Public Goods: Using Pervasive Computing to Inspire Grassroots Activism

Can creating public goods—that is, artifacts that represent those things we value most about our communities—inspire grassroots action focused on local concerns? Several projects using pervasive computing investigate this idea in communities across London.

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By enabling social mapping and local knowledge sharing, pervasive computing technologies can help us create relationships beyond the established social and cultural boundaries, letting us develop new practices established around place, identity, and community. For more than a decade, the artist-led Proboscis studio and its collaborators have explored the potential costs and benefits of this codiscovery approach with communities across London.[1,2] A core ingredient of these explorations is to engage participants in making artifacts, which helps provide a focal point for communal experiences and results in the production of *public goods*—that is, tangible representations of the intangible things we value most about our communities.

A specific strand within our research program investigates ways to support grassroots activities that help urban communities increase their environmental sustainability. To this end, we've developed specific projects to explore alternative material representations of stories, skills, games, songs, techniques, memories, hyper-local lore, and experiential knowledge of the environment. All of our projects share a commitment to an alternative *experience commons*—that is, a collaboratively constructed, independent resource of local knowledge—which is sustained through public goods and gives citizens and urban dwellers the opportunity to be agents, actors, and creators.

Here, we describe several of our projects and how they use pervasive computing technologies to realize these goals.

Pollution Mapping

London Fields is a popular park in Hackney, East London, and an important resource for local communities in a densely populated area with few public open spaces. The first recorded mention of the park was in 1540 as Lammas land, an area for communal grazing. At that time, it was the last piece of common land for livestock on a drovers route from Essex to London Town. In the 1860s, agents for landlords began promoting the site for development, dismissing the Lammas rights as rarely used and pointing to the neglected state of the fields. However, the land's importance as one of a handful of large open spaces close to the city was recognized, and the fields became a public park in 1872.

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Figure 1. Feral robots. (a) The original Feral Robot, followed by an augmented version developed for the Robotic Feral Public Authoring (RFPA) project. (b) A close-up of the sensor modules at the front of the toy car. (c) Feral Robot workshops with students of the Jenny Hammond School.

Today, local people use the park for various social and recreational activities, including cricket and football games, dog walking, and walking and cycling. In its relatively long history, London Fields has adapted to accommodate the evolving needs of the surrounding population, which has made it a suitable location for the exploration of community attitudes toward pollution in Hackney, which is regularly in breach of the European air quality thresholds. Its nitrogen dioxide levels are often twice the legal limit. The London Air Quality Network (LAQN) monitors London's air quality hourly using observation stations in fixed locations across its boroughs, but Hackney has only one observation station covering the entire borough, so there's ample opportunity to investigate air quality at a much finer resolution.

The collection of this kind of information by non-experts, however, is often seen as lacking scientific rigor, and some would argue that evidence collected in this way can't be comprehensive or authoritative.[3] Others claim that citizen scientists lack the knowledge to interpret results. Nevertheless, collection of detailed pollution data at the grassroots level can trigger an open dialogue about environmental issues, help develop arguments on how pollutant-sensing technology placed at the grassroots level can function, and identify potential applications for community action and interaction.

Feral Robots

We explored the issues around fine-grain hyper-local air quality monitoring in collaboration with Natalie Jeremijenko, extending her Feral Robotic Dogs (Figure 1a) with location and augmented environmental sensing. We used a mesh network to wirelessly link the dogs to both the Internet and the Urban Tapestries platform, our crowd-sourced micro-blogging platform.[1] Feral Robots[4] provide a blueprint for reconfiguring toy robot pets with various low-cost chemical sensors typically used in fire and carbon-monoxide alarms and home and car ventilation systems to trace environmental pollution.[5]

Our priority was to develop an easy-to-assemble, low-cost platform using widely available commodity components (Figure 1b). All software and hardware designs are open source and available for anyone to freely reuse, build, or modify at http://socialtapestries.net/feralrobots.

Community Workshops

In addition to its rich heritage as common land, London Fields was selected as the location for a series of experiments due to its strengths as a public space used by distinct local communities. Community pollution mapping workshops were organized in collaboration with Space Media Arts (www.spacemedia.org.uk), a local arts and education charity. Feral Robots provided the focus for these workshops, with participants exploring wider concerns about pollution, both visible and invisible, and the potential application of technology to detect it.

