooth transitions between the test hall, the office spaces and the presentation area, the interior gives the impression of operating at one functional level. The building's center is a communication area with flexible furniture, which facilitates informal meetings during breaks.

Ecological features | A combination of smooth plaster surfaces, bamboo flooring and the use of white as the dominant color of the building's interior creates additional lightness and supports the sustainable, energy-efficient equipment. Both the heating and cooling of the rooms is regulated by a concrete core activation system. Waste heat from the main building serves as an additional energy source.

THE COMMUNICATIVE CHAMELEON

TRANSFER CENTER FOR SMART STRUCTURES

Fraunhofer Institute for Structural Durability and System Reliability LBF

2

Architects | JSWD Architekten, Cologne

Years of construction | 2008 - 2010

Move-in date | November 2010

Funded by | BMBF, State of Hessen

Awards | TECU Architecture Award, 2010 (2nd prize)

Profile of the institute | Fraunhofer LBF in Darmstadt has been known for its work on the safety and reliability of lightweight structures for more than 80 years. The industry-oriented research institute specializes in data, processes and relevant interactions at the material, component and system levels. It employs a staff of roughly 400 experts to work on the development and consistent improvement of virtual, real and cyberphysical methods. They create solutions for the most important broadscale issues of the future, such as sustainability, digitalization and future mobility. Their clients come from sectors such as automotive and commercial vehicle manufacturing, aviation, machine and plant construction, electrical engineering, medical engineering and the chemical industry.

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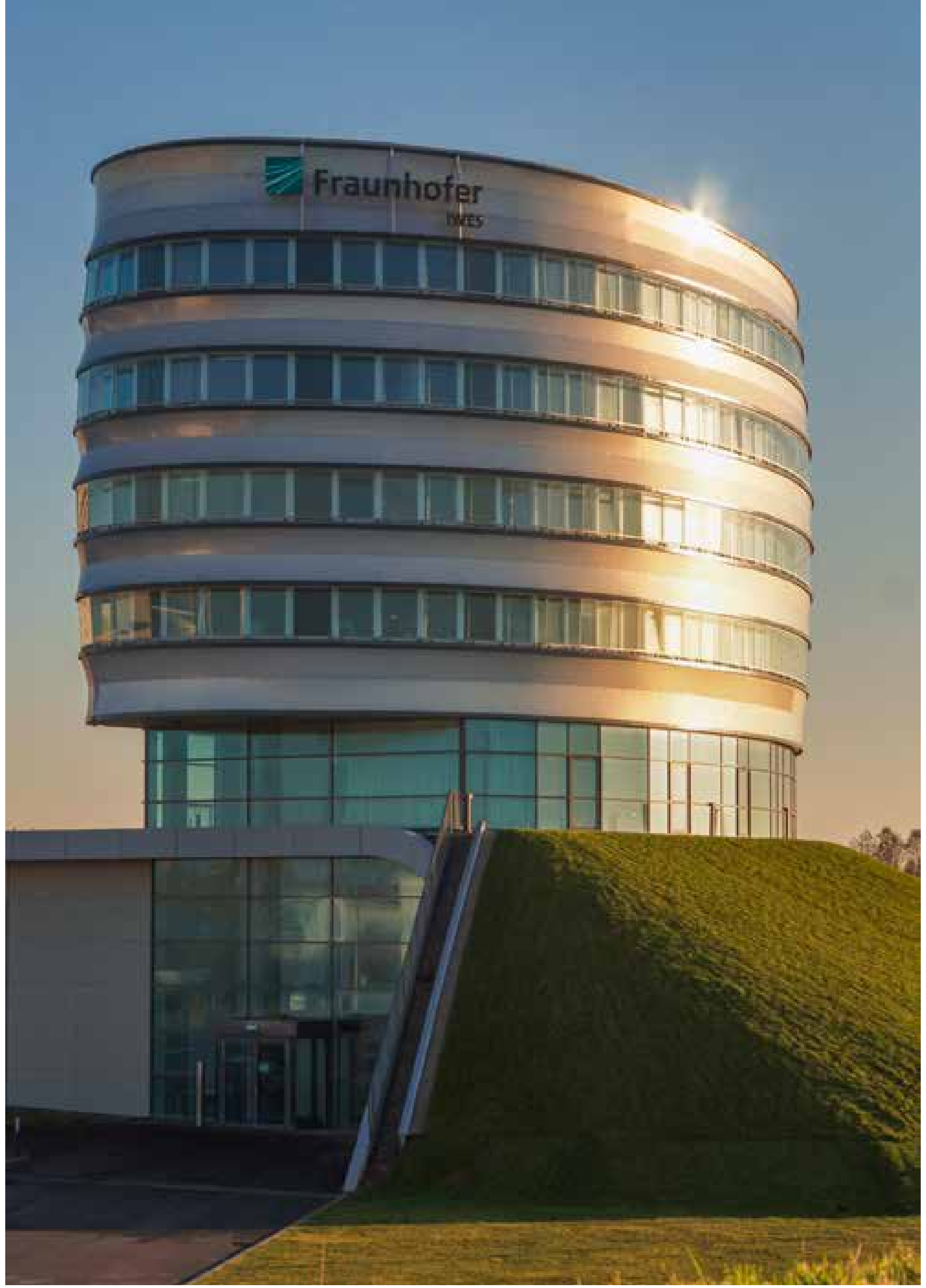

