

ORNILUX

BY ARNOLD GLAS



 **SYNAPSE**
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A BIOMIMICRY CASE STUDY

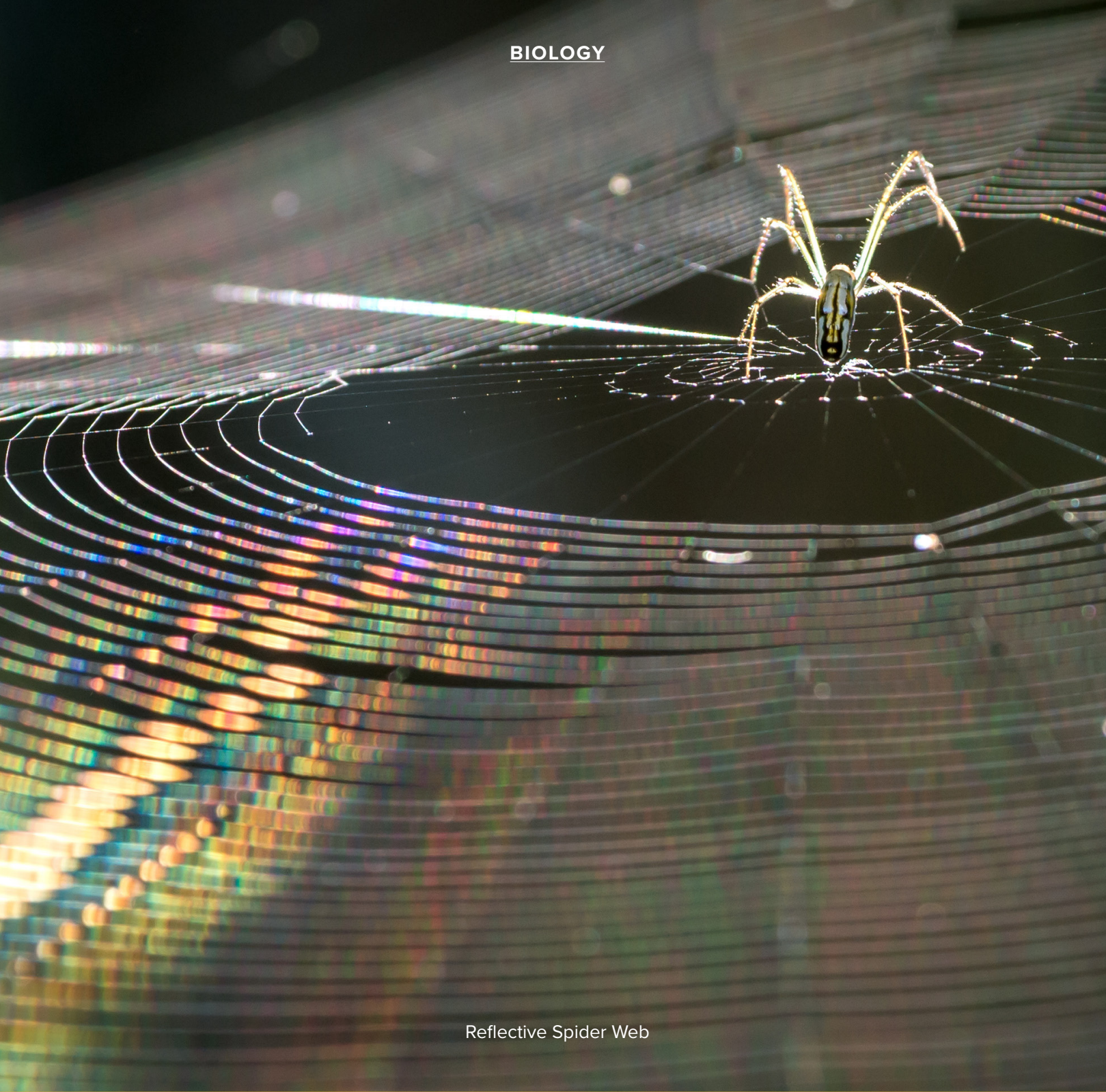
ORNILUX

BY ARNOLD GLAS

The commercialization story behind the insulated glass that mimics the reflectivity of spider webs to keep birds safe

Published by Synapse by Biomimicry 3.8
Written by Biomimicry Business Intelligence

BIOLOGY



Reflective Spider Web

DESIGN



Ornilux Glass Installation
Rosewood Beach
Park District of Highland Park IL
David Woodhouse Architects, LLC

Forward

Biomimicry for Innovative Business Opportunities

Biomimicry is not itself a product but a process, drawing on strategies observed in natural organisms and practices in order to spark innovation.

*Biomimicry (from **bios**, meaning life, and **mimesis**, meaning to imitate) is a scientific design discipline that seeks sustainable solutions by emulating nature's time-tested patterns and strategies.*

The core idea of Biomimicry is that nature, after 3.8 billion years of research and development, has already developed solutions to many of the problems facing industry, government and agriculture. Such problems include packaging, transportation, energy production, non-toxic chemistry, carbon sequestration, and crop production.