We discovered that grassroots pollution mapping is not necessarily about producing accurate scientific data. Instead, it's a tool to highlight concerns, map knowledge, enable community involvement in the data collection process, and provide the focus for communities to come together. As one workshop participant remarked, "We have come to accept air pollution because we are culturally habituated in it—that's got to change and if this doesn't happen at a grassroots level with tools that we can handle ourselves, governments will not shift."

Nevertheless, not all workshop participants took the same view, and some expressed the opinion that ordinary people have no control over their local environment. For example, vehicle emissions are the major cause of air pollutants in London, and in many cases they are due to pass-through traffic,

(a) (b)

Figure 2. Building structures that reflect an ideal environment: (a) Story Cubes constructed by the Jenny Hammond students and (b) Diffusion notebooks and Story Cubes.

over which local people have little power to intervene. This viewpoint can lead to passivity and resigned acceptance of the situation. As one participant expressed it, "The more I think about it, the less I want to have any access to any data about air pollution in my locality or information about this park. I don't have a garden, I have a kid, and I'll always use [the park]."

In addition to views of the here and now, community mapping workshops prompted participants to reminisce about the history of London Fields, highlighting past activities in the area that might have left an environmental footprint. This type of local knowledge is invaluable and can help locate pollution hotspots that would otherwise require an external expert and the investment of considerable surveying resources.

Self-Publishing

Building on the use of made objects to provide the focus for codiscovery, our subsequent work emphasized the public goods concept—that is, tangible representations of stories, memories, and experiential knowledge of the urban environment. We further explored these ideas with Loren Chasse, an artist and educator at the Jenny Hammond School in Waltham Forest.

Our weeklong workshop with 30 nine- and 10-year-old students involved several activities, including extensive use of Feral Robots to gather evidence about the world around them (see Figure 1c). The activities were linked to specific modules within the national curriculum—focusing on transport, architecture, and climate—and helped the students develop an understanding of how these subjects fit with the environmental sustainability agenda.

One of the activities, "Know your way to the school," invited students to observe and record different types of pollution they encountered each morning. A long list was put together: rubbish on the road, litter and dog feces, car fumes, factory smells, plastic bags, cars, trucks, vans, and buses. Such evidence collection was at the center of the workshop, which attempted to make gathering this evidence fun and engaging. Students were introduced to the idea of being archaeologists and finding ways to collect evidence about the environment and world around them.[6] Students worked in rotating groups so that all had a chance to experiment with the different evidence-collection methods, both in the playground and at a nearby park. In addition to the Feral Robots, they used a variety of tools to capture images, audio, and samples in Urban Tapestries.

Storytelling and reflection was an equally important aspect of the workshop. Throughout the week, the students were encouraged through drawing and writing to imagine their own robots to help the environment and to design an actual space that they'd like to live in, thinking about both what they'd include and exclude from the space. They were encouraged to think freely and become architects of their own environment. Students had their own individual electronic notebooks to record their reflections on each day's specific activities and to build their knowledge over the week.

Story Cubes

Students used Story Cubes, a tactile thinking and storytelling tool developed by Proboscis, to build structures reflecting their ideas about their ideal environment (Figure 2a). Each face of the cube can illustrate or describe an idea, a thing, or an action; placed together, the cubes can create narratives or explore the relationships between cubes. Initially, students constructed their own cubes choosing six of the images they collected during the week. They then brought them together in groups to illustrate their ideal environment. Through this process of discussion and negotiation, the cubes were put together to create a single structure. The lively discussions about how individual choices affect the structures—arguing their cases and making compromises as part of the group effort—offered students a direct experience in the workings of a grassroots community.

Story Cubes are one of the two Diffusion foldable designs invented by Proboscis to combine the ease of sharing digital media with the tactile pleasures of material objects. Story Cubes were one of our first experiments with public goods. The second design, Diffusion notebooks (Figure 2b), similarly allows participants to author stories and record their experiences, which are automatically converted into the Diffusion format (an open platform for automatic notebook generation is available at http://bookleteer.com). This format can be printed and folded into a book, thus extending the book's reach beyond what would be economical or physically possible with traditional books. This approach takes readers away from the computer screen and engages them with the collected information in a different context and medium.