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1 *Engineering building in Bremerhaven, built on a terp.*

2 *View of the building ensemble from the sea dike.*

PERFECT SYMBIOSIS BETWEEN LANDSCAPE AND RESEARCH TOPICS

ENGINEERING BUILDING BEHIND THE WESER DIKE

Fraunhofer Institute for Wind Energy Systems IWES

Architecture and utilization plan | This freestanding structure is the first great landmark visitors see as they approach Fraunhofer IWES along the Weser dike. It marks a starting point for the infrastructure that unfolds behind, i.e., testing halls and other ancillary buildings. The building's curved shape was derived from the idea of basing the plan of the office floors on a cross-section of a wind turbine rotor blade. The building rests on a terp, which has been formed as a counterpart to the dike opposite. The technical center has been skillfully integrated into the plinth within the terp, with the office building sitting on top. At the same level as the top of the dike, the building has a floor with a fully glazed facade. The seminar rooms located here benefit from the unique panoramic view.

Ecological features | The choice of material further emphasizes the modeling of the curved facade. The glass elements mounted in front of the window bands alternate with panels of ethylene-tetrafluoroethylene foil (ETFE).

In planning the building technology, the architects put special emphasis on sustainability and the use of renewable energies. The building has a concrete core activation system for heating in the wintertime and cooling in the summertime. As it has a heat pump for heat generation, the building can be heated using 100 percent green electricity. In addition, heat is recovered from the hydraulic system of the testing equipment.

PERFECT SYMBIOSIS BETWEEN LANDSCAPE AND RESEARCH TOPICS

ENGINEERING BUILDING BEHIND THE WESER DIKE

Fraunhofer Institute for Wind Energy Systems IWES

2

Architects | wörner und partner planungsgesellschaft mbh, Dresden

Years of construction | 2009 - 2012

Move-in date | May 2012

Funded by | BMBF, Free Hanseatic City of Bremen, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer IWES focuses on research in the field of wind energy, combining its employees' competencies with an extensive testing infrastructure – the only one of its kind worldwide. As such, it accelerates the certification and market introduction of innovative products and increases their quality level. The institute's comprehensive rotor blade development process is an excellent example of its work in this field. The process covers and validates all relevant development steps from the specification of the wind field and quality assurance for materials and components to the testing of complete rotor blades.

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Dr. Sylvia Schattauer (Acting Managing Director)

A WORKSHOP FOR DIGITAL MEDICINE

NEW HOME FOR THE DIGITAL TRANSFORMATION IN HEALTHCARE

Fraunhofer Institute for Digital Medicine MEVIS

1

1 *Institute building in the Technology Park of the University of Bremen.*

2 *The building in profile.*

Architecture and utilization plan | The new institute building, with its rounded geometry and curved white facade, consists of three interlocking structures in a form inspired by the shape of nerve cells. The building has a floor space of roughly 2,600 m² and can accommodate up to 210 workspaces across four floors. The design for the interior space includes offices, seminar rooms, conference rooms, technical areas and laboratories. It offers both retreat options for concentrated work and open spaces for communication and cooperation. As a workshop for digital medicine, the building is intended to be perceived as a driver of the digital transformation in healthcare, providing room for meetings and dialog around the topic of digital medicine.

Ecological features | During the building design phase, the main focus was on implementing a sustainable energy model, using both district heating and heat recovery. The location on campus within the Technology Park of the University of Bremen allows for close proximity to other facilities and easy access by bike and public transportation. In addition, the center is well-connected to the national autobahn network, as well as the long-distance and local rail networks. Three charging stations with six charging points (five AC and one DC) are available to support e-mobility. The roof is prepared for the installation of photovoltaic modules.

A WORKSHOP FOR DIGITAL MEDICINE

NEW HOME FOR THE DIGITAL TRANSFORMATION IN HEALTHCARE

Fraunhofer Institute for Digital Medicine MEVIS

2

Architects | Haslob Kruse + Partner, Architekten BDA, Bremen

Years of construction | 2018 - 2021

Move-in date | May 2021

Funded by | BMBF, Free Hanseatic City of Bremen, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer MEVIS develops software and IT solutions for the digital medicine of the future. In cooperation with clinical, academic and industrial partners, the institute aims to make the growing complexity of medicine manageable. The institute's focus is always on the human being, as it strives to detect diseases earlier and more reliably, tailor treatments to each individual, make therapeutic success more measurable, and reduce side effects. To achieve this goal, it applies state-of-the-art methods such as artificial intelligence, biophysical modeling and simulation, cloud computing and MRI sequence development. The standards of responsible research and innovation as well as lifelong transdisciplinary learning are reflected in all scientific areas.