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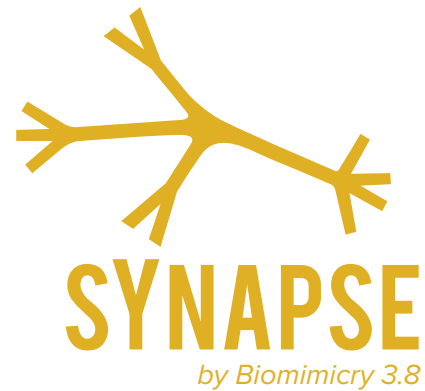
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At Synapse by Biomimicry 3.8, we are dedicated to providing biomimicry intelligence that informs, inspires, and empowers businesses to leverage nature's genius in solving their own innovation challenges.

By publishing biomimicry case studies that detail the commercialization stories experienced by biomimetic innovators, we hope to expose key insights and lessons learned about getting the most value out of the biomimicry approach as evidenced by real world projects so that others are better prepared to take advantage of nature's 3.8 billion years of research and development.

While these case studies are detailed, we have highlighted critical take aways throughout the document to provide at-a-glance learnings about market viability, the competitive landscape, the environmental issues, industry drivers, biomimetic insights, and more. Whether you are browsing or diving deep into the details, this case study will provide strategic insight for your next biomimicry project regardless of sector.



The ability to innovate is a key driver of productivity, competitiveness, and prosperity. Innovation requires entrepreneurs to rethink their strategies and adopt new approaches to their businesses, embracing new technologies and manufacturing opportunities that can be the difference between success and failure in the business world.

Biomimicry innovations are fertile hunting grounds for innovative business opportunities. Due to this immeasurable potential, corporate executives, investors, policymakers, and entrepreneurs across many industries look to this emerging field to drive sustainable growth.

But what are some powerful technology trends that can drive company success? What are the important factors that should be considered when trying to identify the next big trend? Biomimicry's inherent value lies in the answers it proposes to these questions.

BIOMIMICRY ADVISORY SERVICES

(BAS) is an independent financial market research and advisory organization that provides strategic advice and ongoing intelligence on emerging biomimicry technologies. BAS is a project initiative of Biomimicry Switzerland.

MISSION

BAS' mission is to help leaders in the commercial, public, and social sectors develop a deeper understanding of biomimicry innovations and to provide a fact base that contributes to financial decision making on these emerging technologies.



Executive Summary

Architectural glass has become one of the fastest growing markets in the construction industry, but this growth comes with a price. Ornithologists have demonstrated that glass facades, like windows, are responsible for millions of bird fatalities worldwide. These fatalities are caused by the birds' inability to recognize the glass, or rather than the glass not being able to alert the birds of its presence. The problem of bird collisions has caught the attention of advocacy groups and local governments, as well as some manufacturing companies. A group of manufacturers in the industry have launched projects to design, manufacture, and produce glass that protects birds by using varying technological innovations, such as patterned, UV reflective, transparent glass.

ARNOLD GLAS BRINGS ORNILUX TO MARKET

Arnold Glas is one of Germany's largest insulating glass manufacturers, with a strong focus on innovation. Arnold Glas CEO, Hans-Joachim Arnold, was astounded by the number of birds killed each year by his products. While talking with his attorney, Alfred Meyerhyber, Mr. Arnold was introduced to the special UV-reflective layer called Stabilimenta, which was believed at time to deter birds and other animals from colliding with and destroying spiderwebs. Hans-Joachim went on to invent ORNILUX, which he designed to mimic

the spider's ability to protect its web. The research and development team, headed by Christian Irmscher, was able to create a patterned UV-reflective glass coating that would balance visibility to birds and transparency to people. They called this new product ORNILUX. In 2001, Arnold Glas was given the patent for the transparent patterned UV reflective coating, and currently is the only company that has been able to produce a glass panel of this kind.

STATE OF THE MARKET

The ORNILUX line is currently being offered on a global scale. Lisa Welch-Schon, the company's current Director of Sales & Marketing in the U.S, introduced this special bird-friendly glass to the U.S. in 2010. Although sales have grown since then, the company is currently facing several competitive challenges. Arnold Glas seeks to lower delivery times as well as prices. The marketing team thinks that by doing so they will be able to retain a bigger share of this growing market. Despite these challenges, things are looking up for Lisa and her team. They have connected with a number of educated individuals, universities, and governmental agencies who recognize the importance of this product and its potential in solving this critical environmental issue.

Office Building, Hamburg, Germany Building Society Gartenstadt Wandbek © Arnold Glas





BIRD MORTALITY CAUSED BY WINDOW COLLISIONS ARE ESTIMATED TO REPRESENT ROUGHLY 2 - 9% OF ALL NORTH AMERICAN BIRDS³

Industry Overview

BIRD COLLISIONS IN THE US

Bird collisions with buildings, homes, and other infrastructure has become a major driver of bird fatalities in the United States. Ornithologists estimate that in the U.S. alone hundreds of millions of birds are killed each year by collisions with windows¹. Research has proven that “the risk is biologically significant for certain bird species”². All types of commercial glass

can cause bird collisions and mortality, regardless of whether it is a high-rise skyscraper in a major metropolitan area or a residential home in the suburbs. The reflective and transparent characteristics of glass are dangerous for birds. Birds can see the reflection of their surroundings in a window and this misperception can be fatal to them.