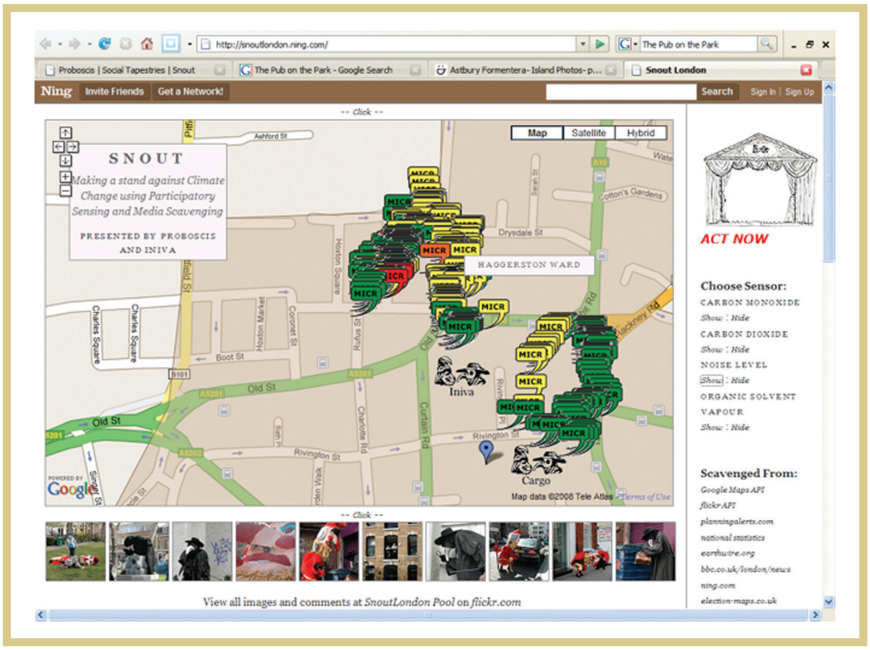


Figure 3. The Snout community art project aims to attract a wide cross-section of local communities. This social networking website was created using the Ning.com platform, data harvested during Snout performances, and crowd-sourced media contributed by community members.

Participant Perceptions

Teachers were not immune to the excitement that the project generated. As the head teacher observed, "There is a buzz… that is infectious around the school." Their experiences during the workshop helped them develop their academic skills as well as understand the link between individual actions and their impact on the local environment. The classroom teacher recognized this, noting that, "I've seen them progress throughout the week, and their understanding about pollution and what they need to do to care for the environment are really clear in their minds now."

In the students' own words, it is important to think about the environment "because you live in it," "so we can stop global warming," and because "without the stuff, earth is very dull." Indeed, the workshop encouraged students to feel that they could kick-start change and improve society. They were encouraged to think of real ways that they could achieve this, starting with their immediate environment—or, as one student suggested, "I would write a letter to the Queen so the people from the Houses of Parliament would put more bins in the city."

Community Activism

Aiming to attract a wider cross-section of local communities, we developed the Snout community art project, adopting a participatory sensing approach over community wireless networks and employing a variety of chemical environmental sensors.[7] Community art is

- fundamentally participatory and rooted in a shared sense of place, tradition, and spirit;
- as much about the process of involving people in the making of the work as the finished object itself; and
- situated in public, accessible, and resonant places, geared to a specific audience and time.

Moreover, community art fits well with an activist agenda, because it's developed around commonalities and the collective rather than a pursuit of strictly individualized expression that is typical in other art forms. In this context, art is seen as the catalyst that illuminates a political issue in a way that leads to mobilization and action.

The Snout Project

For these reasons, we saw Snout as an opportunity to develop a community around environmental sustainability by providing both the practical recipes for action and a supporting conceptual framework. Snout brings together community art and grassroots activism, focusing on shared concerns about educating the public and building social capital through grassroots networks that enable people to move information and ideas to a broader audience and make change happen (see Figure 3).