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1 *New institute building with connection to the existing building.*

2 *View into the entrance hall.*

THE ICEBERG

NEW BUILDING COMPLEMENTING EXISTING INFRASTRUCTURE

Fraunhofer Institute for Secure Information Technology SIT

Architecture and utilization plan | The increase in staff at Fraunhofer SIT in Darmstadt called for a new building that would form an extension to the existing institute infrastructure. Now, a single-story plinth building serves as a connecting element, entrance hall and storefront, while a five-story building with research and administration areas sits on top of it.

The prominent, curtain-like facade consists of a supporting structure and a building shell with panels of different lengths, heights and depths. These elements have been mounted with different spacing in between, resulting in a shadow play that creates associations with the pattern of an authentication (QR) code. In this way, Fraunhofer SIT's activities are reflected in the architectural design.

Ecological features | The energy consumption of the compact triple-glazing structure lies 20 percent below the values mandated by the EnEV regulations. The primary aim with the design was to achieve a high flexibility of use and to include short ducts for supplying technical equipment. The engineering floor was therefore placed between the plinth building and the office wing. The laboratories with their multitude of HVAC systems are located right underneath. The media supply for the office wing is based on centralized ducts and floor-by-floor subdistribution in the middle of the floor plan. To ensure that other possible uses are not excluded, the office stories have double floors for installations. The accessible roof terrace and a highly biodiverse inner courtyard provide communication and relaxation spaces for the employees.

THE ICEBERG

NEW BUILDING COMPLEMENTING EXISTING INFRASTRUCTURE

Fraunhofer Institute for Secure Information Technology SIT

2

Architects | Sehw Architektur, Berlin

Years of construction | 2012 - 2014

Move-in date | September 2014

Funded by | BMBF, State of Hessen

Awards | German Design Award, 2019

Profile of the institute | Fraunhofer SIT is one of the world's leading research institutions for cybersecurity and privacy protection. The institute deals with the most pressing security challenges in industry, administration and society as well as with ongoing cybersecurity and data protection issues. Fraunhofer SIT regularly publishes their results at leading scientific conferences and supports their partners in the design of new IT systems, the protection of IT infrastructures and the development of new ideas and prototypes for products and services. Although its headquarters are located in Darmstadt, the institute maintains an additional branch in St. Augustin near Bonn and offices in Berlin. It is also represented at an international level through outposts in Israel and the USA.

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Director |
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The beginnings

Modern institute construction

Making intelligent use of existing structures

ARCHITECTURE BY FRAUNHOFER

NEW LIFE FOR OLD BRICKS – MAKING INTELLIGENT USE OF EXISTING STRUCTURES

Creating a high-quality environment for research in existing buildings is a special challenge. Reasons that make this practice necessary include dense urban spaces, a lack of vacant lots, the desire for proximity to existing facilities, economic constraints, or simply the wish to assign a new purpose to previously existing buildings – perhaps due to preservation considerations.

Fixed building axes, low story heights, limited ceiling loads and a lack of distance to neighboring structures are a great challenge to the integral creativity of the architects and engineers in the planning teams. The same high standards that guarantee the safety of employees, visitors and neighbors when it comes to new structures also need to be applied when making modifications to existing buildings. Therefore, much effort is required to persuade fire departments and the authorities for occupational health, safety and hygiene to make even small concessions.

The reward for this effort is often an individual, very stimulating environment that sets itself apart from many bland workspaces in a pleasant way. But it is also surprising to see how older buildings can facilitate many different usage scenarios if they were well thought-out to begin with, and if they are approached with intelligence, curiosity and extensive engineering expertise. Although only a minority of “historical highlights” among the Fraunhofer buildings are put to new uses, there are still a number of successful examples that prove the compatibility of modern, cutting-edge research with structures listed as landmarks.

If the climate goals of the German Federal Government are to be tackled resolutely, this topic will become increasingly important in the future. In addition to ambitious, energy-focused renovation projects, the growing use of renewable energies and corresponding mixed energy provision strategies, the number of buildings that need to be used for longer periods or put to new uses will increase. When making comparisons regarding the question of whether to modernize old buildings or to build new structures, we will more frequently give preference to the former solution because of its potentially smaller CO_2-eq footprint.

With our knowledge of the quality of existing buildings when used intelligently, we will be able to face this challenge, too!

CAMPUS RESET

RESOURCE-EFFICIENT ENERGY TECHNOLOGIES

Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP

1

1 *View of the nanotechnology center at the Dresden site.*

2 *Work areas in building N.*

Architecture and utilization plan | The Nanotechnology Center is part of Campus RESET. Before its renovation, the building was used as a vehicle hall. It consisted of a head building and a single-bay hall that was divided into three segments by internal walls. In order to enable the building to be used as a technical center for research, the floor had to be lowered by roughly 1.20 meters and renovated to integrate installation ducts for the required imposed load of 20 kN/m². The vacuum pumps are located in a hall-like extension building, equipped with a separate crane rail system and gates at the side. The head building was extended by an intermediate floor and a top floor to accommodate the necessary auxiliary functional areas and the building automation and control systems. In 2021, a photovoltaic plant (42 kW) was installed on the roof.

