

**BIOMIMICRY CASE STUDY**

**ENTROPY<sup>®</sup>: NON-DIRECTIONAL  
CARPET TILES**



**BIOMIMICRY**  
INSTITUTE

# Entropy®: Non-Directional Carpet Tiles

## Biomimicry Case Study: From Challenge to Biology

In the heart of the forest, leaves lie randomly scattered at the behest of wind and gravity, softly carpeting the landscape. Inspired by the organized chaos of nature’s ground coverings, one carpet manufacturing company has developed a ground-breaking design that is revolutionizing the carpet tile industry. InterfaceFLOR’s Entropy® Carpet Tiles are made with varied patterning and coloring within one style. This variation means dye lots need not be matched during production, carpet tiles can be placed in any order or direction, and individual tiles can be replaced without the need to re-carpet an entire room. These features greatly reduce manufacturing, installation, and replacement waste.

*“We all do our bit. If we don’t all do our bit, the bit doesn’t get done, so it’s up to you and it’s up to me.”*

– Ray Anderson

PRODUCT	Entropy® Non-Directional Carpet Tiles
INNOVATORS	Researcher   David Oakey Designs Company   InterfaceFLOR, LLC
WEBSITE	<a href="http://www.interfaceflor.com/Default.aspx?Section=3&amp;Sub=11">http://www.interfaceflor.com/Default.aspx?Section=3&amp;Sub=11</a>
SUSTAINABILITY WIN	Non-directional carpet tiles with mergeable dye lots
EMULATING FORM, PROCESS, OR SYSTEM?	Form
LIFE’S PRINCIPLES MET	Leverage cyclic processes, Use readily available materials and energy

# The Innovators

---

## THE COMPANY

The company that introduced free-lay carpet tiles to America is InterfaceFLOR, LLC, originally founded in 1973 as Carpets International.<sup>20,30</sup> Based in Georgia, this award-winning global carpet manufacturer has annual sales exceeding \$1.1 billion.<sup>20,29,30</sup> InterfaceFLOR has become the world's largest manufacturer of modular carpet tiles as well as an industry leader in sustainable business practices.<sup>20,25,30,33</sup> It has been guided since 1994 by the vision that "We will be the company that, by our deeds, shows the entire industrial world what sustainability is in all its dimensions: people, process, product, place and profits by 2020 – and, in doing so, we will become restorative through the power of

our influence."<sup>3,6</sup>

## THE FOUNDER

Ray C. Anderson was named one of *Time* magazine's Heroes of the Environment and one of MSNBC.com's Top 15 Green Business Leaders in 2007. He and Interface have been featured in three documentary films, including *The Corporation* and *So Right So Smart*. He co-chaired the President's Council on Sustainable Development and the Presidential Climate Action Project. He and Interface have been featured in *The New York Times*, *Fortune*, *Fast Company*, and many other publications.<sup>34</sup>

## THE DESIGNER

David Oakey Designs was founded in 1985.<sup>10,23</sup> David Oakey was educated in carpet design at Kidderminster College and serves as the exclusive design consultant for InterfaceFLOR.<sup>10,23,31</sup> Oakey leads global efforts in sustainable design incorporating the principles of biomimicry and his work and philosophies have been featured in numerous publications, including *The Smithsonian Magazine* and *New York Times Science*.<sup>10,23</sup>



© InterfaceFLOR (top), David Oakey Designs (right)

## The Challenge

---



Photo: Ed Luschei

### HOW TO IMPROVE ON EXISTING PRODUCTS AND THEIR MANUFACTURE

Traditionally, carpet manufacturing is a petroleum-based and environmentally unfriendly business, creating vast amounts of waste and pollution. Carpet tiles and the more traditional rolls of broadloom carpeting are usually made with nylon, a synthetic fiber refined from petroleum products. Two of the main components in carpet backings, fiberglass and polyvinyl chloride (PVC), are known carcinogens. As this story of innovation began, hundreds of gallons of toxic wastewater and more than 900 different pollutants were released into the environment by the carpet-manufacturing process.<sup>17,24,25</sup>

