Memos and Mega Projects

Applying Planners' Perceptions of Their Software to a Framework for the Future of Planning

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Richard L. Davis

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All errors are entirely my own.

The font used in this report is Charis SIL.

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Executive Summary

Software powers the modern urban planning department. However, the majority of academic attention on software in the planning profession has focused on highly specialized land use models, ignoring the importance of common applications that most planners rely upon throughout their workdays. For example, email's impact on planning has gone largely undiscussed in the literature despite its role as one of the most commonly used software by planners. This report has a twofold purpose: 1) create a protocol for interviewing planners about the software they use routinely; 2) synthesize needs and expectations of planners gathered during interviews with relevant literature on planning technologies into a framework for the future of planning software. The framework presented in this report unifies, for the first time, disparate fields of research on software related to urban planning into a single set of guidelines for developing the future of software for public agencies. This framework provides a research agenda for urban planning software systems that mutually strengthen one another, and a valuable conceptual overview of the diverse information systems involved in the planning profession.

Eleven interviews were conducted with mid- and senior-level planners in local governments across Santa Clara County, better known around the world as Silicon Valley. Santa Clara County was selected as the study area for two reasons: well-resourced governments in the area can invest in modern planning software, and to question if the stereotype of the area's technological leadership extends to its local governments. Senior-level planners were interviewed in a semi-structured format with the interview adjusted based on a short survey about the software most used in the individual's professional role (such as email, a permit

tracking software, and ArcGIS Online). Key findings from the interviews informing the framework include:

- Planners in local governments in Silicon Valley are transitioning into modern software tools, like electronic plan review and permit management systems. There is no special technological advantage in Silicon Valley among public agencies. Planners were eager to fully implement and adopt software features available to them, particularly features that would improve communication about project status with applicants;
- Planners were unafraid of software automation. Limited automation features available in electronic plan review systems were yet to be fully implemented, and planners embraced the time-saving potential;
- The volume of email burdened interviewees. This draws attention to the significance of generalized productivity software in the practice of planning;
- Planners had no immediate need for "big data," despite the recognized importance of big data in the urban planning technology literature.

Perceptions from planners about the software that they use informed key problems and set goals for the framework developed here. Extensive research into emerging software targeting the construction and engineering trades with relevance to planners, as well as software designed to assist creative knowledge workers, informed the development of the future framework for planning software. Features of the framework include:

- A planning data model that underpins land use codes, development guidelines, and planning department procedures, providing machine-readable logic that underpins rule-based systems in email, project tracking, permit management, electronic plan review, and staff reports;

- Template-based and data type-aware word processing that encodes standardized practices for writing documents and requires numeric data be stored and represented as such.
- Electronic plan review systems that assist in checking both objective zoning codes and subjective design guidelines using generalized adaptable rule language;
- Integrated BIM-GIS supporting both the plan review and permit management process by organizing and visualizing spatial and physical data about the built environment; and
- Predictable, structured times to respond to email from applicants and the public and process-integrated calendars that recover time for focusing on long-term planning efforts;

The generalized productivity software that planners have been using for over thirty years is inadequate for the predicted era of big data generated by networked urban environments. Excel is not designed to support real-time analytics, Word is not designed to assist in describing or associating analytics with textual information, and no application has yet been designed to visualize or organize such data for engaging the public. This framework gives planners and researchers of planning technology insight into the range of software used by planners and develop an innovative class of software fit for stewarding the cities of the coming century.

The primary contribution of this report to the planning literature is the framework for advanced planning software. Future research may be directed towards bridging the literature on software for public outreach (social media or e-government) and planning support systems with the framework. In addition to the framework, this report offers a model protocol for interviewing urban planners about their professional software, encouraging follow-up studies in different institutional settings.

Chapter 1. Introduction

Background

Over the past thirty years, urban planning, like virtually all other professional disciplines, has become mediated by software. Communicating with the public, managing appointments, analyzing property data – administrative or technical tasks that were once handled on paper, in passing in the department hallway, or in conversation at the planning desk have largely been computerized. Demands on planners have also increased over the past thirty years as the pace of urban development has intensified. Computers have allowed architects and engineers to produce intricate schematics more quickly, the public has more channels to communicate with planners, and decision-makers expect planners to provide more quantitative data to support their recommendations.