Specific location features | Campus RESET houses the Fraunhofer institutes FEP, IKTS, IWS and IFAM across a surface area of roughly 1.8 ha. The space lies approximately 2.50 meters below street level and thus near the groundwater level. The use of renewable energy sources is guaranteed by ground heat exchangers for cooling (120 kW).

The lower floors accommodate various Fraunhofer institutes and their central logistics facilities, infrastructures, building automation and control systems, and large equipment (vacuum technologies). Through their flexibility, they allow for optimal use and operation.

The fragmented development of the site corresponds with the local conditions.

CAMPUS RESET

RESOURCE-EFFICIENT ENERGY TECHNOLOGIES

Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP

2

Architects | JSP ARCHITEKTEN Gesellschaft für Bauplanung mbH Dresden

Years of construction | 2009 - 2011 (nanotechnology center); 2010 - 2021 (Campus RESET)

Move-in date | June 2011 (nanotechnology center)

Funded by | BMBF, Free State of Saxony, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer FEP focuses on developing innovative technologies and processes for surface modification and organic electronics.

The institute's core competencies in electron beam and roll-to-roll technologies, plasma-activated large-area and precision coating, technologies for organic electronics, IC design and the development of technological key components present a broad range of research, development and pilot manufacturing opportunities – especially for the treatment, structuring and finishing of surfaces and for OLED microdisplays, organic and inorganic sensors, optical filters and flexible OLED lighting.

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1 *View of the office and laboratory building in Dresden, built in 1984.*

2 *Renovated interior of the institute building.*

FIT FOR TODAY'S CHALLENGES

GOOD AS NEW: MORE SPACE FOR MICROSYSTEMS DEVELOPMENT

Fraunhofer Institute for Photonic Microsystems IPMS

Architecture and utilization plan | Built in 1984 as an office and laboratory building, the institute was superficially renovated in 1993 and later underwent complete modernization from 2015 to 2017. Built via lift slab construction methods, it has a precast concrete skeleton and loadbearing reinforced concrete walls. The building received an upgrade when the fourth floor was redesigned and the structure was adjusted to suit the requirements of a modern institute. Offices, conference rooms and laboratories for physical measurements are located here. A spiral staircase connecting all floors livens up the interior and creates space for communication. The new cleanroom building has its own identity, but it has also been integrated into the overall color scheme. The multilayer construction offers a column-free cleanroom space of 1,500 m².

Specific location features | Since 1992, the location has played an important role in Fraunhofer's microelectronics activities in Dresden. The majority of the city's semiconductor industry sites are located nearby, offering excellent opportunities for cooperation.

Ecological features | By installing modern windows in combination with a thermal insulation composite system and automated outdoor blinds, the renovators reduced the office building's energy consumption considerably. Using heat recovery also resulted in high energy savings in the cleanroom building. To compensate for sealed surfaces, a rainwater seepage system was installed.

FIT FOR TODAY'S CHALLENGES

GOOD AS NEW: MORE SPACE FOR MICROSYSTEMS DEVELOPMENT

Fraunhofer Institute for Photonic Microsystems IPMS

2

Architects | Kilian Architekten, Dresden; Architektengemeinschaft Fehr, Berlin (office building); CRC Clean Room Consulting GmbH, Weßling (cleanroom building)

Years of construction | 2005 - 2007 (reconstruction of the office building and construction of the new cleanroom building)

Move-in date | January 2007 (office building and cleanroom building)

Last major renovation | 2015 - 2017

Funded by | BMBF, Free State of Saxony

Profile of the institute | Fraunhofer IPMS is a worldwide leader in R&D services for electronic and photonic microsystems in the fields of smart industrial solutions, medical and health applications, and improved quality of life. Its technology serves as a basis for innovative products on all large markets – such as ICT, consumer products, automobile technology, semiconductor technology, and measurement and medical technology. The institute works on developing electronic, mechanical and optical components and integrating them into miniaturized modules and systems. Its services range from design and product development right up to sample and pilot production within Fraunhofer IPMS' own labs and cleanrooms, for everything from components to complete system solutions.

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1 *The IZM institute building at the Berlin site.*

2 *View into the showroom.*

MICROELECTRONICS RESEARCH IN A LISTED BUILDING COMPLEX

THE TRADITIONAL HUMBOLDTHAIN SITE

Fraunhofer Institute for Reliability and Microintegration IZM

Architecture and utilization plan | The parties involved in the modernization project were faced with the task of adjusting the premises, originally tailored to the needs of heavy machine construction, to the complex requirements of a high-tech microelectronics research institute. In the process, it was necessary to comply with the regulations for the protection of historical monuments. Over the course of 30 years, various areas for laboratories, cleanrooms, offices and functional purposes have been set up within the complex. They include a cleanroom with a size of 850 m², a multifunctional seminar area with an adjacent showroom and a reception area with an integrated goods receiving department. For the “Start a Factory” project, one of the halls was equipped with six overseas containers and a production line for manufacturing prototypes.