Dye lots of yarn used in the manufacture of colored carpets frequently vary. For the carpet manufacturer, if dye lots don't match, they are either rejected or put into a product and sold at a discount. For the carpet consumer, mis-matched dye lots mean that quantities of "attic stock" must be purchased to ensure that they will have matching carpet for replacing worn-out sections or re-carpeting individual rooms in the future.<sup>17,24,25</sup>

When rolls of broadloom carpet get worn out or excessively stained, they are usually sent to landfills. Since the late 1980s, billions of pounds of discarded carpet have made up a growing part of landfill waste.<sup>17,24,25</sup>

*"We realized that we were part of an industrial system – a take, make, waste linear system – that's literally digging up the Earth and converting it to rubbish. And of course it can't go on [and on]; the Earth is finite."*

– Ray Anderson

# Looking to Nature

---

## THE CHALLENGE

In the mid 1990s, InterfaceFLOR customers began to ask questions about the company's environmental policies and use of recycled materials. Founder and CEO Ray Anderson formed a task force that organized an internal conference to review and establish the company's position on these important topics. Ray Anderson was asked to speak at this event, and quickly realized he wasn't sure of the answers himself. Shortly before the conference, the inspiration he sought landed on his desk in the form of a book. In *The Ecology of Commerce* author Paul Hawken discusses the environmentally destructive nature of many current business practices, while offering a vision of how business can change to become environmentally healing instead. Ray Anderson was so moved by this book that he launched a sustainability movement within the company, challenging all his employees to help convert InterfaceFLOR into a restorative business.<sup>3,6,17,30</sup>

Challenging his employees to help carry the company into a sustainable future, Ray Anderson began assembling employee teams tasked with innovating ideas for action.<sup>32</sup> Experts in the field of sustainability--including Paul Hawken, author of the book that helped inspire the company-wide transformation--provided insight and direction. Hawken recommended the teams read a recently released book by Janine Benyus, *Biomimicry: Innovation Inspired by Nature*.<sup>23,24,30,32</sup> Design consultant David Oakey, inspired by what he read, immediately grasped how his design team might impact the sustainability movement within the company by applying the principles of biomimicry to their design work. A series of workshops was set up with the Biomimicry Guild (now Biomimicry 3.8), and the employees of InterfaceFLOR and David Oakey Designs dove into learning about biomimicry.<sup>23,24</sup>

## The Ecology of Commerce

A Declaration of Sustainability



Paul Hawken

AUTHOR OF *GROWING A BUSINESS AND THE NEXT ECONOMY*

### HOW *THE ECOLOGY OF COMMERCE* LANDED ON ANDERSON'S DESK...

While studying solid waste management in graduate school, the daughter of an InterfaceFLOR employee noted the vast quantities of carpet filling the local landfills. After attending an event where Paul Hawken spoke, she read his book, *The Ecology of Commerce*. Struck by the message of this book, she sent it to her mother at InterfaceFLOR, telling her, "You guys have some work to do." The book was passed along until it was placed among stacks of others on Ray Anderson's desk. Serendipitously he picked it up, and a sustainability revolution was launched.<sup>21</sup>

*"As soon as I read the book I said  
'This is it. I understand.'"*

– David Oakey

## The Inspiration

---

In late 1999, employees from every department at InterfaceFLOR gathered for the first biomimicry workshop. They received a basic introduction to biomimicry and learned about other companies and innovators who had successfully applied its principles. The workshop participants were then taken outside to look at “flooring” in nature. They were challenged to think about how nature would design a carpet tile.<sup>1,23,24</sup> What they discovered outside was that nothing in nature is the same, an idea counter-intuitive to traditional carpet design. From leaves to wildflowers to river stones, every individual unit is unique, different in size and shape. Rather than trying to match exact colors, nature uses multiple hues of similar values. By decorating with elements (a fallen leaf blown over here, a seed washed over there), a natural randomness emerges in the arrangement of individual units, while the overall aesthetic appears continuous.<sup>22,23</sup> The workshop participants noticed that whether one leaf or a handful were picked up and scattered elsewhere, the visual appearance of the forest floor remained the same. Inspired by the principles they saw, David Oakey’s design team set to work developing a design concept that mimicked nature.<sup>23,24</sup>