Software shapes the practice of the profession. Email impacts how planners communicate with the public and elected officials. Permit management systems help planners share the status and condition of urban assets with their colleagues across departments. Electronic plan review systems allow planners to provide clearer, more precise feedback on plan sets sand identify violations of city policy with fewer oversights and in less time. Despite the importance of enterprise software to the urban planning profession, it has largely escaped academic attention.

Planners wear many hats as communicators and analysts.[1] The role of communicator is multifaceted, with planners variously performing as educators, negotiators, and enforcers of the

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[1] Simin Davoudi, "Planning as Practice of Knowing," Planning Theory 14, no. 3 (2015): 316–31, https://doi.org/10.1177/1473095215575919.

municipal code.[2] At senior levels, planners may be tasked with defending controversial recommendations on projects to decision-makers and the public. All planners act as stewards of their local government's plans and ordinances, helping the public understand how they can develop their communities within the limits of the law. These tasks can never be automated out of existence. However, software can automate out certain time-consuming aspects of the profession that have been inflicted by the rise of computerized communication and design.

Planning departments across the United States have undertaken a landmark transition from traditional paper-based plan reviews and permitting processes to digitized systems that partially automate plan set checking and inter-departmental coordination. Where implemented, these new systems have been adopted and customized to each department's specific procedures and local rules, at significant financial cost and expended staff time. During this transition, an entirely new generation of urban information systems has emerged. Scholars anticipate the future growth of urban environments to be driven by vast amounts of diverse types of data collected with high precision and often in real-time.[3] Engineering and construction researchers have begun developing prototypes and theoretical models that will automate complex analytics of the physical built environment. A new class of software capable of marshalling the data-rich built environment of the future into a coherent body of information that supports public goals for land use has yet to be described. Therefore, it is timely to theorize how the next generation of urban information systems could support the planning profession.

[2] Joongsub Kim, What Do Design Reviewers Really Do? Understanding Roles Played by Design Reviewers in Daily Practice (Springer Nature Switzerland, 2019).

[3] Michael Batty, Inventing Future Cities (Cambridge, MA: MIT Press, 2018), 182–93.

Study Overview

This report examines the wide range of software used by public sector urban planners with the aim of developing an idealized framework for the future of planning software. The research is based on in-depth interviews with a sample of eleven planners in various job titles and levels of seniority from several local governments in Santa Clara County.

Santa Clara County, better known around the world as Silicon Valley, faces peculiar challenges that should make it a subject of interest to planning generally. For example, Cupertino is a mid-sized Silicon Valley city (pop. 60,000), best known for being home to the headquarters of the world's most valuable company, Apple, Inc. The planning department faces an extraordinary range of projects, from mega-structures like Apple Park, to mixed-use development streamlined by California state housing regulations to small home-improvement projects with hand-drawn plan sets. Experiences from planners in these well-resourced local governments may contain insights that could help planners in less well-resourced departments prepare for the software they may eventually acquire. The study sets out to answer two questions:

- Can the everyday tasks and long-term challenges faced by the planning profession be addressed more effectively through improved software?
- How can the perceptions of planners about the software they use inform new software tailored to their role as communicators and decision-makers in complex urban settings?

Responding to the first question motivates the literature review and interview protocol. The framework developed for this report responds to the second question, incorporating data from the interviews and literature review.

I approached these questions with the following theoretical assumptions about the relationship between urban planners and their software:

1) Planners can express ways that their software is adequate and inadequate;
2) Planners feel that the software they spend the most time in has not improved;
3) Planners find the need to communicate existing data, particularly legal information, more cumbersome than any lack of data.

The study draws upon semi-structured interviews to capture planners' perceptions directly. As discussed in greater detail in the conclusion of this report, this approach comes with several notable limitations. However, it is a pillar of design to understand the needs of the end user. Further, there is some historical interest as many planners are adjusting to the digitalization of the plan set review process.

The Need for This Study

This report aims to use perceptions from planners in Silicon Valley to outline a practice gap between the profession and its software. The literature on urban planning software emphasizes planning support systems, what they are and how they can be made to better meet land use forecasting needs. Examples of planning support systems vary widely, from tools designed to enhance walkability[4] to better planning for green infrastructure[5]. Planning support

[4] Claire Boulange et al., "Improving Planning Analysis and Decision Making: The Development and Application of a Walkability Planning Support System," Journal of Transport Geography 69 (May 1, 2018): 129–37, https://doi.org/10.1016/J.JTRANGEO.2018.04.017.