Specific location features | Fraunhofer IZM was founded at the initiative of TU Berlin in 1993. In order to guarantee close cooperation with the university’s Research Center for Microperipheric Technologies, it was decided to establish the institute in close proximity to TU Berlin on the historic premises of the Humboldthain Technology Park. The building complex now accommodating Fraunhofer IZM was built for AEG under the auspices of Prof. Peter Behrens around 1910 and is listed as a historical monument. The spacious steel skeleton frame constructions have a clinker brick facade and can still be used today, thanks to their far-sighted planning and sound design. In addition to several research institutes and companies, the site also accommodates the BIG, Germany’s first start-up center.

MICROELECTRONICS RESEARCH IN A LISTED BUILDING COMPLEX

THE TRADITIONAL HUMBOLDTHAIN SITE

Fraunhofer Institute for Reliability and Microintegration IZM

2

Architects | Architektengemeinschaft Fehr, Berlin

Years of construction | 1994 - 1995 (upgrading for use as an institute)

Move-in date | December 1995

Last major renovation | 2015 (reception area)

Funded by | BMBF, State of Berlin, European Regional Development Fund (ERDF)

Profile of the institute | Fraunhofer IZM specializes in applied and industrial contract research with a focus on the integration of multifunctional electronics into systems. Its four technology clusters cover the entire spectrum of activities for developing technologically optimized, reliable electronics and transferring them into practical application.

The institute's customers are as varied as the applications for electronics. Fraunhofer IZM addresses branches such as automotive industries, communication technologies, medical engineering, industrial electronics and even textile engineering.

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“Despite a conspicuous, paradigm-related neo-modernist mainstream within the Fraunhofer building stock, the Fraunhofer-Gesellschaft’s building portfolio is extraordinarily varied.”

Prof. Dr. Michael Heinrich

RESEARCH BUILDINGS AND HOW THEY ARE PERCEIVED

CONCLUSION

In essence, the result profiles of this metadisciplinary aesthetic investigation based on the correlation model of value, impact, architecture and design show an average degree of visual-aesthetic staging of values, not their actual presence in the corporate culture. Each individual value of an institution may play a strong role in the intentions for a building and the process of creating it, but this does not necessarily mean that it will be presented in a form the senses can perceive or in a form in which a value is semiotized through design. The value "stability", for example, is certainly realized flawlessly in terms of engineering in all the buildings examined above, but it is by no means an outstanding factor of visual-aesthetic communication in all instances. In any case, the average for all the value profiles from the individual property analyses shows a rather clear course, despite some scattering: among the eight values addressed, "excellence, success" and "innovation" are the most intense in terms of visual communication, while the values of "sustainability", "diversity" and "social integrativity" – which, like all other values, can also be accompanied by a variety of sensually perceptible cues – are assigned relatively little importance in aesthetic rhetoric. The values of "stability", "passion" and "togetherness, warmth" fall within the lower midfield.

Among the aesthetic impact modes that are frequently addressed, "contextuality" is particularly striking, but not so much as a strategy for placing the building in a landscape or urban context (as is evident, for example, in the IWES Bremen or the IIS research campus), but rather as a deliberate contextual break through form, color, material and – particularly frequently – through additional monolithic dimensionality. These context breaks form a strong distinguishing feature and make the corresponding buildings appear as assertive, dominant structures in their respective surroundings. The frequency of these context breaks thus not only correlates noticeably with the higher valuation of the categories "excellence, success" and "innovation", but also provides a good explanation for this higher value. Another aesthetic mode of action that is often used in accordance with modernist conventions is "abstraction". In the case of architecture, this means simplifying, generalizing or typifying traditional form differentiations, such as classical building forms, for example. It corresponds to the Gestalt principle of conciseness in that it makes it easier and quicker, i. e., more "fluid", to assign objects to schema categories during visual perception by offering a range of forms and bodies that have mostly been abstracted into a basic shape. Thus, in a less fluid environment, it attracts the greatest attention in the short term. However, the downside of such abstraction can be an overall loss of complexity, a gradient that is important for a setting's medium-term attractiveness. Various buildings show that the advantages of abstraction and those of complexity are compatible with each other. For example, the LBF Transfer Center compensates for the abstraction of its basic volume and contours with the complexity of a tense breakthrough pattern in its shell. This provides for tension between the different structural layers.

What are the conspicuous features within the Fraunhofer architectural portfolio in terms of the formal-aesthetic qualities of the design implementation? In particular, a number of older institute buildings as well as some new buildings follow a traditional paradigm of architectural rationalism, in that they use strongly repetitive grids and rhythms, i.e., with few variations, internal groupings or accents that rhythmize and facilitate visual reading. This form of design uses aesthetic means to serve the desire for structural control and the need for order and stability and corresponds to the rationalist-functionalist scientific paradigm of the era of growth, which is now coming to an end. However, it is very difficult for this form of design to semiotically connote dynamically oriented values such as innovation, creativity, passion, interconnectedness or warmth, since an articulation of dynamic progressions, condensations or accent formations – as they can be seen in many biomorphic form analogies and fractal, self-similar iterations – would be the most direct and process-oriented language for this.