A Public Performance

The performance developed for Snout explored relationships between the body, community, and environment.[8] The carnival was selected as the theme, because it's a time when the normal activities of everyday life are suspended; a time when social hierarchies are inverted and everyone is equal—a viewpoint highly compatible with the Snout objective to invite participation. Two costumes were built and instrumented with sensing, processing, and actuation capabilities: the English puppet theatre character Mr. Punch and the Venetian Plague Doctor (Figure 4a). Our open source platform was extended to provide longer autonomous operation and support for LED-based displays, which provided immediate feedback of the sensing data.

(a) (b)

Figure 4. Outcomes of the Snout community art project: (a) the Plague Doctor costume was fitted with sensing, processing, and actuation capabilities; (b) public participation during the Snout performance around Hoxton Square and Rivington Street.

Proboscis designed and built the costumes with the electronics worn inside and the sensor arrays embedded into the masks. Snout was performed by London-based performance artists Jordan Mackenzie (www.jordanmckenzie.co.uk) and William Aitchison (www.billaitchison.co.uk) around Hoxton Square and Rivington Street during the day (see Figure 4b), with a related community forum held the same evening. Because a carnival has no audience other than the carnival-goers, the performance was based on improvised interactions with local residents, office workers, drivers of pass-through traffic, and anyone who happened to be in the area at the time. For example, Mr. Punch confronted professionals from the nearby Silicon Roundabout who littered around the square after having lunch, and the Plague Doctor garnered support by a group of local youths to petition truck drivers to use alternative routes to reduce transient pollution. Improvisations engaged hundreds of individuals and facilitated self-reflection on everyday practice and its consequences for environmental sustainability.

The Snout performance concluded with a workshop in which local participants (recruited during the day's performance and online) made their own devices using our open source system (all source code and hardware designs are available online via http://socialtapestries.net/snout).

Sharing Sensory Experiences

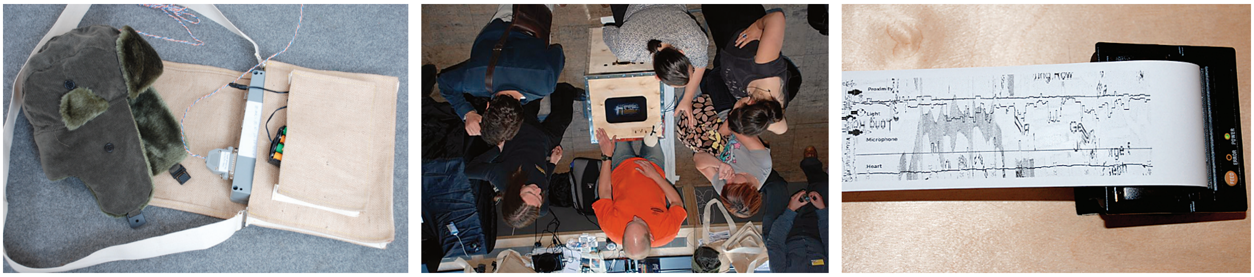
Next, we turned our attention from public goods that are external to participants to investigations of the human body as a vital part of the environment. In the Sensory Threads project,[9,10] we combined environmental and biosensing technologies to probe the imperceptible patterns and rhythms that occur when individuals explore the urban environment as a unit.

Sensory Threads events involve two groups: four expedition participants who carry wearable sensing technology incorporating real-time audio feedback; and gallery visitors who interact with an installation representing the sensory experiences of the expedition group using a combination of tactile, visual, and audio feedback. Contrary to other technologically mediated urban experiences—such as pervasive games and urban participatory sensing[11]—Sensory Threads focus on codiscovery by explorers and remote participants, who experience the urban environment without a specific end goal (such as finding a target location).

Sensory Threads

Each expedition member carries a device that records data from sensors (heart rate, light and sound, electromagnetic radiation, and spatial density) and streams it to a personal server, also carried by a member of the group (Figure 5a). The data is aggregated at the server to create a soundscape that is broadcast back to the whole group via wireless headphones. Each sensor influences a different aspect of the generated soundscape, which has been developed to create a complex group dynamic[12] in which participants engage with both their own actions in the space and the communal sensing experience (details on the generative algorithm are available elsewhere[9]).