[5] Martijn Kuller et al., "Building Effective Planning Support Systems for Green Urban Water Infrastructure—Practitioners' Perceptions," Environmental Science and Policy 89, no. June (2018): 153–62, https://doi.org/10.1016/j.envsci.2018.06.011.

systems themselves are not widely adopted[6] and characterizing the planning support system as a major software tool of urban planning ignores the reality of practice. Planners' perceptions of their software, which includes familiar programs like Excel and Outlook, do not appear in the literature. A need has been established for research on PSS that focuses on practical applications, rather than the technologies themselves.[7] This report extends this pragmatic, practice-oriented calling towards the full range of practitioner software. Planners take on diverse roles depending on the needs of their department, but all of these roles are mediated digitally, resulting in the term "e-planning."[8] The technical burden incurred by software necessary to run complex models for legally required studies has contributed to the rise of private policymaking through consultants.[9] Capturing perceptions from city staff on how software affects their range of tasks could reveal fundamental concepts for designing a software platform suited to the complexity of urban planning.

This report focuses on widely used software systems relevant to practitioners. The voices of planners are also rarely heard in the literature,[10] and what little attention is paid to planners' perceptions of their software is focused on specialized long-range or strategic planning software (i.e. planning support systems). As the interviews summarized in this report

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[6] Guido Vonk, Stan Geertman, and Paul Schot, "Bottlenecks Blocking Widespread Usage of Planning Support Systems," Environment and Planning A 37, no. 5 (May 1, 2005): 909–24, https://doi.org/10.1068/a3712.

[7] Marco te Brömmelstroet, "Towards a Pragmatic Research Agenda for the PSS Domain," Transportation Research Part A: Policy and Practice 104 (October 1, 2017): 77–83, https://doi.org/10.1016/j.tra.2016.05.011.

[8] Ernest R. Alexander, "'Planning' or e-Planning?," International Journal of E-Planning Research 3, no. 1 (2014): 1–15, https://doi.org/10.4018/ijepr.2014010101.

[9] Tyler A. Scott and David P. Carter, "Collaborative Governance or Private Policy Making? When Consultants Matter More than Participation in Collaborative Environmental Planning," Journal of Environmental Policy & Planning 7200 (2019): 1–21, https://doi.org/10.1080/1523908X.2019.1566061.

[10] Tuna Tasan-Kok et al., "'Float like a Butterfly, Sting like a Bee'*: Giving Voice to Planning Practitioners," Planning Theory and Practice 17, no. 4 (2016): 621–51, https://doi.org/10.1080/14649357.2016.1225711.

clearly indicate, widely used productivity software, particularly email, shapes the experience of the profession much more. Researchers should devote more attention to the holistic interaction between software used by planners to improve urban planning practice. Practitioners might benefit from hearing their concerns expressed in the interviews and recognizing the value of research in overcoming these concerns.

Report Overview

The report proceeds as follows:

Chapter 2 defines critical software in the context of the planning profession, including generic productivity software such as Microsoft Word and Adobe PDF and specialized software such as electronic plan review. A brief introduction to emerging software is also provided.

Chapter 3 presents an overview of the academic literature on the role of software in the planning profession currently, and the potential for planning software, particularly stemming from "Smart city" discourse.

Chapter 4 describes the interview methodology.

Chapter 5 summarizes the interview findings.

Chapter 6 presents the framework for the future of planning software in light of planners' perceptions of their current software.

Chapter 7 reflects on the interview protocol developed for this report, discusses limitations of this study, and suggests future directions for research.

Chapter 2. The Tools of Planning in the Modern Planning Department

Substantial scholarly attention has been dedicated to the application of GIS and its potential in urban planning. In reality, the practical tools of planning are much broader. This chapter provides an overview of the range of software used in modern planning departments, defining them in the context of their use. An overview of the concepts of "small data" and emergent "big data" is also provided. These definitions form the background for concepts discussed in the literature review and interview findings chapters of this report. More importantly, this chapter offers a panoramic view of the information technology used in urban planning.