1 http://www.birds.cornell.edu/AllAboutBirds/faq/attracting/challenges/window_collisions

2 Standards for Bird-Safe Buildings. (n.d.). Retrieved June 24, 2015, from <http://www.sf-planning.org/index.aspx?page=2506>

3 Loss, Scott R., Tom Will, Sara S. Loss, and Peter P. Marra. “Bird–building Collisions in the United States: Estimates of Annual Mortality and Species Vulnerability.” *The Condor* 116.1 (2014): 8-23. Ornithological Applications. Cooper, 02 Jan. 2014. Web. 23 May 2017. <http://www.audubon.org/sites/default/files/documents/loss_et_al_bird-building_collisions_condor_2014.pdf>.

INDUSTRY DRIVERS

The problem of bird collisions has caught the attention of advocacy groups and local governments, as well as some manufacturing companies. A group of manufacturers in the industry have commissioned projects to design and manufacture glass that specifically protects birds through a variety of technological innovations, such as patterned UV reflective glass or acid-etched markers on the glass surface. However, due to a lack of

economic motivation and governmental regulation, bird-protective glass has not widely been adopted by consumers, unless they have a high level of awareness regarding the importance of environment protection and animal conservation. Because of the price premium and inadequate consumer awareness and education, the market for bird-friendly glass is relatively small.

The main industry drivers for reflective bird-friendly glass can be divided into three (3) categories: **advocacy, local government, and consumers.**



ADVOCACY



LOCAL
GOVERNMENT



CONSUMERS

1



ADVOCACY

Advocacy groups and nonprofit organizations (NPO) like American Bird Conservancy, Bird & Buildings Forum, Fatal Light Awareness Program, Audubon organizations, researchers and ornithologists are trying to raise public awareness through publications and education.

For example, American Bird Conservancy has a special Collisions Program that conducts research and educational programs, and also writes reports for bird-friendly building designers, to generate awareness of the problem of bird mortality. LEED (Leadership in Energy and Environmental Design) is a rating system for design, construction, operation, and maintenance of green buildings, homes, and neighborhoods and was developed by the U.S. Green Building Council, a NPO. Other NPOs such as New York City Audubon Society and Audubon Minnesota's bird safe building guidelines support the same cause.

2



LOCAL GOVERNMENT

Local governments have implemented policies and legislation to change public's behavior and incentivize the building of bird-safe architecture. The standards implemented by these local governments include the Chicago Bird Safe Design Guide, the San Francisco Standards for Bird-Safe Buildings, and the Toronto Bird-Friendly Development Guidelines. These requirements help promote a market for bird-friendly glass.

San Francisco has a specific requirement that "Bird-Safe Glazing Treatment is required such that the Bird Collision Zone consists of no more than 10% untreated glazing. Building owners are encouraged to concentrate permitted transparent glazing on the ground floor and lobby entrances to enhance visual interest for pedestrians".

In the Standards for Bird-Safe Buildings, San Francisco's government also created a Bird-Safe Building Checklist, in which risk assessment legends (gray and red) and certification legends (yellow, green and blue) are used to indicate whether there are a potential risk or whether a building can be certified as bird-safe⁴.

For example, if the quality of the glass is best described as "mirrored or visible light reflectance exceeding 30%", then a red legend will be tagged to indicate prohibited conditions or conditions which are prohibited unless bird-safe treatment is applied. Specific policy requirements like these promote the development of a bird-friendly glass industry.

4 Standards for Bird-Safe Buildings, San Francisco Planning Department, Adopted July 14, 2011: http://www.sf-planning.org/ftp/files/publications_reports/bird_safe_bldgs/Standards%20for%20Bird%20Safe%20Buildings%20-%202011-30-11.pdf

3



CONSUMERS

Institutions like universities, research centers, wildlife reserves, and zoos are major consumers of technologically-advanced bird-protective glass, as they are open to this kind of change and are structured to promote research and innovation⁵. For example, the University of Massachusetts Science Building was one of the biggest projects for ORNILUX Bird Protection Glass thus far.

These three groups have been early adopters of bird-friendly design thus helping to develop the market, especially in North America. In Europe, the original epicenter of innovation in bird-friendly glass, marketing strategies and the social environment have not yet matured enough to drive the adoption of this innovation.

5 <http://www.law.utah.edu/a-better-building-biomimicry-glass-working-with-nature-to-reduce-bird-window-collisions/>

COMPETITIVE LANDSCAPE

As a natural result of the slow adoption of a new technology, thus far there is little competition in the bird-friendly glass market. Major companies in this field include Arnold Glas, Walker Glass, Goldray Industries, and Viracon. Each company currently competing in the bird-friendly glass market niche has developed its own in-house technology, which differs across companies. Examples are as follows:

BIOMIMETIC

ARNOLD GLAS

Arnold Glas' technology is a patterned UV-reflective glass coating

WALKER GLASS

Walker Glass' Bird Friendly Glass uses acid-etched or UV markers

GOLDRAY INDUSTRIES

Goldray Industries adopted First Surface Ceramic Frit into its Bird Friendly Glass

VIRACON

Viracon is testing the effectiveness of silk-screen patterns as a means of collision mitigation

Arnold Glas created and included the essential elements for an enduring solution to the bird collision problem into their company, which are referred to as the three pillars of bird safe architecture. These are:



Arnold Glas' main work refers to solutions and thereby technological innovations that are available, deliverable, and affordable to install in a bird-friendly building. Considering that the three aforementioned groups raise awareness & education, a future task might be to support these groups in order to implement the third pillar, behavioral change.

