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GEODESIGN AND THE FUTURE OF PLANNING

By Shannon McElvaney and David Rouse, AICP

Our world is facing many challenges: from extreme weather, population growth, urbanization, and globalization, to increasing levels of social inequity, environmental damage, and resource depletion. Never before has there been such a need for planners to anticipate future trends, propose solutions, and help communities and decision makers make the most informed, wisest choices possible.

But how can planners successfully address these increasingly complex, interrelated challenges given today's economic and political realities? How can we determine the long-term impacts of choices made today? How can we reconcile competing priorities, such as economic development and environmental protection? How can we work across scales to determine the cumulative impact of our decisions?

This PAS Memo explores a new design approach that is rooted in the history of planning practice and enabled by rapid advances in digital technology. This approach — called *geodesign* — provides a framework and set of tools for exploring issues from a transdisciplinary perspective and for resolving conflicts between differing points of view. This article introduces the concept of geodesign and its recent history, provides examples of how it is being used in practice, and explores how it can enrich the future practice of planning. Included is a guide for planners who may wish to apply the geodesign process in their communities.

Geodesign is an approach that can be applied to many types and scales of planning projects and processes. As such it is a potentially powerful tool to apply to the comprehensive plan, the leading policy document guiding the long-range development of local jurisdictions in the United States. A forthcoming supplement to this Memo will address the application of geodesign across scales of planning practice, with a particular focus on the comprehensive plan.

Reframing an Old Idea

Design that considers geography has been ongoing since humans started altering their environs to meet their needs. Ancient cultures built settlements in close proximity to water and good views; they designed cities to maximize shading and natural cooling; and they positioned themselves in proximity to natural resources and trade routes (McElvaney 2012).

Over time, "progress" moved us away from design driven by natural opportunities and constraints. Technological advances made it much easier for humanity to subdue — and even defy — nature. Today we extract resources at rates never seen before and we literally move mountains, often with little or no consideration for the environment. It was in this historical context that the architect Richard Neutra wrote *Survival through Design* (1954). An early environmentalist, Neutra's approach to architectural design applied elements of biological and behavioral science and stressed the "inherent and inseparable relationship between man and nat ure" (Neutra 1954).

In his book *Design with Nature* (1969), landscape architect Ian McHarg advocated a framework for design that helped humans achieve synergy with nature. In his view, design that considers both environmental and social values in the context of space and time helps ensure a natural balance. Building on the work of Warren H. Manning (1860–1938), a landscape architect and early proponent of overlay mapping, McHarg expanded the use of overlay analysis, which both influenced the up-and-coming discipline of environmental planning and solidified the core concepts of the new field called geographic information systems (GIS) (Miller 2012).

Around the same time, a number of individuals were developing a substantial body of knowledge related to environmental planning (geodesign) at the Harvard Lab, founded by Howard Fisher, the inventor of computer mapping. In his thesis, Carl Steinitz would become the first to apply the use of computer mapping to planning; later he became a professor at the Harvard Graduate School of Design (Steinitz 2013).

Jack Dangermond, who studied landscape architecture at the Harvard Graduate School of Design under Steinitz, was hugely influenced by what computers offered: a way to take McHarg's manual overlay method of designing with nature into the digital world. In 1969, Dangermond founded the Environmental Systems Research Institute (Esri). His hope was that GIS would become a framework for modeling earth's systems so they could be managed more sustainably. In 2002, Dangermond envisioned that GIS would "evolve into a kind of nervous system for our planet," foretelling what GIS could become (Esri 2002).

These thought leaders recognized the interconnectedness between humans and nature. They saw that we have unintentionally created many of the problems we face today, and that we can ameliorate those same problems through better planning and design. But we can't accomplish this by using the same thinking or tools that got us here in the first place. We need to deploy a holistic, integrated approach to planning, one that accounts for the interdependencies between systems, helps us to identify and anticipate the unintended consequences of our planning and policy decisions, and leverages the results for positive change.

Introducing Geodesign

So exactly what is geodesign? In its simplest form, geodesign is a made up of two words — geography and design.

Geography is about place and processes, the human and the natural, across both space and time. It seeks to organize, understand, and describe the world. GIS — the computerized system by which we organize and analyze geographic information to support wise decision making — is well established in the planning world.

Design is about intent or purpose. A creative act requiring imagination, design can produce something entirely new, or improve upon something that already exists. It often requires the creation of a sketch or model, followed by an iterative process of rapid redesign and evaluation of alternatives in order to attain the desired result.

Geodesign combines the best of both of these worlds, providing a new way of thinking that integrates science and values into the planning and design process. In many ways, geodesign is the evolution of GIS, made possible by advances in technology — from so-called "cloud" computing and open data, to distributed networks and sophisticated modeling (Dangermond 2010).

A short definition well suited for planning was given at the American Planning Association's National Planning Conference in 2013: "*Geodesign is an iterative design method that uses stakeholder input, geospatial modeling, impact simulations, and real-time feedback to facilitate holistic designs and smart decisions*" (McElvaney and Walker 2013).