Although readers may be familiar with software discussed in this chapter, such as Microsoft Word and ESRI ArcMap, descriptions are provided in the context of their use for planners as public communicators, advisors to decisionmakers, and administrators. The productivity effects of software on planners remains understudied, despite the essential role of desktop software in the routine tasks and long-term projects of planners. Similarly, the diversity, quality, and management of data used in planning departments remains understudied, despite the growing body of literature on smart cities and government decision making driven by urban big data. The latter portion of this chapter describes what traditional "small data" is, how it is used in planning and administration, and the potential for "big data" in urban development.

Supporting technologies, operating systems, browsers, and server infrastructure, have been omitted since they are not directly used for planning. While planners certainly use browsers to access information, planning work is not done directly using these tools. Differences between one browser or another would not impact their work. Supporting server hardware and backend data infrastructure constrains the technology available to planners; reviewing the literature on hardware supporting public administration requires technical treatment outside of the scope of this report.

Types of Planning Software

Generalized Software

Collaboration and Project Management

Urban planning requires the input of department colleagues, members of the public, private sector counterparts, and public officials for the design of plans and written statements.[11] This section presents software in alphabetical order.

Calendars

Calendars record staff schedules, task timelines, and time-critical project-management information. Important dates relevant to a department may be managed by an administrator and subscribed to by effected staff. Individuals may add their own tasks and timelines to the calendar at their workstation.

Example applications: Microsoft Outlook, Google Calendar, Apple iCal

[11] Robert Laurini, Information Systems for Urban Planning (London: Taylor & Francis, 2001), 220.

Email

Email is a popular form of exchanging text, pictures, and documents over the Internet through personally registered accounts. One of the defining features of email is that it is a form of asynchronous communication, allowing responses between participants in a conversation at various times. By comparison, traditional telephone calls are a form of synchronous communication, where a conversation happens in real time. A widely-cited 2004 diary study of information worker activities found that 23% of all tasks performed by information workers during the day were related to email.[12] Riggs & Gordon (2017) found in their survey study of the mobile applications used by California planners that that 99% of planners used email, 94% used mobile email, and 82% used email most often out of all mobile applications, even more than search engines.[13] Emails are known to be distracting to task performance, with regular interruptions contributing to work-related stress and a higher potential for angrily-toned email messages.[14] One recent study has identified a potential for re-organizing the email interface around separating messages with tasks (messages that need replies) and information (notifications), and integrating virtual activities with real environments.[15]

Example applications: Microsoft Outlook, Gmail, Apple Mail

[12] Mary Czerwinski, Eric Horvitz, and Susan Wilhite, “A Diary Study of Task Switching and Interruptions,” in CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2004), April 24-29, 2004, Vienna, Austria., vol. 6, 2004, 175–82, https://doi.org/10.1145/985692.985715.

[13] William Riggs and Kayla Gordon, “How Is Mobile Technology Changing City Planning? Developing a Taxonomy for the Future,” Environment and Planning B: Urban Analytics and City Science 44, no. 1 (2017): 100–119, https://doi.org/10.1177/0265813515610337.

[14] Fatema Akbar et al., “Email Makes You Sweat : Examining Email Interruptions and Stress with Thermal Imaging,” in CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4 - 9, 2019, Glasgow, Scotland UK., 2019, 1–14.

[15] Thomas Bertrand, Laurent Moccozet, and Jean Henry Morin, “Augmented Human-Workplace Interaction: Revisiting Email,” Information Visualisation - Biomedical Visualization, Visualisation on Built and Rural Environments and Geometric Modelling and Imaging, IV 2018, 2018, 194–97, https://doi.org/10.1109/iV.2018.00042.

Instant Messaging

Instant messaging is intended for short-form communications between collaborators who may have information or supportive advice. Instant messaging can happen on a networked application on a personal computer or through a cellular network, typically called text messaging. Staff members may communicate with the public through instant messaging, and these messages are considered part of the public record.

Example applications: Slack, Google Chat, Apple iMessage

Shared Cloud Drive

A shared cloud drive is a remotely managed, virtually limitless capacity file system (a cloud drive) that allows collaborative access and manipulation of many large files. Staff and administrators may use shared cloud drives to work collaboratively on complex documents or presentations. The public may use a shared cloud drive to access template administrative documents, administrative records, scans of paper documents, and open data.

Example applications: Dropbox, Box, OneDrive

Teleconferencing

Teleconferencing systems facilitate simultaneous multi-party meetings, similar to traditional phoneline teleconferencing lines, with video or computer screensharing and high-clarity voice-over-Internet Protocol audio transmission. Teleconferencing systems support ongoing cooperation on complex projects with internal and external stakeholders.