Environmentally-Friendly Guidelines⁶

In addition to their wide scope of work, the company cares about its impact on the environment and takes action to preserve it for future generations. The company places a high priority on natural resources management and environmental protection, which can serve as a role model for others.

Arnold Glas supplies its customers with environmentally friendly, cost-effective products and services

• All processes and methods are permanently monitored and modified as necessary to comply with the latest technical standards and environmental aspects

• Staff training incorporates awareness of laws and directives associated with environmental protection

• Avoidance of waste takes absolute priority over waste disposal and recycling

• Unavoidable waste is recycled or disposed, using environmentally sound methods

Company Overview

ARNOLD GLAS IS ONE OF GERMANY'S LARGEST INSULATING GLASS MANUFACTURERS WITH A STRONG FOCUS ON INNOVATION. THE COMPANY HAS OVER 1,000 EMPLOYEES IN 10 PRODUCTION FACILITIES IN GERMANY AND AUSTRIA. THE COMPANY HAS BEEN GRANTED OVER 40 PATENTS IN THE LAST 6 DECADES.

In 1959, Alfred Arnold invented ISOLAR, an innovative technology at the time. Compound-insulating glass edges were soldered using customary inflexible joints until he created a flexible binding technology. Since then, the range of products for Arnold Glas has grown to encompass a wide variety of products: single-pane and laminated safety glass, fittings,

and installation products, in addition to a full complement of services, from initial planning to project implementation. They are permanently engaged in development of new products and research into new areas of application and improved production methods. One of their most recent innovations was the creation of a bird-friendly glass coating, which they called ORNILUX.

Arnold Glas works closely with architects and planners, always striving to develop new functions for their transparent material. Their work ranges from domes, spot-fixed curtain walls, sloping and all-glass facades, glass for technical applications, as well as glass sanitary fittings.

THE ORNILUX STORY

In 2000, Arnold Glas CEO, Hans-Joachim Arnold, became aware of the window collisions problem and its large scope. As a glass manufacturer, he felt a sense of responsibility for having profited by contributing to the problem and he desired to be part of the solution. This was the origin of the ORNILUX Bird Protection Glass story.



**ALFRED
ARNOLD**

Founder of
Arnold Glas



**HANS-JOACHIM
ARNOLD**

CEO of
Arnold Glas

INITIAL

DEVELOPMENT

In the late 1990s Dr. Alfred Meyerhuber, a German attorney with a personal interest in birds and science, read an article in a magazine about orb weaver spiders and their use of stabilimenta. Back in the 1990's, it was thought that the stabilimenta was a decorative coat of UV-reflective threads that spiders used on their webs to enable birds and

other animals to detect them and prevent collisions and therefore the destruction of their web, however, this theory has since been disproven.

Dr. Meyerhuber mentioned the article to Mr. Arnold and encouraged him to research how this biological phenomenon might be applied to glass to prevent birds from striking windows and killing or injuring themselves. After

years of development and the realization of a small, almost non-existent market, the board decided that they wanted to discontinue the ORNILUX offering, but despite this Mr. Arnold chose to continue to work on developing a product that would have the same UV-reflecting qualities as spider silk.

TECHNOLOGY

BREAKTHROUGH

Arnold Glas's head of research and development, Christian Irmischer, led the technical product development of ORNILUX. He was tasked with developing a patterned UV-reflective glass coating that would balance visibility to birds and transparency to humans by taking advantage of the inability of the human eye to see UV light. Humans perceive light with wavelengths ranging from about 400nm to about 700nm, while birds are also capable of sensing ultraviolet light with wavelengths from about 400nm to 100nm, polarized lights and magnetic fields. The coating was developed in cooperation with technicians at Arnold Glas' sister company Arcon. Arcon, which is located in Feuchtwangen, Germany, specializes in thin Low-E (Low

Emissivity) and solar coatings for architectural glass. In collaboration, they designed the new production process and developed the required chemistry to apply a patterned coating to glass, which is only visible to birds or other organisms that can detect UV light.

During the development process the researchers tested many different coating types and patterns. The result is a patterned coating that made the contrast of the glazing more intense. Although the specific pattern of a spider's web inspired the solution, Irmischer and his team had to design a unique pattern for the window coating in order to make the application process practical.