Nevertheless, despite a conspicuous, paradigm-related neo-modernist mainstream within the Fraunhofer building stock, the Fraunhofer-Gesellschaft's building portfolio is extraordinarily varied. This is due to the fact that architectural firms, some local and some international, are encouraged to apply their own design signature to each individual institute building project, thus giving each building a distinctive character and representing a clear added value for the profile of the specific location and the creation of a communal identity. A future strategy for developing an architectural brand for the Fraunhofer-Gesellschaft's corporate building design could consist of two main elements: maintaining the cultivation of individual design signatures and ensuring that the processes of preparing and tendering for new building projects are consciously value-oriented and take both scientific and aesthetic factors into consideration. It would then be possible to adapt the aesthetic mean value profile of the building portfolio to changing social concepts and paradigms of progress in the long term by purposefully selecting competition designs according to previously outlined aesthetic criteria profiles.

Categories and examples

Four institute buildings serve to highlight relevant differences in the focus of the architectural impact profiles of the Fraunhofer institute buildings presented in this book. They stand out as aesthetically particularly intense and coherently profiled representatives of specific kinds of architectural categories that do not correspond to a conventional typological classification. Instead, they refer to fundamental interpretive bifurcations of the aesthetic perception of architecture. Inherently sustainable new variants with particular contextual and urban value could be created for all three categories by combining them with the renovation and conversion of existing buildings.

The Lübeck **Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE** stands for a classical design approach, which is defined by structural analogies to wall, pillar and architrave systems and the associated stability and materiality. The visibility of the stone and staged solidity of the base floor alludes to pre-Bauhaus building semantics, while the main zone also includes an analogy of a classical colossal order. This approach is a suitable method of giving focus to Fraunhofer's architectural image, provided that the aim is to communicate a rather conservative basic attitude within an understanding of science that is conscious of tradition and willing to integrate scientific advances in existing structures. Within this framework, various gradients – like traditional architectural formulas of dignity with corresponding analogies of form and material – can represent values such as excellence and success, and, by transferring them to modern contexts, build the bridge to innovation.

The **Fraunhofer Institute for Silicate Research ISC** in Würzburg is a consistent example of a process-related approach that uses legible deformation traces at building volumes of former stereometric purity to suggest the impact of forces on animate or inanimate matter of various consistencies. This approach is a common basis for both deconstructivist and many instances of parametric architecture.

The underlying attitude no longer conceives of architecture primarily as an orthogonal-rhythmic load-bearing structure, but interprets it – thanks to parametric design and planning techniques and excellent material processing technology – as a free-form sculpture that is equally expressive on all sides. Buildings that follow this paradigm generate strong attention in the media and in physical and social space, often forming solitary, original one-offs in their urban or landscape context.

Precisely for this reason, however, it is almost impossible to add attachments or extensions to these kinds of building; moreover, they are costly, require a lot of maintenance and are always in danger of neglecting important utilitarian functions of architecture, especially when they take into account the inherent laws of a dynamic, moving sculpture seriously and consistently. Since the building's dynamic of deformation is usually completely simulated, it is not easy to entirely dismiss accusations that it resembles stage scenery and lacks congruence between its inner functions and outer appearance.

However, the merits of this architecture in terms of general, empirically grounded aesthetic preferences lie in its often flowing, curvilinear lines, its soft contrast transitions and therefore also in its particularly sensitive reactivity to ambient light. In the portfolio of a major research association, accents of this kind are very effective in attracting media attention, but as a standard aesthetic formula they are, in our opinion, more difficult to functionalize and contextualize, and are also perhaps even more dependent on the zeitgeist than other approaches.

The Darmstadt **Transfer Center for Smart Structures of the Fraunhofer Institute for Structural Durability and System Reliability LBF** exemplifies a modernist design approach, which is characterized by the concealment of the load-bearing structure or skeletal building behind a separately suspended shell or curtain wall. This approach is often expanded to create an updated version of modernist, technophilic machine metaphors by means of high-tech exterior installations, such as filigree sun visor systems. However, since the innovative half-life of such installations is quite short when compared to their maintenance costs, and their aging behavior quickly neutralizes the main attraction of technical innovativeness and sophistication, the fact that they have been omitted at the LBF supports the sustainability and lasting attractiveness of the building. In our opinion, the manner in which focus is directed toward the Fraunhofer value profile in the Darmstadt Fraunhofer LBF Transfer Center for Smart Structures building represents an exemplary aesthetic profile in terms of sustainable future viability. Excellence and innovative capacity are aesthetically correlated with creativity and team culture and thus correspond to advanced ideas of technological and social progress. The LBF is therefore an extremely suitable best-practice example for future branding initiatives within the Fraunhofer institute building culture.