All sensor data, the soundscape, and the group's location are recorded locally on the mobile server and concurrently transmitted to the Urban Tapestries system so that the information becomes available to the gallery installation components. More information can be found at the project website



(a) (b) (c)

Figure 5. Sensory Threads components. The wearable sensor kit for expedition group members includes (a) a hat with spatial proximity sensors and a bag that holds the processing, location-sensing, and communications equipment. (b) The Rumbler installation includes a box with an embedded video screen that shows the map of spaces explored by the expedition group. (c) The sensor printer is mounted on a second box that prints out sensor data.

http://proboscis.org.uk/rojects/2005-2010/sensory-threads.

Figure 5b shows the Rumbler, which is the main element of the Sensory Threads installation: it consists of a spring-mounted wooden box (made from a tea crate) that's approximately three feet high and has a video screen embedded at the top for displaying the map of places that the expedition group explores. The Rumbler also contains a large subwoofer speaker that creates very low frequency sounds that cause the box to resonate; the movement is intensified by the spring foundation. This, in turn, creates a nuanced set of vibrations that participants can experience through touch.

Four mini resonators extend to the sides of the Rumbler, constructed from repurposed computer game control pads, each using vibration to represent the data from a different sensor source. Speakers positioned around the exhibition space provide audio playback of the soundscape generated by the mobile server. In this way, phenomena normally imperceptible to the human senses are transformed into vibrations that can be sensed as audio or through resonance. Finally, a small, embedded printer mounted on a second wooden box produces a visual representation of the sensor information in a manner reminiscent of an electrocardiogram (Figure 5c).

The Rumbler can be used in two modes: The live mode embeds expedition experiences into the gallery while the expedition group is actively exploring; the playback mode lets participants journey through time and space to explore the sensory data repository previously recorded. In the former case, the Rumbler is noninteractive: the displayed map moves according to the expedition group's location, with the actual sensor readings visualized on the map. The large and small resonators provide tactile feedback to the sensor readings, and the soundscape is performed as the explorers hear it. In playback mode, the Rumbler becomes an interaction device, and tilting the box causes the map to scroll.

This allows the exploration of pathways through the sensor repository selected by gallery visitors. The Rumbler's form factor affords multiple people tilting concurrently, engendering a new form of codiscovery of the imperceptible. Experiencing the mini resonators requires two or more people to collaborate, so that one is tilting the Rumbler to discover new data while the other holds the device. This design encourages the formation of groups around the Rumbler in a manner intended to correspond to the shared experience of the expedition.

Festivals and Exhibits

Sensory Threads events have been staged on several occasions, including at the Dislocate Festival in Yokohama, Japan, and extensively during the Surface Tension exhibition at Science Museum London's Dana Centre. One particular aspect of these events that appeared especially engaging for remote participants in live mode was the experience of biosensed data harvested in real time during the expedition. Specifically, the experience of holding the mini resonator relaying the heart beat of one of the expedition members and its changes in response to the experiences they had seemed to create a sense of intimacy between the two groups and a strong affective response for those interacting with the Rumbler.

Exploiting Public Goods

In Feral Robots, Snout, and Sensory Threads, we used public goods to mediate the assembly of grassroots groups around local environmental sustainability issues by facilitating appealing codiscovery experiences. We found that their material nature can be more engaging for group members than purely screen-based information representations, because these artifacts weave themselves into the narratives of everyday life that people construct for themselves. Indeed, public goods are part of the material environment and, as such, are appropriated as material culture, which dictates the ways in which the objects are experienced and acquire meaning.[13]

In this context, public goods function as a source of inspiration for the development of open-ended activities rather than to epitomize the goal of tightly prescribed pursuits. For example, although we initially considered our open source maker platform as the main ingredient for community projects around participatory authoring, we quickly discovered that the complexities of hardware customization—despite our modular approach and design for accessibility—caused participants significant difficulties. Instead, our projects in general, and the specific designs of public goods in particular, offered ideas, directions, and encouragement for others to assemble collections of devices that achieve the same functionality, but didn't require expertise. Indeed, the platform's most significant contribution is in providing concrete proof that the development and operation of a low-cost public sensing and authoring platform is feasible with limited resources and restricted specialist skills. Nevertheless, the rapid proliferation of hackerspaces and fablabs might, in the longer term, address the spread of the required skills, which would warrant a reassessment of this strategy.