PATENTING AND

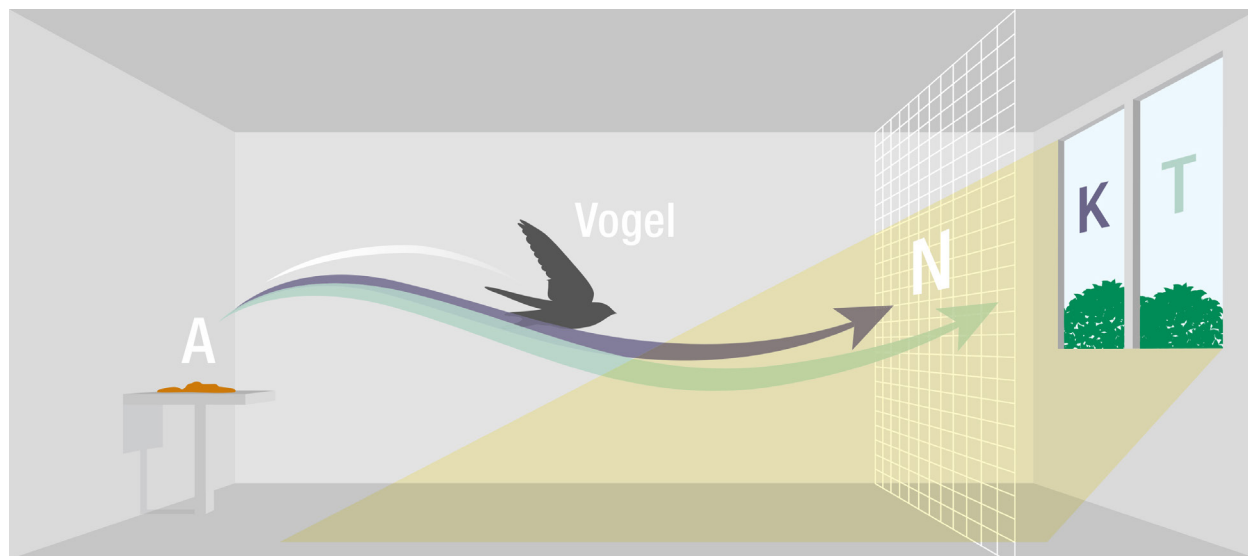
COMMERCIALIZATION

The patent for the transparent UV coating was granted in 2001 and Arnold Glas introduced ORNILUX SB1 Bird Protection Glass, its first commercial product harnessing the technology, in 2006. The vertical lines of UV-reflective coating used in this product were sometimes perceptible but very subtle and not visually distracting. Three years later, the company introduced an improved second-generation product, ORNILUX Mikado. The name refers to the crisscrossed UV patterns of the design and comes from the German name for the game of pick-up sticks. Mikado's new pattern and improved coating is nearly invisible to human eye.

ORNILUX EFFECTIVENESS

LABORATORY STUDIES

Independent pre-market testing by the German Ornithology Institute demonstrated that ORNILUX glass is highly effective at protecting against bird strikes⁷. To test the glass, a variety of bird species were released inside a 30' flight tunnel with two glass panes at the far end—one being a control pane with standard glass and the other a pane of ORNILUX glass. In total there were 1384 test flights from 2003 to 2010. During the tests, the birds tried to fly out through one of the perceived “openings” (a net protected them from actually striking the glass) and researchers marked each bird’s chosen flight path. The patterned UV-reflective glass significantly reduced bird strikes compared to standard double-glazing.



Representation of German Ornithology Institute experiment with ORNILUX glass. © Arnold Glas

⁷ <http://www.ornilux.com/history-research.html>



Polar bear enclosure at Munich's Hellebrunn Zoo © Arnold Glas

FIELD STUDIES

Remarkable differences in the number of bird strikes have been noted in the field at buildings equipped with ORNILUX glass. The first project in the USA to use ORNILUX was the Center for Global Conservation at the Bronx Zoo, which was completed in 2009. ORNILUX SB1 was used only in a corner conference room which presented the highest risk to birds. An ongoing monitoring program has noted a dramatic difference in bird strike frequency between the portions of the building with and without the bird-safe glass.

A year later, Munich's Hellebrunn Zoo used ORNILUX Mikado in the design of the polar bear enclosure and pelican house. Zoo officials were pleased to find a solution that did not block the visitor's views of the animals and noted several months after it was installed that no birds had collided with the glass.



USF&W Visitor Center, Cambridge, MD © Arnold Glas

Commercialization

Process & Strategy

Arnold Glas has offered their special bird-friendly coating, ORNILUX, in the North American market since 2010. Lisa Welch-Schon was interviewed to provide insight into the commercialization process and strategy. At the time of writing, she is the company's current Director of Sales & Marketing in the U.S, has done most of the advertising and marketing work. Ms. Welch-Schon and her team are working on a consulting basis, and serve as a direct channel between American customers and the German company. The team's focus is on the successful introduction of ORNILUX to the market, identifying potential customers, and managing projects. Their scope of work includes preparing invoices for architects, developers, and owners and signing contracting and forwarding the order details to headquarters in Germany.

MANUFACTURING, DELIVERY, & INTELLECTUAL PROPERTY

When the company first began to manufacture ORNILUX, actual product manufacturing in Germany would only begin after an order had been processed. In order to attract more customers, the company saw a requirement for shorter delivery times. In order to achieve this, they recently decided to work with ORNILUX glass in stock. The design of the ORNILUX glass was changed from a more defined pattern to a pattern known as Mikado, which was introduced in the most recent version of ORNILUX.

This was primarily an aesthetic decision that was made to improve transparency, but

there were other benefits.

Using a random pattern, the amount of waste generated during the production process is reduced, which brings down production costs notably. By stocking ORNILUX, delivery times have been shortened from 12 to 8–10 weeks and total waste generated by each glass unit in the production phase has decreased significantly.