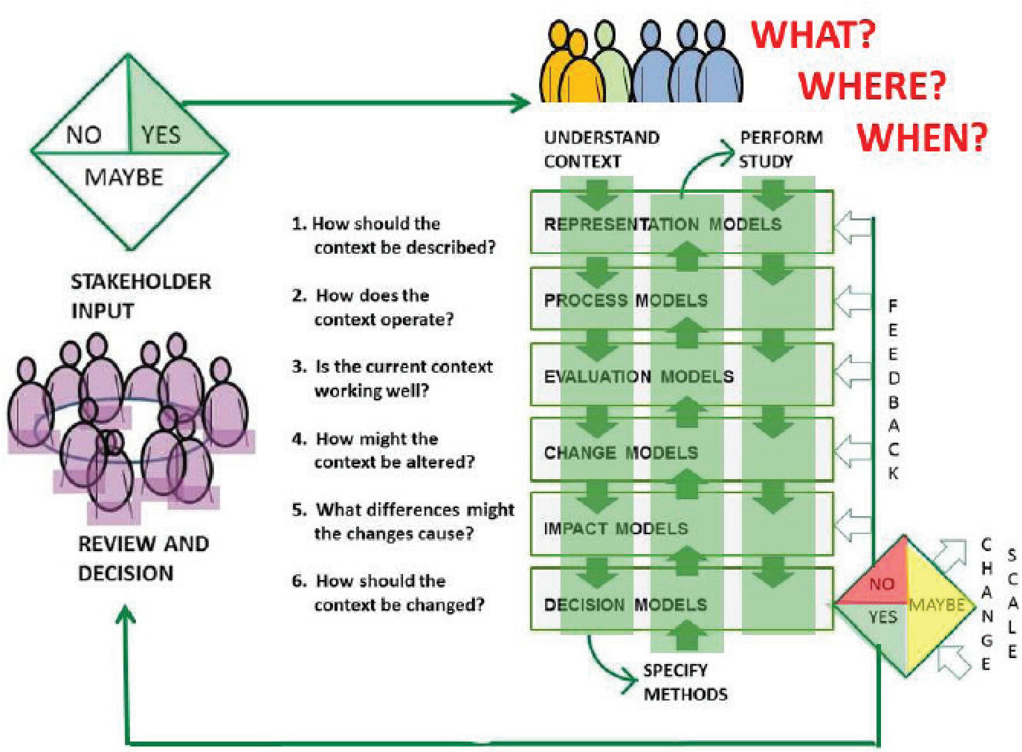
Tom Fisher, dean of the College of Design at the University of Minnesota, states simply that geodesign "marries the data rich, analytic, scientific power of GIS" that allows us to look at what was and what is, with the "creative, speculative power of design" that allows us to look at what could be (Fisher 2014).

In this sense, geodesign is both a *decision support framework* and a *set of tools* that helps planners work collaboratively with a diverse set of stakeholders to make well-informed decisions.

The Geodesign Framework

Carl Steinitz, professor emeritus of landscape architecture at Harvard University's Graduate School of Design, first described how the geodesign framework worked by posing it as a series

Figure 1: *Carl Steinitz's geodesign framework, which uses a series of questions to guide the collaborating participants through the process of geodesign. Courtesy Carl Steinitz.*



of six questions relevant to landscape change (Steinitz 1990). The first three questions describe the world as it is, assessing its condition and whether it is working well or not (the *assessment* process). The last three questions describe the world as it could be, evaluating proposed design alternatives and their impacts (the *intervention* process).

Over time, the framework evolved from a focus on landscape to the more inclusive concept of *geographic context*, which includes the physical, environmental, and social processes one might expect in any given place or area (Steinitz 2012).

Assessment Process

The **first** question, "How should the context be described?" consists of defining the study area's extent and abstracting relevant geography into a series of spatial data layers (e.g., transportation systems, waterways, utilities, building footprints, jurisdictional boundaries, parks and open space, etc.). These can also include imagery, photographs, reports, and other relevant data.

The **second** question, "How does the context operate?" combines geospatial data and the use of spatial analysis and modeling techniques to describe geographic processes and predict how spatial phenomena and processes might change over time. This is where science steps in to define natural and social processes such as erosion and sedimentation, the hydrologic cycle, ecosystem functions, or demographic changes.

The **third** question, "Is the context working well?" involves the creation of composite maps that combine discrete data layers in a way that shows areas that are more favorable than others for certain activities. This is McHarg's overlay method made more powerful through geospatial processing models and tools that create what Steinitz calls "evaluation models" (i.e., that can be used to examine existing conditions and determine whether the current conditions are operating well or not). These take on the form of site suitability layers and other composite maps, often divided into constraints (e.g., earthquake, flood, or erosion hazard zones; protected habitat, etc.), and opportunities (e.g., favorable slopes or soils, proximity to existing transportation systems, etc.).