Cultivating Participation

Reflecting on Feral Robots in particular, we found that, although the artifacts themselves are widely appealing (especially to younger male users), they offer limited opportunities for interaction besides remote control. While collecting data, they remain opaque and provide little indication of any data transmission. Operators know whether the different system components function correctly due to several LED indicators, but they don't receive feedback on the currently detected levels of air pollution, which in the long run makes data harvesting sessions rather unexciting. We found that embedding feedback within public goods to provide an immediate response to data-collection tasks benefits participants considerably, increasing their engagement and the quality of their interpretations.

Because of the initial formulation of Urban Tapestries' participatory public authoring, our work's emphasis has shifted from pollution mapping to what we today describe as *everyday archaeology*. This approach places less emphasis on the specifics of data collection and instead traces closely the process of excavating information about the local environment and its relationship to communities. We discovered that it's the process of gathering such data that is the most valuable, because it can sustain the incentives for local people to campaign and thus become the locus of creative activity in itself.

Evolution of Public Goods

Public goods—and physical outputs from digital experiences in general—are a critical ingredient for developing effective grassroots activities that enable urban communities to take action. Our exploration of such physical outputs began in the early 2000s with Urban Tapestries' tangible souvenirs (manually generated foldable designs), which subsequently evolved in the Diffusion foldables, and the *aides du memoir* produced by the Experience Recorder at Birkbeck, a system used to capture and visually reconstruct visitor experiences in museums.

Many of these objects are made using materials (such as paper) that would be considered low-tech in this context, but the process through which they're generated incorporates pervasive computing as the key enabler for their production. Unlike data visualizations, public goods are created through a process of data transformation that doesn't confine them to an instrumental purpose, such as relaying the original data as information in a simplified and easy to comprehend manner. Instead, they're embodiments of the data, transformed from the abstract and ephemeral into the concrete and present.[14] They establish the potential for uncommon insights—such as into individual lifestyle patterns—recognized in the setting within which the data was collected and prompted through a process of tactile contemplation.

Public Goods and Materiality

Public goods are simultaneously informational objects—representing a state gleaned from sensor data—and physical things that act as triggers for intuitive reflection. As such, a single entity coalesces different traditions of investigation and meaning-making: both being and becoming. This capacity is maintained across use contexts and allows for the information qualities of public goods to transcend the screen and extend beyond cyberspace's frantic pace, thus letting citizens explore information constructs in a state not typically associated with computing. For example, the information represented by a specific artifact remains intelligible and present in periods of reflective contemplation, thus reuniting pervasive computing with the concept of calm technology and its aspiration to reduce the stress of information overload.

To be sure, the most interesting development in this regard is the widespread availability of low-cost additive 3D printers that allow the fabrication of objects in a form that closely traces their informational features. In particular, combining captured sensor streams with nature-inspired generative processes enables the organic growth, through computation, of structures that go beyond knowledge representation in a transactional commodity form. Instead, made objects become a path to knowing that arises from an ongoing process of continuous interaction with and intervention within everyday habits—an avenue that Proboscis currently explores within the Lifestreams project (http://proboscis.org.uk/projects/2011-2015/visualise-lifestreams).

The motivation for our work here is to show how artists and engineers can collaborate to bridge the gulf between pragmatic technical solutions to social problems and the cultural interventions that artists can bring to their communities. Through this collaboration, we demonstrate how using affordable electronics and open source software make it possible to create engaging experiences around hyper-local concerns, employing public goods as the focal point for community mobilization.

The greater the emphasis on participation at every level of society and culture, the greater the diversity of voices, ideas, and knowledge contributed to society at large. Indeed, stable and healthy democracies are the product of wider participation and the sense of responsibility that is often expressed when grassroots communities form around specific issues. Public goods capitalize on the inherent capabilities of citizens to construe material culture and provide an effective means to communicate the activist message of grassroots groups to a wider audience in a manner that is engaging and appealing—and thus facilitates the codiscovery of uncommon insights. P

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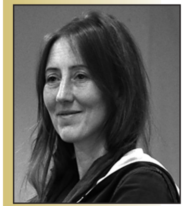

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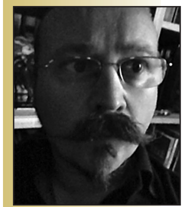

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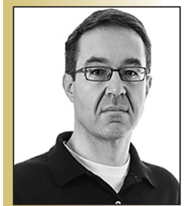

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