An additional task for Ms. Welch-Schon and her team is arranging shipment for the glass, either by sea or by air. Air delivery is rare, as the costs are high due to the economics of transport. One of the company's greatest competitive challenges vis-a-vis

American companies are its longer lead times, caused by a lack of domestic production since all the glass has to be shipped from Germany. Arnold Glas' efforts to reduce price through technological innovation in production, as well as achieving shorter delivery times, are crucial to the company's competitive edge in the American market. One goal for the company is to reduce the lead time to six weeks.

A glass fabrication facility in the U.S. would further decrease lead times, enabling Arnold Glas to offer more competitive prices in the future, but this approach is expensive. A less

expensive and more likely alternative would be a partnership with an existing company in America. In a scenario like this, Arnold Glas could supply the ORNILUX glass panels and the American company could be responsible for the glass fabrication, or an American company could manufacture the ORNILUX panels on a contract basis, which would eliminate shipping costs from Germany altogether. These approaches would allow Arnold Glas to pass these savings along to the consumer, and will also contribute to decreasing overall lead times. Furthermore, advantages for both companies such as technology sharing in the production process, easier market entrance for other products in Europe or the U.S., and many others, are likely to

be created once a relationship is established. Although building a manufacturing facility in the U.S., or contracting an American company to manufacture and fabricate the glass for them seem like good options, the company will have to invest a lot of capital which could be a risk they would like to avoid at this moment under their current market strategy.

Another critical part will be the sharing of intellectual property. Thus far, all research and development has been done in Germany, and sharing technology, especially across borders, always increases the risk of losing control over patents and ideas. One possible scenario could be that Arnold Glas is waiting to see how the U.S. market evolves

over the next few years. If the U.S. market proves to be stable and profitable enough, the company could decide to build a manufacturing facility or enter into a contract with an American company.

GOVERNMENTS & ADVOCACY GROUPS ROLE

The total premium for bird-friendly windows ranges between 15% and 25% above the cost of traditional glass windows of comparable characteristics. The unique manufacturing process of the glass panel is what drives the additional cost. The cost of production is another challenge Arnold Glas faces when trying to compete against standard glass manufacturers. Ms. Welch-Schon has tackled this issue by educating customers and helping them understand that the long-term environmental impacts of regular windows are more expensive than the added cost of a bird-friendly window.

However, long-term environmental costs are social costs, which are very difficult to

measure in monetary terms, and only a few people are willing to pay to defer them. Among those who are willing to invest in the future of birds we can find universities, governmental agencies, and educated people who are aware of the environmental impact of losing millions of birds yearly. By investing, these organizations and individuals display a sense of environmental responsibility. They also must have access to sufficient resources to afford a more technologically sophisticated window. Environmental advocacy groups, cities, states, and the federal government have done a great job of raising awareness of the problem.

The U.S. Fish and Wildlife Service (FWS) reports that “that the incidental, accidental or unintentional take of migratory birds is not permitted by the Service and is a criminal violation of the Migratory Bird Treaty Act”. The FWS’ first strategy to reduce bird fatalities has been to work with industries and individuals who unintentionally cause bird deaths before prosecuting them (U.S. Fish and Wildlife Service 2002). In April 2011, Congressman Mike Quigley introduced a bill (H.R. 1643) in the U.S. Congress that, if passed, would have mandated bird-friendly construction practices for all federal buildings. Unfortunately, this bill did not pass and federal buildings are not required to use bird-friendly windows.

Many major cities are along the migration routes of waterfowl across the US. Some of these cities have already adopted bird protection regulations, such as San Francisco's Standard for Bird Safe Buildings.



Migration routes of waterfowl across the United States

To compensate, several major cities are addressing the issue through local legislation. **Chicago** passed an ordinance requiring that all new buildings and major renovations incorporate design elements to reduce the likelihood of bird collisions. **San Francisco** added a new section, Standard for Bird-Safe Buildings (139), in the city's planning code. The rules in San Francisco require the use of bird protection measures for all new or changed building facades which face an Urban

Bird Refuge within 300 feet. Additionally, free-standing transparent obstacles such as glass walls at monuments or bus shelters must be equipped with bird protection glass or other measures ensuring bird safety⁸. Keeping track of these changes as additional cities adopt them will be important. An order of glass to upgrade all bus shelters in one or more cities could easily be worth many millions of dollars.

Political and social awareness have played and will continue to play a key role in the implementation of bird-friendly technologies like ORNILUX, which will expand the market for this type of technology.

Every city that adds a bird-friendly regulation to its building code is effectively an expansion of the market for bird-friendly technologies like ORNILUX.

Another way to encourage the public to implement bird-friendly practices is to give them LEED credits for their use of these technologies. The Pilot Credit 55: Bird Collision Deterrence is a LEED pilot credit, which means it is being tested and commented on for possible inclusion in future versions of LEED⁹. If this pilot credit is incorporated into the LEED program, the bird-friendly market will see huge gains. In 2014, 675.9 million square feet

of real estate became LEED certified, with a 13.2% increase in total certified square-footage over 2013. Achieving LEED certification is a top sustainable goal for both private and public organizations, with LEED Gold certification being the goal for a majority of organizations¹⁰.