Typically the assessment phase involves the participation of a diverse set of subject matter experts and stakeholders who are involved in defining issues, metrics, and the proper method of analysis.

Intervention Process

Once the assessment is complete, the *geodesign intervention process* begins. This is where alternative scenarios are developed.

The **fourth** question, "How might the context be altered?" involves the sketching of design alternatives directly onto a geospatially referenced surface or data layer within a GIS application.

The **fifth** question, "What differences might the changes cause?" is answered by the rapid evaluation of the impacts of those changes using the site suitability and other composite maps developed during the assessment process. In the digital world, this feedback consists of real-time or near-real-time impact simulation using dashboards or charts of various kinds.

Finally, the **sixth** question, "Should the context be changed?" integrates considerations of policies (e.g., regulations, capital improvement programs) and values into the decision process. The information produced by the impact models is used to help stakeholders and decision makers weigh the pros and cons of each decision factor so they can weigh alternative solutions and make the most informed decision possible.

Geodesign in Practice

To better understand how geodesign works, imagine assembling a team of diverse stakeholders whose goal is to improve public health by implementing complete street guidelines. A transportation engineer, a biking advocate, a sustainability director, an arborist, a health official, and a city planner all contribute valuable knowledge, including metrics that can be used to measure performance and help guide decision making. A GIS analyst uses this information and the local zoning code to create a set of rules, a kind of city DNA that essentially encodes the team's values directly into how the street might look, feel, and function as they suggest changes. And it is not one size fits all. The rules can be modified or recombined with any number of other factors to allow the impacts of different design variations to be evaluated and discussed.

Esri's CityEngine, a three-dimensional (3D) modeling software application that specializes in the procedural generation of 3D urban environments, is such a city DNA generating tool. The complete streets standards are just one variation built into a set of procedural rules that outline how the road, bike lane, sidewalk, bus stop, and adjoining buildings might perform, much like your DNA instructs a protein to build muscle.

Now imagine picking up a stylus and sketching the initial design for a four-lane boulevard through a new area of town. As you sketch, a "dashboard" (digital chart) provides "on-the-fly" assessment of the economic, social, and environmental impacts of the proposed design, such as:

- Construction and maintenance costs of sidewalks and bikeways
- Storm water runoff and nonpoint source pollution
- Predicted vehicle related deaths and injuries based on a 40-mph speed limit
- Estimates of air pollutants and their impact on health and climate
- Heat island estimates
- Benefits of trees for carbon sequestration and stormwater reduction

All these assessments have one thing in common. They are performed using software that references *geographic space*: precise locations on the earth that are influenced by the natural and built environment. This close coupling of design with geography is what sets geodesign apart from regular design.

In this example, you might conclude from the assessment of the original boulevard design that the number of injuries and the amount of air pollutants are too high. The dashboard further

Figure 2: *Using CityEngine's* [complete streets rule,] *a planner can optimize a street scene across multiple variables such as walkability, bikeability, transit, carbon sequestration, and stormwater infiltration by changing parameters. Courtesy Esri.*

reveals that certain design modifications — shielding pedestrians from vehicles by sketching trees between the road and sidewalk and calming traffic by sketching in curb extensions — lowers the predicted impacts significantly, but not enough. An additional iteration is needed to meet the team's goals.

A decision is made to divide opposing lanes with a median to further decrease vehicle-related death and injury. Someone then recommends changing the median type from concrete to a bioswale planted with trees. These changes are sketched, and the dashboard reveals that the new design reduces runoff, nonpoint source pollution, and air pollutants while also reducing injuries. The trees provide added public health benefits, such as shading of pedestrians and reduction of the urban heat island effect. The geodesign team is satisfied with the latest design.

That is geodesign in practice. It allows the planner to receive near real-time feedback on the impacts of sketch designs or policy decisions from GIS analyses being performed in the background. The vision of the geodesign approach is to provide a fundamental alternative to the way planning and design are currently done, leading towards better solutions, better designs, and a better future.

Geodesign Examples

Geodesign is particularly useful for investigating future development alternatives at the scale of a corridor, campus, or district. However, as projects grow in scale and complexity, so do the analyses. That is where the geodesign framework, empowered by integrative workflows, intuitive design tools, GIS-driven geoprocessing, and feedback dashboards, can help to guide a planning or design project from start to finish.

The specific ingredients of each project will be dependent on the issues, participants, and data; local knowledge, culture, and values; and the geographic context and available technology. The goal is to inform the design process based on the project's geography and history to help designers and stakeholders make the wisest decisions possible, taking into account potential impacts.

Austin, Texas

A good example of geodesign in practice comes from the City of Austin, Texas, which worked with the University of Texas at Austin's Center for Sustainable Development, the Capital Area Council of Governments (CAPCOG), and Civic Analytics (a private planning firm) to evaluate return on investment from the city's proposed urban rail program. The Austin metropolitan area is experiencing rapid growth, and the Imagine Austin comprehensive plan projected that the city and its extraterritorial jurisdiction would add approximately 750,000 new residents and 300,000 new jobs over the 30-year time horizon of the plan (Austin 2012). Issues include housing affordability, traffic congestion, economic development and job opportunities, water availability, walkability, and the infrastructure required to support projected growth.