Let us therefore take a closer look at some of its qualities here. The cubic building corpus is horizontally oriented and, at three stories, it has a moderate height that blends unobtrusively into both the landscape and structural context. At the same time, the simplicity of the extremely minimal stereometric contour gives the building a strong sense of unity. However, this unity is significantly loosened in terms of both surface and depth at a second structural level –the zoning level in this case. The window band on the top floor serves as an analogy for a viewing or sighting zone with a "viewing direction" that runs perpendicularly to the facade surface and is emphasized and guided by rhythmically placed blinds or swords, thus taking up the communicative dynamic of the in-out direction of gaze. The verticality of this rhythm implies a sense of tense alertness that often characterizes vertical alignments, especially of openings. The upright rhythm of the window-door zone on the ground floor adopts this delicate axial structure and invites stepless entry into the building volume, i. e., a low-threshold, depth-emphasized transcendence of the building envelope. The horizontal orientations of the first and second structural levels (the overall contour and the zoning) are thus dialectically complemented by the third structural level (the vertical axis formation) in an exciting way while being simultaneously endowed with depth directions. A fourth, comparatively small-scale structural level adds a very playful, dynamic accent to this already very exciting, but also geometrically strict composition of alignment, rhythm and surfaces. Irregular swarm formations made up of square breakthroughs of different sizes create an appearance of an almost weightless shell with delicate openwork. The inherent dynamics of compression and loosening suggest temporal processes of gathering or swarming, in terms of aesthetic morphodynamics: In this conceptual framework, many kinds of differentiations of basic shapes are considered to be signs of movement and exposure to physical forces that tend to suggest interactivity and transformativity. Finally, at a fifth structural level, a shiny bronze materiality with cloudy patination suggestive of the irregularities found in nature covers all the positive surfaces of the shell and allows the entire structure to lively interact with the changing ambient light.

Of the various aesthetic impact modes, the refinement of the center's multilayered gestalt formation and its high analogy potential should be particularly emphasized here. Despite the high degree of abstraction of its formal language and despite the renunciation of curvilinear lines, the building appearance succeeds in claiming for itself the high attention potential of biomorphic features with the abovementioned characteristics. It also manages to realize a high degree of order with simultaneous high complexity and liveliness on many complementary structural layers of the shape formation. The golden sheen activates biologically anchored attention dynamics, while simultaneously serving as an analogy for intrinsic value. Openings and rhythms suggest communicative openness and subtly indicate the primacy of order, while the irregular swarm formation of the breakthroughs acts as a metaphor for HR team structures that are free to creatively adapt to their specific situation. These features allow the building to encode the idea of cooperation in the sciences in an unmistakable, tangible manner. In addition, the breaking of the orthogonal structure acts as a further means of attracting attention.

The Waischenfeld **research campus of the Erlangen-based Fraunhofer Institute for Integrated Circuits IIS** complements the three examples mentioned above in many ways, and we can perhaps best do justice to its character by describing it as a contextual approach. First of all, the building does not appear as an impressive solitary form with extensions, but as a group of pavilions that is primarily intended not to stand out in terms of design or dimension. Instead, the aim is for the complex to fit into the existing structure of partly rural, partly bourgeois lower gabled houses with a somewhat random-seeming orientation in terms of its scale and placement. This resolute contextualization with the vernacular architecture of the surroundings is continued in the beveling of the roof edges, in the wooden facade cladding, the sometimes erratic distribution of the windows outside of partially established axes and the adaptation of the complex to the landscape terrain and height profile. The square shape of the windows and their deliberately staged framing show a refusal to accept the modernist ideas of horizontal dynamics and frame-minimized surface abstraction, so that this structural layer also indicates a staged relationship to its surroundings. Through this consistent contextualization, the building communicates a new, contemporary understanding of science as a citizen-oriented, socially, spatially and energetically sustainable generator of progress that knows how to set aside competitive values such as dominance in favor of cooperative values.

At the same time, the appearance connotes warmth and togetherness, the integration of individual units and the use of diversity as creative potential. The varied contours, the sculptural recession and protrusion of building fronts, and the all-sided design – exploiting different height levels – activate perception, the exploration instinct and curiosity, thereby connoting creativity and establishing a sense of closeness, interest and bonding, which naturally transfers to the institution and its goals. The importance of innovation as a value is expressed in a tangible way despite the formal contextualizations, in that contextual factors are always varied in unusual ways.

The multifunctional entrance hall does not paraphrase the appearance of the exterior construction in the main interior spaces (such as the central reception and distribution halls and attached stairwells) as is the case in most other Fraunhofer institute buildings. Instead, it surprises the viewer with an asymmetrical meandering expanse of interior landscape illuminated by skylights and inspired by crystalline shapes. This area takes up all the remaining space between the pavilions, where it creates a completely independent, innovative spatial interpretation.