⁸ Standards for Bird-Safe Buildings, San Francisco Planning Department, Adopted July 14, 2011: http://www.sf-planning.org/ftp/files/publications_reports/bird_safe_bldgs/Standards_for_Bird_Safe_Buildings_7-5-11.pdf

⁹ <https://www.go-gba.org/resources/green-building-methods/bird-friendly-design>

¹⁰ <http://www.usgbc.org/articles/green-building-facts>

UNIVERSITIES & GOVERNMENT INSTITUTIONS AS TARGET CUSTOMERS

Universities and government institutions are good opportunities to grow the market for ORNILUX. They are good customers and have proven to be great supporters of green building and sustainable design. In addition, their orders are relatively large. In 2014, Arnold Glas worked on two separate projects with the University of Utah and Vassar College (the UMASS project predated these, as it was implemented in 2012–2013). These two projects accounted for about 66% of the company's total ORNILUX sales in 2014, underlining the importance of focusing on large-scale projects.

Although sales have increased over the years and progress has been made, there is still a lot of opportunity for future growth. The decision on whether or not to create a manufacturing facility in the US or to develop a partnership with an American company will play a vital role in determining the future competitiveness of ORNILUX in the U.S.

Governments, local and federal, are likely to increase their efforts to reduce bird fatalities through changes in planning codes, bill creation and approval, and law enforcement, all of which will further enhance the market for

bird-friendly technologies like ORNILUX. Experts also expect to see growth in the green building and sustainable design industry, which will also create a bigger market for ORNILUX glass. The green building market has been growing steadily in the last five years, and with its current CAGR of 19.5% it is estimated to have achieved a market value of \$173.5 billion in 2015¹¹.

¹¹ <http://www.fastcompany.com/1666282/report-us-green-building-market-will-balloons-1735-billion-2015>



Above | The S. J. Quinney College of Law at the University of Utah, Salt Lake City, Utah. Designed by VCBO Architecture and SmithGroupJJR. Photograph by Paul Richer.



Above | Vassar College, Integrated Science Commons, Poughkeepsie, New York. Designed by Ennead Architects. © Arnold Glas



Above | University of Massachusetts, Boston, MA Campus. © Arnold Glas

Financial Strategy

ARNOLD GLAS IS ONE OF THE BIGGEST GLASS MANUFACTURERS IN GERMANY. IT EMPLOYS 1,050 PEOPLE AT 10 DIFFERENT LOCATIONS IN EUROPE AND HAD REVENUES OF 110 MILLION EURO IN 2014¹². BEYOND EUROPE, THE COMPANY'S MAIN FOREIGN MARKET IS THE MIDDLE EAST, WHILE ASIA AND THE AMERICAS ACCOUNT FOR A SMALLER PORTION OF OVERALL REVENUE.

FOCUSING ON LARGE SCALE PROJECTS

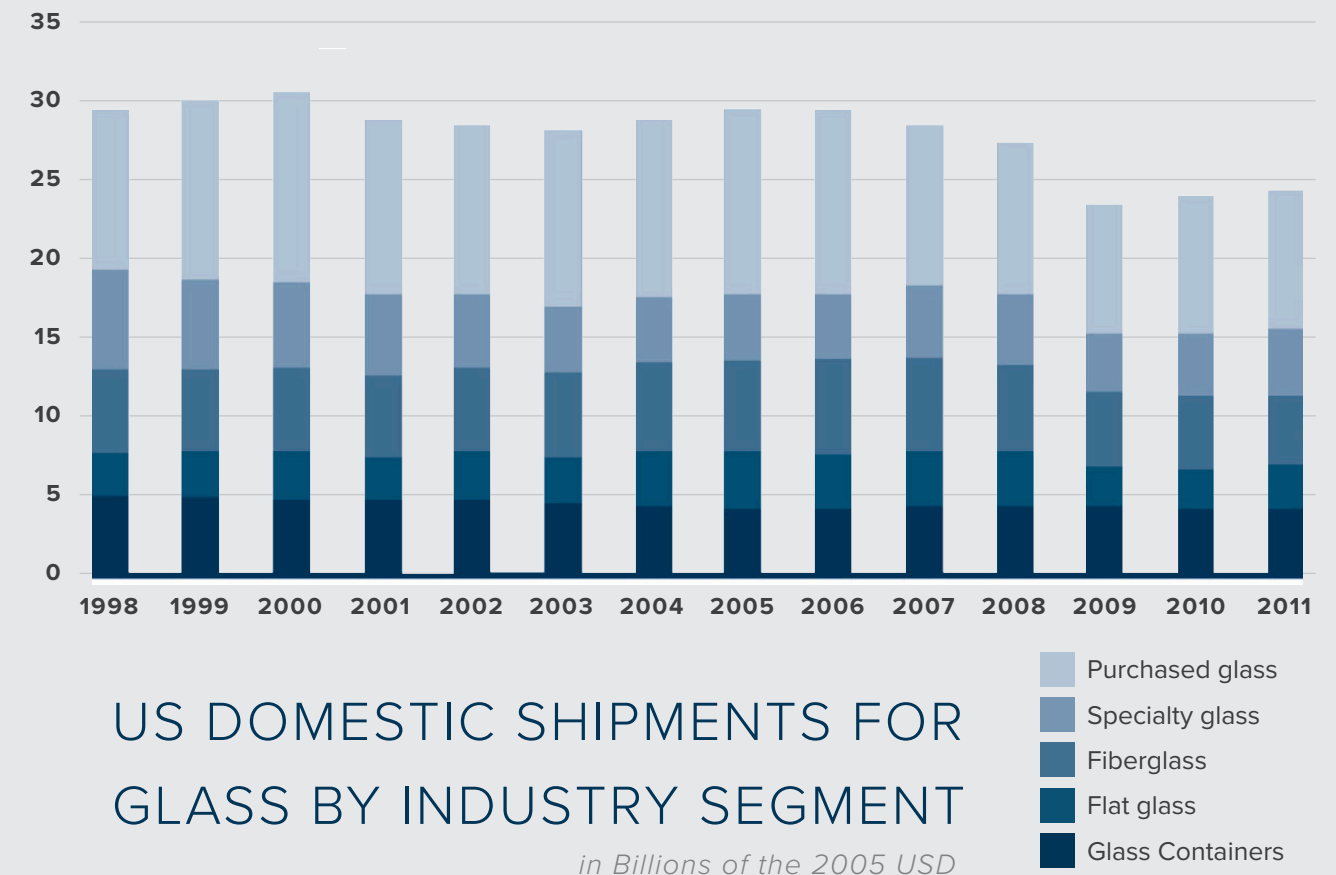
Due to the complexity of the current manufacturing and delivery systems for ORNILUX glass, a strategy that Ms. Welch-Schon wants to implement in the near future is to focus on bigger projects. From past experience, her team concluded that bigger projects require about the same effort as smaller ones, while also being more profitable. This includes targeting universities and government institutions as ideal customers.