The study was part of the Sustainable Places Project, a regional initiative administered by CAPCOG with major funding coming from a federal Department of Housing and Urban Development (HUD) Sustainable Communities Regional Planning Grant. Austin's portion of this initiative developed and evaluated scenarios for multiple urban rail corridors proposed in and near the downtown.

The geodesign team utilized Envision Tomorrow (a set of open source software tools originally developed by Fregonese Associates), along with Esri's ArcGIS and CityEngine, to demon-

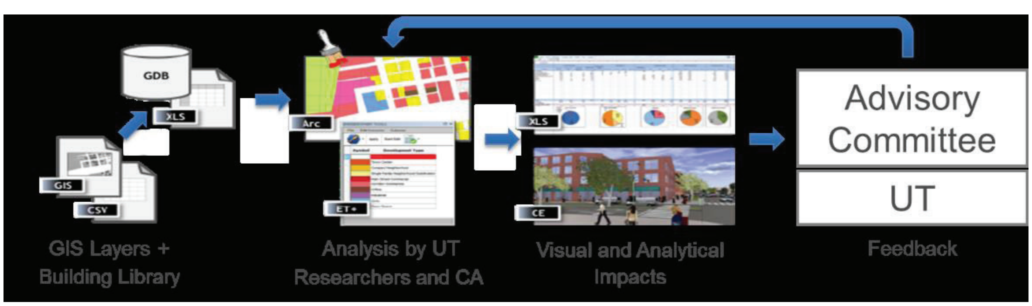


Figure 3: *The geodesign workflow consisted of an iterative design process that included ArcGIS, Envision Tomorrow, and CityEngine (Brigmon 2015). Courtesy Civic Analytics.*

Figure 4: *Fear of the unknown has stopped many a good project from happening. In Austin's geodesign analysis, creating and sharing 3D web scenes allowed the public to get a glimpse of how proposed transit development options might impact their daily lives. Courtesy Civic Analytics.*

strate the impacts of land-use and physical design changes on new city tax revenues, new jobs created, vehicle cost savings from reduced auto trips, affordable housing units created, and parking construction savings. The iterative design process enabled by the analytical power of GIS allowed for key performance indicators (e.g., case tax revenues, jobs created, vehicle cost savings) to be defined and the impacts of scenarios on these indicators evaluated in a real time environment.

Another benefit of geodesign is the communicative power of 3D visualization. The complexity of the many layers of spatial and nonspatial information that can go into a geodesign workflow requires that information be communicated in ways that are easy to understand. As people are visual creatures who see the world in three dimensions, it makes sense that 3D models have the potential to communicate development impacts better than two-dimensional maps. CityEngine was used on the Austin project to build 3D models for each scenario that were then shared with the team, stakeholders, and the public, "completely changing the dynamic of the planning conversation" (Austin 2014).

Austin's Sustainable Places demonstration project illustrates what planning, transportation, and economic development professionals can accomplish together using the geodesign approach and technology. The geodesign analysis concluded that up to $31 billion of new development could occur in the study area by 2030. Among other findings, the study projected that urban rail investment would result in $107 million in annual net tax revenue for the city and 25,000 additional transit trips yielding $296 million in vehicle cost savings by 2030 (Austin 2013).

Menlo Park and Benicia, California

Analytical tools being developed by PlaceWorks, a California-based urban planning and design firm, provide other