Example applications: Zoom, Uber Conference, Skype for Business

Productivity Software

Urban planning requires thorough written examination of urban policy issues and the recording of findings related to decisions on urban development. The same productivity software used in many professions for the presentation of text and imagery and the manipulation of quantitative and qualitative data have seen nearly universal use in the planning profession.

Word Processing

Word processors store and format text and allow for the basic manipulation and positioning of supplemental visual material, such as pictures or tables. According to Yeh (1988), word processors are highly applicable to the core tasks of urban planning, which in his framework of urban planning includes ordinance enforcement and liaison with the public and decisionmakers.[16] Three types of routinely created planning documents, internal memos on practices, staff reports, and draft long-range plans, are all developed on word processors. The basic services provided by the word processors, storing and formatting text for presentation, have changed little since the mid-1990s.

Example applications: Microsoft Word, Google Docs, LibreOffice Writer

PDF Readers

PDF readers display and may allow annotation on digital documents that use the PDF standard. Plan sets, policy documents, and informational materials may be distributed as PDFs.

[16] A Gar-On Yeh, "Microcomputers in Urban Planning: Applications, Constraints, and Impacts," Environment & Planning B 15, no. 3 (1988): 241–54, https://doi.org/https://doi.org/10.1068/b150241.

Broadly, there are two types of PDF readers: free PDF readers with basic feature sets, and premium PDF readers with suites of tools for annotating and revising a range of documents.

Planners may use premium PDF readers to alter documents rather a desktop publishing tool or word processor. The Principal Planner/Planning Manager of Cupertino's civil deposition in the referendum on the Vallco Project Piu describes how an accident using Acrobat Pro impacted the General Plan resolution reviewed by the City Council.[17]

Many electronic plan review protocols accept PDFs as their intake format. Planners may use comment tools available in free PDF readers with limited feature sets to annotate submitted plans. Planners with premium PDF readers may draw on the document in addition to commenting. Specialized electronic plan review systems (described below) integrate PDF readers with features that automate some of the checks that a planner might manually make on a plan set.

Example applications: Adobe Reader DC, Adobe Acrobat Pro DC, Microsoft Edge PDF Viewer

Spreadsheets

Modern spreadsheets store numeric and text data as a table and can perform mathematical calculations, statistical analyses and simple modelling. For planners, most of the data stored in spreadsheets is administrative, originating from a census or other periodically updated descriptive records.[18] Spreadsheets may be used to track the status of physical assets, for example whether a property is vacant or not, or the last pavement date of a road segment. Spreadsheets may also be used to develop special tools. For example, San José makes public its

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[17] "Referendum Petition Against City of Cupertino Resolution No. 18-085: Declaration of Piu Ghosh" (Superior Court of the State of California County of Santa Clara, 2019).

[18] Laurini, Information Systems for Urban Planning, 71–72.

Excel spreadsheet-based tool to model the VMT impacts of new construction based on an address input and user-selected variables related to transportation impacts.[19] Over time, these spreadsheets expand and evolve. Spreadsheets expand when more data is added, either by the digitization of paper records or findings about physical assets from public works officials. Spreadsheets evolve when technical guidance on formulas used to interpret the data changes[20], or when there is a mandate to interpret the data differently, such as the switch from Level of Service to Vehicle Miles Traveled to determine environmental impacts due to development. Spreadsheets are known to be error prone. Errors in spreadsheets have been found to contribute to incorrect decisions made in enterprise and the public sector.[21]

Spreadsheet software implement a limited set of instructions for the creation of formulas and a programming language for the creation of more complex models and tools to manipulate data entered into the spreadsheet. Microsoft Excel, the most popular spreadsheet application uses Visual Basic for Applications (VBA) as its programming language. VBA has notable flaws that have led to persistent errors in spreadsheets.[22] Researchers have been developing new paradigms for more easily maintainable spreadsheets,[23] automated

[19] City of San Jose, "City of San Jose VMT Evaluation Tool," last updated 2/28/19. Retrieved from: http://www.sanjoseca.gov/DocumentCenter/View/75866.

[20] Bas Jansen, Felienne Hermans, and Edwin Tazelaar, "Detecting and Predicting Evolution in Spreadsheets-a Case Study in an Energy Network Company," Proceedings - 2018 IEEE International Conference on Software Maintenance and Evolution, ICSME 2018, 2018, 645, https://doi.org/10.1109/ICSME.2018.00074.