*“[N]obody ever visits the forest and thinks that the colors and patterns clash.”*

*-David Oakey*

## Moving from Inspiration to Design

---



### PRODUCT DESIGN

Through subsequent workshops and additional team meetings, a new design idea began to emerge for David Oakey and his team.<sup>23,24</sup> The principles they saw in nature during the first workshop were translated into the modular flooring field. Mimicking the organic design of the natural world, the designers began to experiment with carpet tile patterns and color palettes that varied, a deviation from the consistent, uniform, and monotone styles typical of the carpet industry at the time.<sup>9,23,28,32</sup> They produced a carpet tile concept, called Entropy®--organized chaos. By creating each tile so it would be slightly different in pattern, yet within the same color palette, the resulting product could be placed randomly in any direction while still creating a visually continuous aesthetic.<sup>9,23,28</sup> In February 2000, David Oakey created his first Entropy® design sketch, called "Shifting Blocks," and the product development process began.<sup>24</sup>

*"It's only in our synthetic world that we want perfection – one shade, no blemishes. If we can't match a carpet's color exactly, we call it a defect. Nature doesn't work that way."*

– David Oakey



© InterfaceFLOR

# Moving from Design to Production

## COLLABORATION IS KEY

In March 2000, the Entropy® design idea was introduced to InterfaceFLOR in a collaborative product development meeting, which included employees from different departments in the company. The participants quickly realized that the next large challenge was creating an intentionally random carpet tile in a manufacturing system that was designed to produce uniform products. Fortunately, members of the manufacturing and development departments were present at this meeting and were able to speak to the feasibility of proposed manufacturing solutions as well as to suggest some of their own. Having been included in the original biomimicry workshops and design ideas, these employees felt fully engaged in the entire process of Entropy®'s creation, and were compelled to apply their first-hand knowledge of the manufacturing process to devising solutions. Using a combination of previous InterfaceFLOR manufacturing inventions and innovative adaptations to current carpet tufting processes, they were able to devise a way to efficiently produce these random carpet tiles while simultaneously reducing production waste.<sup>24</sup> Less than a year from the first biomimicry workshop, Entropy® was released to the public, and the world's first biomimetic carpet tile was manufactured.<sup>22,24</sup>

*“The collaboration...may have been one of the best things of the whole project.”*

– David Oakey

## THE ENTROPY® TIMELINE:

1955

Carpet tiles are invented

1973

InterfaceFLOR founded by Ray Anderson (called Carpets International), free-lay carpet tile introduced to America

1994

Ray Anderson inspired by *The Ecology of Commerce*, InterfaceFLOR's journey to sustainability begins

1999

First biomimicry workshop

2000

February 14

First Entropy® design sketch created by David Oakey, called 'Shifting Blocks'

March 9

Design introduced to Interface in product development meeting

April 1

Entropy® copyright obtained, product introduced to the public

April 19

Entropy® product release

2003

i2™ product line introduced

2006

New features increase total recycled content of Entropy® tiles to 62-74%

# Moving from Production to Marketing

## WHY IS THIS PRODUCT BETTER THAN EARLIER PRODUCTS?

Entropy® tiles quickly became a top selling carpet style, doubling InterfaceFLOR's business between 2002 and 2007.<sup>17,32</sup> Because Entropy® tiles use gradations of multiple color palettes, they are said to have mergeable dye lots, meaning that yarn colors don't have to match perfectly to be used in the same product. This means less production waste, since mismatched colors no longer need to be discarded or sold in discounted products. Also, customers no longer need to buy large quantities of backup carpet for replacing worn or stained pieces, saving both storage space and money. The multicolor, random pattern of Entropy® tiles also helps to mask small stains and production anomalies, prolonging the life of the floor covering and reducing waste.<sup>8,9,24,27</sup>