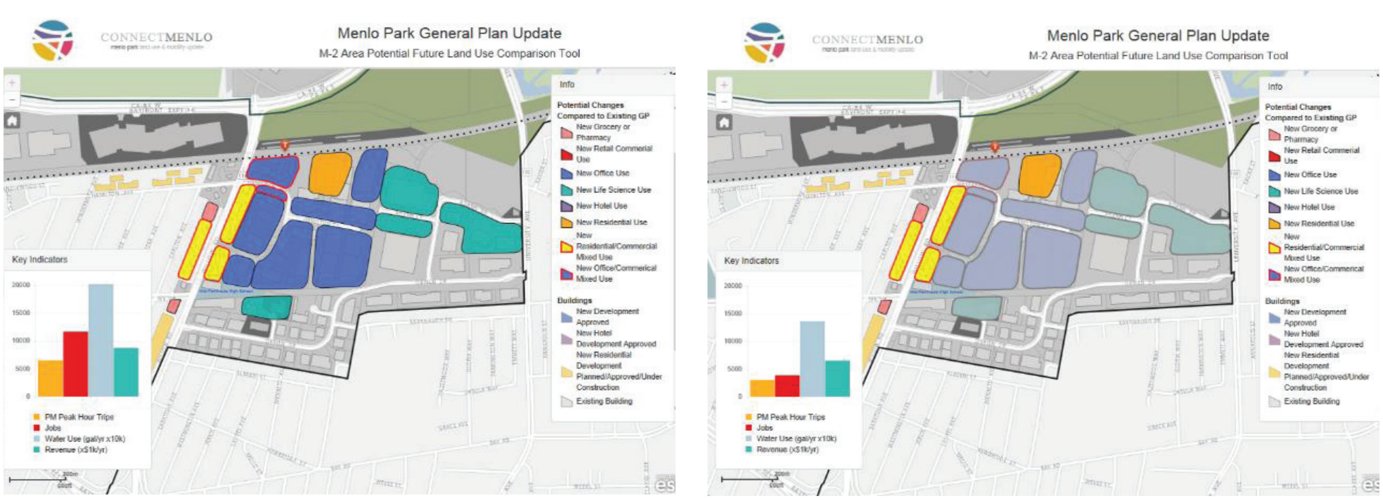


Figure 5: *PlaceWorks created a land-use comparison tool to help the City of Menlo Park examine the impact of land-use choices on jobs, traffic, water use, and revenue. Note the changes in the chart as the land uses change. Courtesy PlaceWorks.*

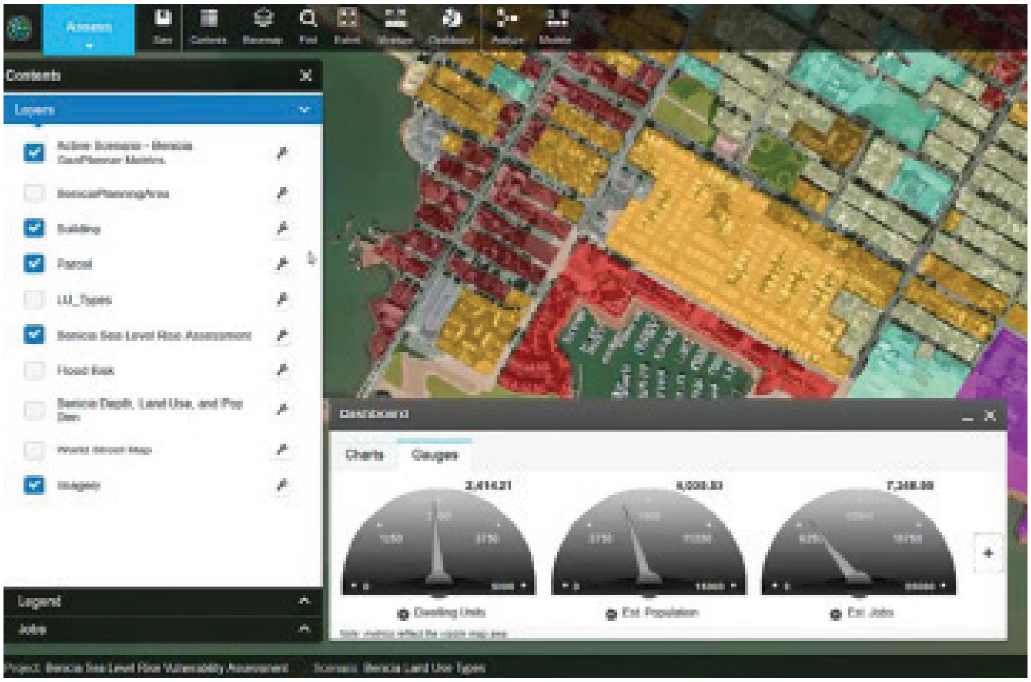


Figure 6: *GeoPlanner supports the entire geodesign workflow, allowing city planners to create, evaluate, and compare scenarios using a configurable dashboard. Courtesy PlaceWorks.*

examples of geodesign in practice. PlaceWorks has developed a proprietary suite of GIS-based tools called GreenScore, which can be used to measure and evaluate the sustainability of an existing built environment or proposed plan. GreenScore comprises about 50 different indicators that a community can choose from depending on its needs.

Placeworks is working with the City of Menlo Park, California, home of Facebook, which is experiencing intense population growth as a result of the growth of the technology industry in the area. For Menlo Park's General Plan, PlaceWorks used Greenscore to track four indicators — traffic, jobs, water use, and the impact on tax revenues — all of which are high priority issues for the city. The customized web application allowed citizens to turn new land uses "on" and "off" on a group of key sites, and then see the impacts of these land-use choices on the four indicators in real time. The project is still under way and evolving, as are the processes used to help the city meet its goals.

Figure 7: *The dashboard uses gauges or charts to display the status of each plan's impact against programmatic goals, for example, areas affected by sea level rise shown in gradations of beige. Courtesy PlaceWorks.*

For another project, in the City of Benicia, California, PlaceWorks utilized GeoPlanner for ArcGIS, a web-based geodesign application built on Esri's ArcGIS Online application, to assess sea level rise vulnerability using projections through 2050 and 2070. City planners wanted to evaluate which areas of Benicia would be affected and what the impact would be on critical facilities, dwelling units, numbers of jobs, and numbers of people. GeoPlanner allowed the city planners to select different land-use designations and view the impacts of these changes across the key indicators using configurable charts and graphs. They could then visually compare future scenarios side by side in a collaborative, iterative process.