Nevertheless, the wooden construction of the ceiling structure functions as a contextual point of reference here, spelling out the crystalline overall shape of the space in smaller segments. Even though the rhetoric of the contextual approach may not be sufficiently eye-catching and solitary enough for a strongly competitive economic view – which is certainly an important target group for the Fraunhofer-Gesellschaft – it is still a very coherent and rare example of the aesthetic implementation of values like sustainability, social integrity and innovation in the sense of team spirit and experimental, playful creativity within the Fraunhofer building stock. It is forward-looking in its preference for human orientation as a guiding value for technology development.

Sequence of analysis stages and evaluation

In accordance with the evaluation criteria described above, 15 architecturally ambitious Fraunhofer institute buildings that were advanced at the time of their construction were subjected to a metadisciplinary aesthetic examination using the correlation model of value, impact, architecture and design. The aim of the investigation (and also the metric used for measuring the quality of an object) was to show the extent and distribution of the correspondences of ascertainable formal-aesthetic and semiotic qualities of design implementation towards value and needs profiles of the relevant target group, whereby the abovementioned, empirically grounded system of aesthetic impact modes was taken as a basis.

The value profile and the careful adaptation of general basic needs to suit the relevant target groups were taken from Fraunhofer's mission statement. Corresponding basic human needs (as defined by Antonovsky, Maslow, Murray, etc.) were assigned to these guiding values.

In addition to values that serve both individual and collective interests (stability; sustainability), this mission statement also includes values that tend to be pursued competitively (innovation as a race; excellence, success) as well as those that tend to be realized cooperatively (togetherness, warmth; social integrity; diversity; passion). The weighing of these subgroups will play a role in the evaluation of individual architectural profiles, because the degree to which the Fraunhofer-Gesellschaft communicates professional-technological distinction, self-assertion, social-collective connectivity and social responsibility by aesthetic means becomes visible in this relationship.

The phenomenal design qualities of the individual architecture structures were assessed gradually and qualitatively on the basis of a series of formal, functional and intentional criteria. These range from the handling of line, surface, volume, plasticity, composition, zoning, material, color and transitions to questions of complexity, rhythm, self-similarity, abstraction and directionality, and from the degree of contextualization, the type of affordances and the staging of static forms to semantic references such as analogies or symbols.

Aesthetic experience is a self-actualizing process of selective and atmospheric perception, affective-emotional meaning-making and cognitive apprehension. The interrogation of its modes of action formed the center of the analysis process [11]. The aim of this investigation was to elicit which of the visually perceived architectural design qualities of the respective institute building actually correspond to the communication intention – the Fraunhofer value profile – and to what extent they manage to do this.

The field of aesthetic impact modes is systematically represented by ten main aspects. They are interdependent, overlap in terms of meaning and can be broken down into approximately 80 granular sub-aspects for operational purposes. In their semantic blurring, they reflect both human language and the structures of human consciousness. The latter function as a network, using multiple perspectives to produce meaning and sense from the flood of sensory input. All of these aspects have been addressed in a wealth of empirical studies that usually describe context-specific aesthetic preferences regarding a certain aspect, although more general aesthetic preferences have also been covered in some cases. These general tendencies include factors such as the preference for a medium level of complexity in the structure of ordering layers in architecture, which corresponds to a medium level of perception activity; in such cases, a simple, concise contour, for example, can provide a striking figure-ground relationship as regards the context, leaving the expression of complexity to subordinate layers.

Other very stable aesthetic preferences apply to curved lines and rounded forms, axial and point symmetries, and complementary form adjustments and function affordances as well as self-similar, iteratively varied, quasi-fractal forms that we know from nature and mathematics and systems theory (branching, budding, rhythmic transformation).

Although the processes of assigning design qualities to aesthetic impact modes and relating these modes to the value profile were necessarily subject to a certain level of diversity, overlapping, blurring and especially subjectivity, it was the quantitative accumulation that ultimately led to a stable trend in the distribution of the assignments. Individual interpretations of the system could certainly lead to subjective distortions in individual assignments; however, the accumulation principle of the observations and assignments prevented an arbitrary, grossly simplified approach characterized by overly monocausal cause-effect relationships.

As such, it is interpretive convergences that are made visible by the brain-friendly network structure of such multidirectional linkages, rather than bare "facts".

However, it also became clear that an aesthetic evaluation of each individual appearance feature of an architectural structure can only be accomplished on the basis of these impact aspects if an aesthetic function or value determination is available as a reference. In this case, we used the abovementioned value profile together with the associated motivational, affective and emotional qualities (amazement, captivation, warmth, security, distanced awe, admiration, etc.) as well as the corresponding triggers and modulators for attention as an agent of orientation and selection.

One option for developing the correlation model of value, impact, architecture and design within the current context in order to create a targeted aesthetic criteria catalogue is a refinement and alignment correction of the value profile in the direction of primary and secondary emotions, the definition of possible target directions for analogies, the determination of values within a range of evolutionary psychological preferences and a nuanced differentiation of the existing terms and concepts.

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