Entropy® was so successful that an entire line of carpet tiles was launched in 2003 based on its design principles, called i2™ Next Generation Modular Carpet.<sup>22</sup> Savings in installation cost and waste with this product line are significant. The non-directional pattern and modular tile format means that tiles can be individually replaced and laid in any orientation. This extends the life of the carpet, allowing localized stains, damage or wear to be easily removed without replacing the entire carpet and carting it to the landfill.<sup>8,9,23,27</sup> The tile format and non-directional patterns also reduce waste and allow faster installation, lowering costs for the consumer.<sup>24</sup> An average installation of broadloom carpeting produces 14% waste versus only 1.5% waste for an average i2™ non-directional installation.<sup>8,9,27</sup> Today there are over 80 InterfaceFLOR products designed on Entropy® principles, making up more than 40% of their carpet tile sales.<sup>17,24</sup>

The average i2™ non-directional installation produces only 1.5% waste versus a 14% average for broadloom:

WASTE COST SAVINGS				
FACTORS	I2 NON DIRECTIONAL	MODULAR CARPET	I2 FT BROADLOOM	12 FT PATTERNED BROADLOOM
Size of facility (sq. ft.)	41,715	41,715	41,715	41,715
Carpeted area -70% (sq. ft.)	29,200	29,200	29,200	29,200
Installation waste (sq. ft.)	1.5%	4%	10.3%	18.2%
Total waste (sq. ft.)	438	1,168	3,008	5,314
Total waste (sq. yd.)	49	130	334	590
Total waste cost*	\$980	\$2,600	\$6,680	\$11,800
Total material cost savings with i2		\$1,620	\$5,700	\$10,820

\*Based upon estimated cost of \$20 (USD) per sq. yd.

Waste Cost Savings Chart ©InterfaceFLOR

## Raising the Bar While Setting the Standard

---

Following the success of Entropy<sup>®</sup>, InterfaceFLOR has gone on to apply the principles of biomimicry to other product designs as well as business and marketing models.<sup>2,18,19,24</sup> The company's unique skills at incorporating biomimicry into its design processes have dramatically improved the company's environmental and financial standing.

TacTiles<sup>™</sup>, released in 2006, represent another successful biomimetic design. These releasable adhesive squares connect the back side of carpet tiles to one another at each corner upon installation to create a floating floor. Once connected, gravity keeps the tiles securely on the floor without them having to be permanently attached to the substrate. Inspired by adhesion seen in nature—such as geckos that can cling upside down on a variety of surfaces—TacTiles<sup>™</sup> are glue-free, eliminating a major source of volatile organic compounds (VOCs) from the carpet installation process.<sup>11,12,15,17,32</sup>

Yet another unanticipated benefit of this inspirational collaboration with nature was the recognition that inter-departmental brainstorming and consideration of new ideas was expansive and efficient, synergistic. InterfaceFLOR managers now hold such collaborative meetings for a variety of purposes.<sup>2</sup>

Applying the principles of biomimicry alongside other sustainability initiatives, InterfaceFLOR has continued, as a company, to pursue its global drive to leave zero environmental footprint by 2020, called Mission Zero<sup>™</sup>.<sup>12,33</sup> InterfaceFLOR has worked hard to incorporate recycled and bio-based materials into its products, including bio-polymer fibers to replace petroleum-based nylon.<sup>13,26</sup> In 2006, the total recycled content of Entropy<sup>®</sup> tiles increased to between 62 and 74%.<sup>12</sup> Waste elimination activities have diverted 200 million pounds of material from landfills since 1995, resulting in over \$430 million in avoided costs.<sup>13,17,26,33</sup> In 2009, use of renewable energy at the company was 30% and total energy use at the manufacturing facilities was down 43% since 1996.<sup>13,26</sup> Greenhouse gas emissions have been reduced by 44%, water intake is down 77%, and fossil fuel usage is down 60% per production unit.<sup>13,17,26,33</sup> As evidence of InterfaceFLOR's efforts, from 2004 to 2009, 85 million square yards of climate-neutral carpet were produced and sold.<sup>26,33</sup> The approach at InterfaceFLOR is a company-wide effort, where everyone is engaged in the sustainability movement. In fact, all employees now receive sustainability training.<sup>29</sup> The success of these efforts has been significant, allowing InterfaceFLOR to emerge as a major industry leader in sustainable business practices.