A Planner's Guide to Using Geodesign

The basic components of geodesign are well known to planners, who have dealt with geographic analysis and design since the origins of landscape architecture and city planning as one profession in the late 19th century. Today, planners are leading practitioners of GIS and routinely carry out community planning processes similar to Steinitz's geodesign framework. And, after all, city and regional planning is simply design at a larger scale: creating something better through a process of analysis, imagination, and collaboration.

So why is the time right to incorporate this approach into mainstream planning practice? Leveraging rapid advances in digital technology, geodesign has great potential to help planners and allied professionals address increasingly complex challenges — from climate change to economic inequality and declining public health outcomes — through the design process. It can:

- provide an objective foundation of data and analytical capabilities that facilitate transparent decision making;

- integrate the work of planners and other professionals across disciplines and scales of practice;
- set a collaborative framework for exploring issues, resolving conflicts, and achieving buy-in of diverse stakeholder groups;
- empower values-driven citizen engagement by informing choices to achieve community goals; and
- improve efficiency and reduce uncertainty in plan development and implementation by measuring the performance of choices (scenarios) and actions (outcomes).

At this point the reader may be wondering how to apply geodesign in her or his community. An important takeaway is that geodesign does not represent an entirely new approach to planning, but rather a framework based in established practice that can be adapted to different types and scales of projects. The key is to tap the increasing power of GIS technology and accessibility of digital information to inform decision making in developing and implementing plans. Planning departments can accomplish this using in-house GIS capabilities, or by hiring an outside consultant with expertise applying GIS applications to planning processes, or by a combination of the two. A useful way to begin is to conceptualize the project in terms of three basic steps:

1. Define the scope
2. Define the methods to be used to carry out the scope (i.e., the design or planning process)
3. Implement the process

In *A Framework for Geodesign,* Steinitz advises performing three iterations of the six questions, each one helping to define and refine the project's scope and methods so that it is representative of stakeholder values and scientifically defensible (Steinitz 2012). And, of course, the strongest plans, especially those involving community development, are transparent, understandable, and the result of collaboration. The following is a condensed version of the geodesign framework that captures the salient topics covered in greater detail in *A Framework for Geodesign*.

Define the Scope

Start by articulating the issues in a narrative format, for example, "The City of Benicia and its citizens are concerned about the impact that sea level rise could have on jobs, dwellings, and other issues." This is an important first step in defining what Steinitz calls the "Why" questions. In essence, why are you doing this project? This helps participants understand why the project needs to take place, what the issues are, who is affected, what systems are involved, and what their area of impact is.

Project scoping questions include: What is the geographic extent of the project? What processes are involved (e.g., erosion, flooding, hydrology, transport)? What scale or scales do we need to look at? What is the physical, economic, and social history and context of the project area? What locations within the area are seen as attractive or vulnerable? What plans are already on the books that should be considered in the project? What major changes are foreseen? Are they seen as beneficial or harmful? And most importantly, who are the stakeholders, and what is the political lay of the land? Who is supportive of what, and what are the areas of contention?

In many cases, the "positions" of people potentially affected by the project are well enough known so that this first step can be done with a small team. When more information is required, a public survey or engagement process should be conducted as part of project scoping. Commercial citizen engagement applications such as MindMixer, thrdPlace, and others are available to assist in this process, or a custom application could be used to gather information on community positions and values.

At this point it is good practice to write a problem statement based on an understanding of the issues. In the case of the City of Benicia, we could say something like: "How might we improve the resilience (problem) of the City of Benicia (place) by reducing flood risk, improving connectivity, and increasing economic diversity (change)?"

With the problem and stakeholders defined, we now can consider who we might need to include on the geodesign team. A typical team includes any combination of professions, domain experts, issue advocates, and what Steinitz calls "people of the place." In the case of Benicia, the team might consist of a city planner, open space and parks planner, coastal engineer, transportation planner, geologist, emergency response specialist, GIS analyst, local government representative, local community representative, and representative of a local environmental nonprofit.

Define the Methods

Now that you have a good idea of the scope and what the advisory team might look like, you are ready to look at methods and process that will be used to carry out the study (the "How" questions). What do the decision makers need to know to make a decision? What impact will the changes bring about? What impact will doing nothing have? How should the impacts be prioritized? How should they be evaluated? How detailed do the processes need to be and over what timeline? And what data will be needed to support the modeling?

Decision makers are driven by many different values, some personal, some political, some pragmatic. It is important to try and figure out what motivates them. Is it logic, emotion, return on investment, or the desire to leave a legacy? The importance of understanding motivation is often overlooked. In the case of the City of Benicia, let's assume that the mayor and city council make the final decisions, but they can't do it without community support.