[21] Stephen G. Powell, Kenneth R. Baker, and Barry Lawson, "Impact of Errors in Operational Spreadsheets," Decision Support Systems 47, no. 2 (2009): 126–32, https://doi.org/10.1016/j.dss.2009.02.002.

[22] Sohon Roy, Arie Van Deursen, and Felienne Hermans, "Perceived Relevance of Automatic Code Inspection in End-User Development : A Study on VBA," in Evaluation and Assessment in Software Engineering (EASE '19), April 15–17, 2019, Copenhagen, Denmark. (New York, NY, USA: ACM, 2019), 1–10.

[23] Patrick Koch, "Now You're Thinking With Structures: A Concept for Structure-Based Interactions with Spreadsheets," in Proceedings of the 5th International Workshop on Software Engineering Methods in Spreadsheets, 2018, http://arxiv.org/abs/1809.03435.

visualization tools for spreadsheet data[24], and spreadsheet-word processor hybrids for data-intensive documents[25].

Example applications: Microsoft Excel, Google Sheets

Presentation Design

Presentation design software organizes text and supplementary graphics using the format of the slideshow to communicate information on a topic. Presentations by staff on new ordinances, policies or major projects are often supported by a slideshow.

Example applications: Microsoft PowerPoint, Apple Keynote, Prezi

Desktop Publishing

Desktop publishing software combines basic word processing with highly customizable what-you-see-is-what-you-get page design capabilities for handouts, fliers, reports, and other visually appealing informational documents. Planners may use desktop publishing software to create materials about new ordinances, major projects, or referenda. Certain large-format materials, particularly public notification posters for upcoming projects, may be designed in a desktop publishing software or a graphics editing software.

Example applications: Microsoft Publisher, Adobe InDesign

[24] Yun Wang et al., "DataShot: Automatic Generation of Fact Sheets from Tabular Data," IEEE Transactions on Visualization and Computer Graphics - Early Access, 2019, https://doi.org/10.1109/tvcg.2019.2934398.

[25] "Stenci.la," accessed November 6, 2019, https://stenci.la.

Graphics Editing

Graphics editing software directly manipulate computer representations of visual images. Maps may require minor touch-ups, modifications, or annotations that are easier for a planner to make in a graphics editing software than in the mapping software itself. Graphics editing software may occasionally be used to produce visual aids for presentation to the public.
Example applications: Adobe Illustrator (vector graphics), Adobe Photoshop (pixel graphics)

Generalized Software for Land Use Management

Code and Ordinance Archives

Code and ordinance archives are websites, not standalone desktop software. Code and ordinance archives serve as a repository for a local government's legal code. Legal resource hosting is not interactive. Rather, planners (and the public) access online archives through their web browser. Urban planners refer to development codes and ordinances that control the rights of way, zoning, subdivisions and other divisions of land, business regulation, among many other code types. Legal resources are typically stored as text with hyperlinks to other relevant parts of the document. The ability to perform a search for text on the web page makes browsing the legal resource more convenient than using a local government's official paper copy of the legal code, which is technically the binding record of local law.
Example hosts: American Legal Publishing, MuniCode, Code Publishing Co.