*“What happened was there was this ‘bang,’ because there were a lot of different ideas brought to the table at the same time...the idea now is that we do that on purpose.”*

– John Bradford

## Online Videos or Interviews

---

Ray Anderson TED talk – The business logic of sustainability.

[http://www.ted.com/talks/lang/eng/ray\\_anderson\\_on\\_the\\_business\\_logic\\_of\\_sustainability.html](http://www.ted.com/talks/lang/eng/ray_anderson_on_the_business_logic_of_sustainability.html)

Nature as Model (video with David Oakey). InterfaceFLOR website.

<http://www.interfaceflor.com/flash/NatureAsAModel>

Invention Machine Sustainable Innovation Podcast

Part 1: Interface on Biomimicry & Innovation <http://www.youtube.com/watch?v=IP3KMv-Aer0>

Part 2: <http://www.youtube.com/watch?v=M5fjeqylx28&feature=channel>

Go Green with Invention Machine

<http://www.youtube.com/watch?v=U3iYfX5fUj8>

Bloomberg. Innovators - Episode 3: Designed by Nature

<http://www.bloomberg.com/video/59739366/>

## References

---

1. Baumeister, Dayna. Interviewed by author. July 8, 2010.
2. Bradford, John. Interviewed by author. July 16, 2010.
3. How can business help the environment? (Part 1) [online video]. 2010 Big Picture TV. [cited June 15, 2010]. No longer available.
4. How can business help the environment? (Part 2) [online video]. 2010 Big Picture TV. [cited June 15, 2010]. No longer available.
5. Innovators – Episode 3: Designed by Nature. [Video]. 2010. Bloomberg L.P. [cited 2010 July 10]. Available from <http://www.bloomberg.com/video/59739366/>
6. InterfaceFLOR, LLC. 2002. Sustainability brief: The journey begins [Internet]. Available from: <http://www.interfaceflooring.com/library/PDF/journeybegins.pdf>
7. InterfaceFLOR, LLC. 2003. Sustainability brief; Beyond the Surface [Internet]. Available from: <http://www.interfaceflooring.com/library/PDF/beyondsurface.pdf>
8. InterfaceFLOR, LLC. 2007. Squarely focused on learning from nature [Internet]. Available from: [http://www.interfaceflor.com/pdf/SF\\_i2Final81409.pdf](http://www.interfaceflor.com/pdf/SF_i2Final81409.pdf)

9. InterfaceFLOR, LLC. 2010. i2® Modular carpet - How nature would design a floor [Internet and video]. Available from: <http://www.interfaceflooring.com/Default.aspx?Section=3&Sub=11>
10. InterfaceFLOR, LLC. 2010. Meet David Oakey - Exclusive designer for InterfaceFLOR [Internet]. Available from: <http://www.interfaceflor.com/default.aspx?Section=3&Sub=1&Ter=1>
11. InterfaceFLOR, LLC. 2010. TacTiles® & adhesives [Internet]. Available from: <http://www.interfaceflor.com/default.aspx?Section=2&Sub=7&Ter=2>
12. InterfaceFLOR, LLC. 2010. History [Internet]. Available from: <http://www.interfaceflor.com/default.aspx?Section=3&Sub=2>
13. Interface, Inc. 2008. Global ecometrics [Internet]. [cited 2010]. No longer available.
14. Interface, Inc. 2008. Interface sustainability [Internet]. Available from: <http://www.interfaceglobal.com/Sustainability/Progress-to-Zero.aspx>
15. Interface, Inc. 2008. Biomimicry. Available from: <http://www.interfaceglobal.com/Sustainability/Sustainability-in-Action/Biomimicry.aspx>
16. Interface, Inc. Interface, inc. fact sheet [Internet]. [cited 2010]. No longer available.
17. Interface chairman Ray C. Anderson on sustainable design. @issue Journal 13(1)[Internet]. c1995-2013 Corporate Design Foundation. Available from: [http://www.cdf.org/issue\\_journal/interfaces\\_chairman\\_ray\\_c.\\_anderson\\_on\\_sustainable\\_design-2.html](http://www.cdf.org/issue_journal/interfaces_chairman_ray_c._anderson_on_sustainable_design-2.html)
18. Sustainable innovation podcast part 1: Interface on Biomimicry & innovation [online video]. 2008. InventionMachine. [cited 2010 June 9]. Available from: <http://www.youtube.com/watch?v=IP3KMv-Aer0>
19. Sustainable innovation podcast part 2: Interface on Biomimicry & innovation [online video]. 2008. InventionMachine. [cited 2010 June 9]. Available from: <http://www.youtube.com/watch?v=M5fjeqylx28&feature=related>
20. KyotoSmart. 2006. Interface, inc: a model of organizational sustainability.
21. Lavalley, Joyce. Interviewed by author. July 1, 2010.
22. Nature as a model [online video]. InterfaceFLOR. [cited 2010 June 18]. Available from: <http://www.interfaceflor.com/flash/NatureAsAModel>
23. Oakey D. 2013. Biomimicry/biodesign. BioInspire [Internet]. Feb 15. Available from: <http://biomimicry.typepad.com/bioinspire/2003/02/index.html>
24. Oakey, David. Interview by author. June 24, 2010.