In a geodesign approach combining science and community values with analytical data provides the basis for defining the evaluation methods to be used in the project. In Benicia sea level rise would have two deleterious effects related to income: (1) loss of jobs would decrease sales tax revenue, and (2) damage to infrastructure would increase costs in operations and maintenance. Another potential evaluation criterion is degree of risk to public safety from inundation due to future extreme weather events. The current situation puts both citizens and business in danger.

Framing these issues in terms of overall quality of life helps translate numbers into something everybody can readily understand. Now that we know how to define the impact (e.g., tax revenue loss, job loss, property loss), we know what processes to model (e.g., projected sea level rise, flood risk, economic growth) and what data we will need to do that (e.g., coastline, roads, infrastructure, parcels, land use, parks and open space, etc.). We also now have a way to value areas based on their attractiveness or vulnerability.

The important thing before moving to the next stage is that you know what is needed to make a decision, what assumptions the team will use, how impacts will be prioritized and evaluated, what processes will be modeled, what data will be needed, and what strategies are likely to drive the design. Again, this is an oversimplification of a complex process which can have any number of permutations, but the geodesign framework provides the necessary scaffolding for such a process.

Implement the Process

Then comes the time to perform the study, what Steinitz calls the "What," "Where," and "When" questions. GIS plays a central role in this last stage as it forms the platform on which the necessary data are collected, organized, and analyzed. This is the norm for many GIS analyses, no matter what the professional context, but geodesign takes GIS a step further by adding design and impact simulations to the equation.

At this stage, the team gathers the relevant data to support the project considering issues of scale, cost, accuracy, frequency or date, mode of representation, whether 2D or 3D, and format. Today, thanks to a large number of government

Geodesign Resources for Planners

Here are a host of resources on geodesign to help planners learn more about the possibilities of using geodesign to inform and shape planning in their own communities.

The most comprehensive resource on using geodesign for planning is Carl Steinitz's book *A Framework for Geodesign: Changing Geography by Design* (Esri Press, 2012). This book provides a detailed description of the framework summarized in this memo, presents geodesign case studies, and concludes with observations on the future of geodesign.

Additional information on the case study examples described in this Memo may be found at the following websites:

- Austin: Watch a video explaining and illustrating the geodesign process Austin used at www.youtube.com/watch?v=ne5rxVmnbbE&feature=youtu.be
- Benicia and Menlo Park: David Early of PlaceWorks describes the geodesign tools used in Benicia and Menlo Park at http://video.esri.com/watch/4164/geodesign-tools-for-planners

The Geodesign Summit is an annual gathering of planners, urban designers, landscape architects, engineers, scientists, and other professionals interested in using geospatial technologies to arrive at the best and most sustainable design solutions. The videos from the last five events are here:

- 2015 Geodesign Summit: http://video.esri.com/series/225/2015-geodesign-summit
- 2014 Geodesign Summit: http://video.esri.com/series/169/2014-geodesign-summit
- 2013 Geodesign Summit: www.youtube.com/playlist?list=PL1U1yOIVhnz8i1li8SyE9iyf2Es4ewwXe
- 2012 Geodesign Summit: http://video.esri.com/series/66/2012-geodesign-summit
- 2011 Geodesign Summit: http://video.esri.com/series/13/2011-geodesign-summit
- 2010 Geodesign Summit: http://video.esri.com/series/5/2010-geodesign-summit

Other very good geodesign resources include the videos, e-books, and bibliography below:

- Geodesign at TED2010: http://video.esri.com/watch/125/jack-dangermond-talks-about-geodesign-at-ted2010
- Geodesign: Past, Present, and Future: www.esri.com/~/media/Files/Pdfs/library/ebooks/geodesign-past-present-future.pdf
- Geodesign in Practice: Designing a Better World: www.esri.com/~/media/Files/Pdfs/library/ebooks/geodesign-in-practice.pdf
- Introducing Geodesign: The Concept: www.esri.com/~/media/Files/Pdfs/technology-topics/introducing-geodesign.pdf
- Geodesign: a Bibliography: http://gisandscience.com/2009/08/13/geodesign-a-bibliography/

Finally, software applications are key in allowing planners to apply the geodesign approach to their planning processes. More information abou t the following programs mentioned in this Memo may be found here:

- Esri CityEngine: www.esri.com/software/cityengine
- Esri GeoPlanner for ArcGIS: www.esri.com/software/geoplanner-for-arcgis
- Esri ArcGIS Pro: http://pro.arcgis.com/en/pro-app/
- Esri ArcGIS Online: www.esri.com/software/arcgis/arcgisonline
- PlaceWorks GreenScore: http://placeworks.com/greenscore/
- Envision Tomorrow: www.envisiontomorrow.org/about-envision-tomorrow/

agencies with "open data" policies, there are many free data sets to choose from. The federal government makes a large amount of 1:24,000 scale data available, while many cities and counties provide access to higher-resolution data suitable for community planning, including LiDAR data and 3D models of buildings.