¹² Glaswerke Arnold. Retrieved June 24, 2015, from: http://de.wikipedia.org/wiki/Glaswerke_Arnold <http://www.ORNILUX.com>

MARKET DEVELOPMENT

Arnold Glas is currently following a niche strategy rather than targeting mass markets. ORNILUX project sizes may seem small compared to the numbers generated by the glass market as a whole, but within the bird-friendly glass market, the size of Arnold Glas' projects using ORNILUX have made a big impact since it is currently the only bird-friendly glass on the market. Arnold Glas' project expenses are not determined by the size of one project and are relatively similar across small and larger projects. Logically, one of the company's long-term goals is to focus on larger projects.

THE U.S. MARKET



US DOMESTIC SHIPMENTS FOR GLASS BY INDUSTRY SEGMENT

in Billions of the 2005 USD

Arnold Glas is relatively new to the U.S. market. They entered the U.S. market in 2010 with only 3 employees and only one of their products, ORNILUX, and are relatively small players. If Arnold Glas is compared to the whole U.S. glass market or the flat glass segment, it is clear that they play a minor role, but this is because ORNILUX is the only Arnold Glas product that is currently being marketed in the U.S. The whole market produced shipments worth \$19.3 billion in 2011, with the flat glass sector alone shipping around \$2.5 billion. The whole market was in decline between 2006 and 2009, most likely caused, or at least exacerbated, by the financial crisis. The market has been slowly recovering since 2009, a year before Arnold Glas entered it.

Conclusion

Going forward, the research and development team at Arnold Glas will continue to provide the highest performing energy efficient bird-friendly glass, while taking into account and balancing visibility to birds and transparency to the human eye. Although the ongoing testing and development of ORNILUX is a high priority for Arnold Glas at this time, they are just as focused on continuing to develop new materials, patterns, configurations and technologies for use in future products, as well as acquiring a range of larger and smaller projects.

In the near future, Arnold Glas is working towards reducing their delivery time to six weeks by improving their production technology, which is important in establishing Arnold Glas as a competitive player in the glass markets of the future. Since establishing a glass fabrication facility in the U.S. is expensive, Arnold Glas is looking to establish a partnership with an existing company in the United States.

There is still a lot of opportunity for future growth, and the decision on whether or not to go ahead and create a manufacturing facility in the U.S. or to develop a partnership with an American company will play a vital role in determining the future competitiveness of ORNILUX in the U.S.

Lessons Learned

BIOMIMETIC INNOVATIONS ARE NOT IMMUNE TO STANDARD CHALLENGES OF NEW PRODUCT DEVELOPMENT

The value of biomimicry is in the new ideas and angles of approach for old or especially challenging problems. Once the inspiration is applied however, the same rigors of production and commercialization for any new technology or product can slow the pace to market.

BIOMIMETIC SOLUTIONS FOR THE BUILT ENVIRONMENT ARE WITHIN THE QUICKLY GROWING, BUT STILL NICHE MARKET-PLACE OF SUSTAINABLE DESIGN SOLUTIONS

For those that work in sustainable design and architecture, the need for a green product marketplace is growing in parallel with the adoption of green building policy and standards at the city, state, and federal levels as well as through growing awareness of environmental challenges evident in advocacy and consumer demand. Ornilux glass occupies a niche market among other important sustainable design solutions that rely heavily on quickly changing mindsets for faster and broader adoption.

THE SCIENCE DRIVING BIOMIMETIC INSPIRATIONS IS NOT SET IN STONE, BUT DOES IT MATTER?

While the original inspiration from spiderwebs for bird-safe glass later went on to be disproven, it nevertheless initiated an innovation that was effective for its intended purpose and ultimately provided the inspiration needed to breakthrough old models.

*For more information
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