25. Patton RL. 2004. Interface, inc [Internet]. Atlanta (GA): The New Georgia Encyclopedia; c2004-2013 [modified 2013 Aug 19]. Available from: <http://www.georgiaencyclopedia.org/nge/Article.jsp?id=h-1857>
26. Ray Anderson on the business logic of sustainability [online video]. 2009. TED Conferences LLC. [cited 2010 Jun 8]. Available from: [http://www.ted.com/talks/lang/eng/ray\\_anderson\\_on\\_the\\_business\\_logic\\_of\\_sustainability.html](http://www.ted.com/talks/lang/eng/ray_anderson_on_the_business_logic_of_sustainability.html)
27. Roberts J. 2004. Interface's back-to-nature carpet create [sic] big profits. [Internet] World Benefit Productions Case Western Reserve University. Available from: [http://worldinquiry.case.edu/feature\\_interface\\_000.cfm](http://worldinquiry.case.edu/feature_interface_000.cfm)
28. Rockwood K. 2008. Biomimicry: Nature-inspired designs. Fast Company [Internet] October 1. Available from: <http://www.fastcompany.com/magazine/129/truly-intelligent-design.html?page=0%2C1>
29. Rosenberg, B. 2009. Interface Carpet and Fabric Company's sustainability efforts: What the company does, the crucial role of employees, and the limits of this approach. Journal of Public Health Policy 30(4): 427-438.
30. Interface, Atlanta, Georgia, USA: A natural step network case study. The Natural Step [Internet]. [cited 2010]. No longer available.
31. Schwartz B. 2001. Landscape of the interior. Fast Company [Internet]. Feb 28 [cited 2010] Available from: <http://www.fastcompany.com/magazine/44/lookfeel.html>
32. Stackpole B. 2008. Flooring company takes innovation cues from mother nature. Design News [internet]. Cannon Communications LLC. Available from: [http://www.designnews.com/article/47336-Flooring\\_Company\\_Takes\\_Innovation\\_Cues\\_From\\_Mother\\_Nature.php](http://www.designnews.com/article/47336-Flooring_Company_Takes_Innovation_Cues_From_Mother_Nature.php)
33. Strutzenberger M. 2009. Breathtaking vision plus strength-based approach ignites employee engagement. Axiom News [Internet]. Available from: <http://www.axiomnews.ca/NewsArchives/2009/November/November26.html>
34. Ray C. Anderson [Internet]. 2008. New York (NY): Macmillan; [cited 2011 Jun 28]. Available from: <http://us.macmillan.com/author/raycanderson>

## Acknowledgements

The Biomimicry Institute is deeply grateful to David Oakey for sharing generously of his time and stories, not only for this case study, but also as a member of our Board of Directors.