Process models describing how systems within the project area work in scientific terms are then built and calibrated against historic data or real-time sensors. For example, projected sea level rise is derived using a place's elevation, bathymetry, coastal ecosystems, and a variety of climate change models to model potential inundation zones. These, in turn, are used to evaluate potential hazards and assess future impact. It is important to gather both historic and current data so that a baseline can be established. Future trends can then be compared against the baseline using the indicators and assumptions agreed upon by the geodesign team working with the stakeholders.

Various design options (scenarios) are then created, each one receiving instant feedback from the process models already set in place. These impact simulations provide valuable information to the designers while in the act of designing, informing each design with valuable data about that place. It takes the guesswork out of the planning process and provides a means for open discussion of design alternatives.

Soliciting feedback on priorities is essential to defining strategies associated with the various design options. For example, what do we need to protect (defensive) versus what do we need to build (offensive)? In this case, one defensive/offensive strategy would be to protect property and life by constructing new wetlands (to decrease the intensity of storm surge) while increasing the amount of parks and open space in future inundation zones (to decrease property damage and job loss). Any number of proposed designs could be put forward, such as to build a seawall or a system of dikes and pumps, but each would be evaluated against the same criteria.

But what if you get a "maybe" — or a "no" — from the decision makers in response to the recommended design and strategy that result from the scenario process? Part of the power of the geodesign framework is that it helps the team to respond to any situation. For example, additional questions could arise: Where might we acquire more land? What if we increase density in a smaller area? And what effect might this have on housing affordability? Such questions could be addressed by repeating the analyses, either to gather more information (e.g., available land) or to change an evaluation criterion (e.g., increase acceptable land use density).

Or perhaps the question requires changing the scale of the project, for example: "How might sea level rise affect accessibility to the metropolitan area anywhere along the route between Benicia and San Francisco?" Since all the work is done in the GIS, changing scale or adding new information or criteria – and visualizing the resulting outcomes — can be rapidly accomplished.

It is important to note that no planning process is without surprises, nor is any planning process entirely linear. As Steinitz puts it, "An advantage of having a clear, succinct, and robust framework is that the geodesign team always knows where it is in the overall process and can more efficiently regroup and restart, if needed — and in an efficient and collaborative manner" (Steinitz 2012, 88).

Conclusion

It is becoming increasingly clear that the world is changing faster than our institutions are able to respond. It is also becoming clear that our previous ways of thinking and working on problems piecemeal through "silos" of practice are outmoded. As former New York City Mayor Michael Bloomberg, now special envoy to the United Nations, noted at the 2014 World Urban Forum in Medellin, "The norms that guided the planning of the past, no longer apply." He was speaking in reference to climate change, extreme weather, and sea level rise, but the implications go much further: the fundamental message is that "business as usual" is no longer feasible.

From a planning perspective, Bloomberg's remark implies that the norms of the past — building codes, policies, and regulations — that protected human life and property may no longer be up to the task. More broadly, it implies that planning practices rooted in the 20th century may no longer be adequate to address 21st century problems. If we are to make smart, livable, and resilient cities, we need to reexamine our assumptions and reboot our thinking about what it means to plan for a rapidly evolving world.

We need to take a systems approach to planning and calculate the cumulative impact of many small acts across disciplines, departments, agencies, and sectors of society. We need clear planning guidance for how to deal with environmental, economic, and social change while allowing flexibility for each community to innovate in addressing its unique values and circumstances. We need tools to help us minimize risk and make more efficient use of our resources. We need applications that help us diversify and strengthen our local economies, improve individual and community health, and build redundancy into our many systems, from transportation to the basic necessities of shelter, food, and water.

Geodesign is about one community thinking across scales. A building does not stand alone, but is part of a neighborhood, city, region, nation, and even the globe. This type of integrative thinking and awareness of the effects of collective actions is the planning of the future. With geodesign, planners can simulate any number of futures, define and communicate the impacts of choices, and, as Jack Dangermond said at the 2015 Geodesign Summit, help us "create the future rather than be at its mercy."

Geodesign is a potentially powerful tool to apply to the comprehensive planning process. A forthcoming supplement to this Memo will address the application of geodesign across scales of planning practice, with a particular focus on the comprehensive plan.

About the Authors

Shannon McElvaney is the community development manager at Esri and a professed geodesign advocate working on developing *tools that will enable people to design, build, and maintain livable, sustainable, and resilient communities. He has more than 20 years experience applying geospatial technologies across a variety of industries and is the author of* Geodesign: Case Studies on Regional and Urban Planning*. He can be reached at* *geodesignsummit.com* *or at* *smcelvaney@esri.com*.

David C. Rouse, AICP, is managing director of research and advisory services for the American Planning Association. In this *position, he oversees the Planning Advisory Service and the three National Centers for Planning: Green Communities, Hazards Planning, and Planning and Community Health. Prior to joining APA in 2013, he was a principal at WRT, a nationally recognized planning and design firm.*

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