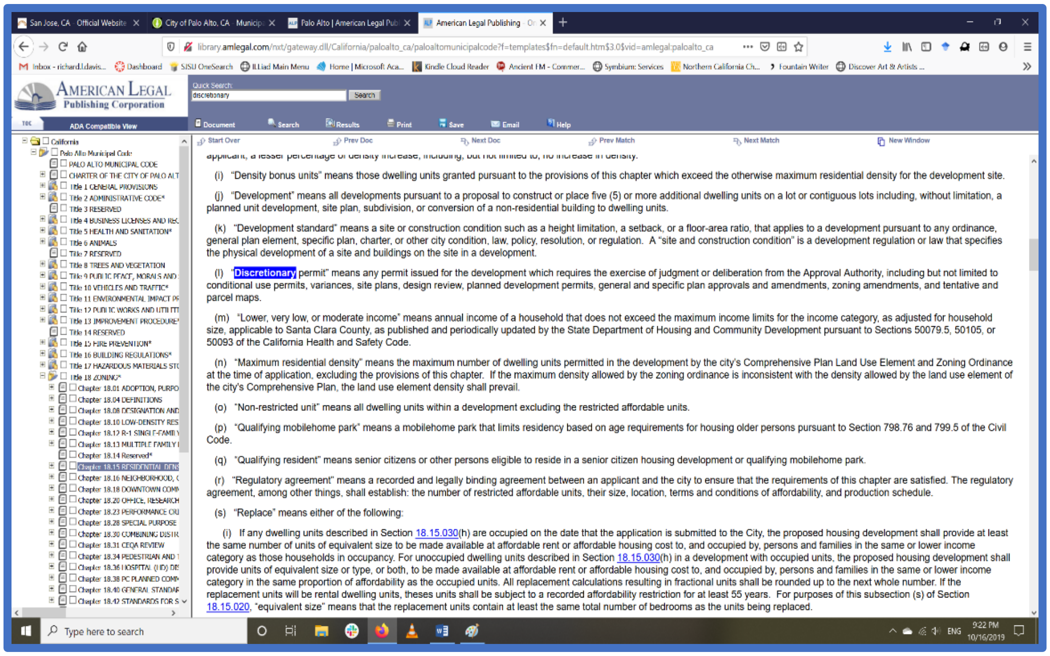

Figure 1. Palo Alto's Municipal Code of Ordinances online, hosted by American Legal Publishing. *Source*: City of Palo Alto, "City of Palo Alto Municipal Code," https://www.amlegal.com/codes/client/palo-alto_ca/ (Accessed October 16, 2019).

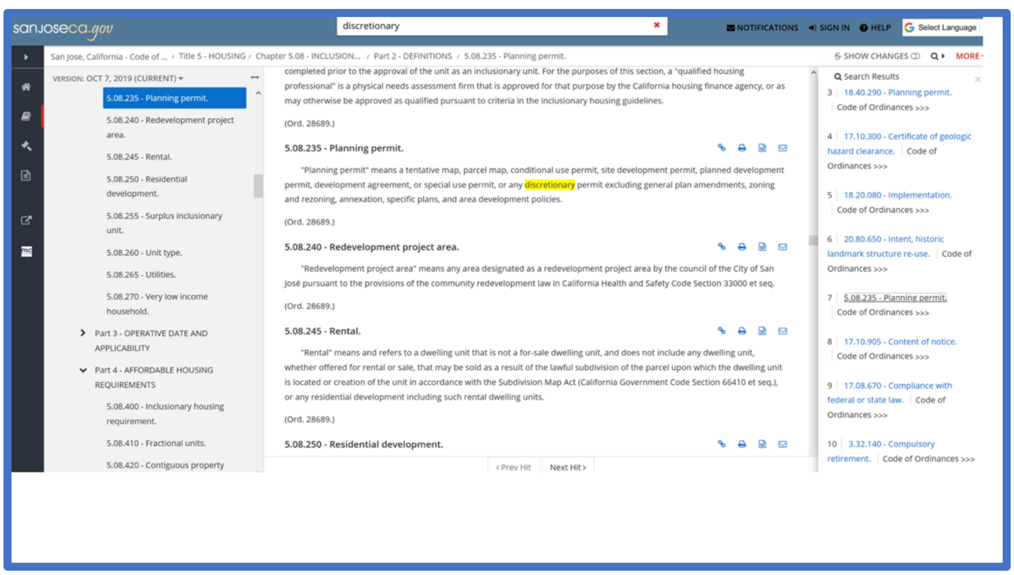

Figure 2. San Jose's Municipal Code of Ordinances online, hosted by MuniCode. Source: City of San Jose, "City of San Jose Municipal Code," https://library.municode.com/ca/san_jose/codes/code_of_ordinances (Accessed October 16, 2019).

GIS is a locational data visualization, analysis, and manipulation software. Uses for GIS are diverse, since planning departments are responsible for effective long-term land use. Generally, GIS is used to display demographic or administrative data on a map to aid situation understanding or decision making. Planners and the public may use an online GIS tool for retrieval of basic physical or codified attributes about a city parcel, such as its general plan designation, zoned density, or proximity to coastal resources. GIS may also be used to represent possible land use under certain conditions for planning purposes.

Example applications: ESRI ArcGIS Online, QuantumGIS (QGIS), Pitney Bowes MapInfo.

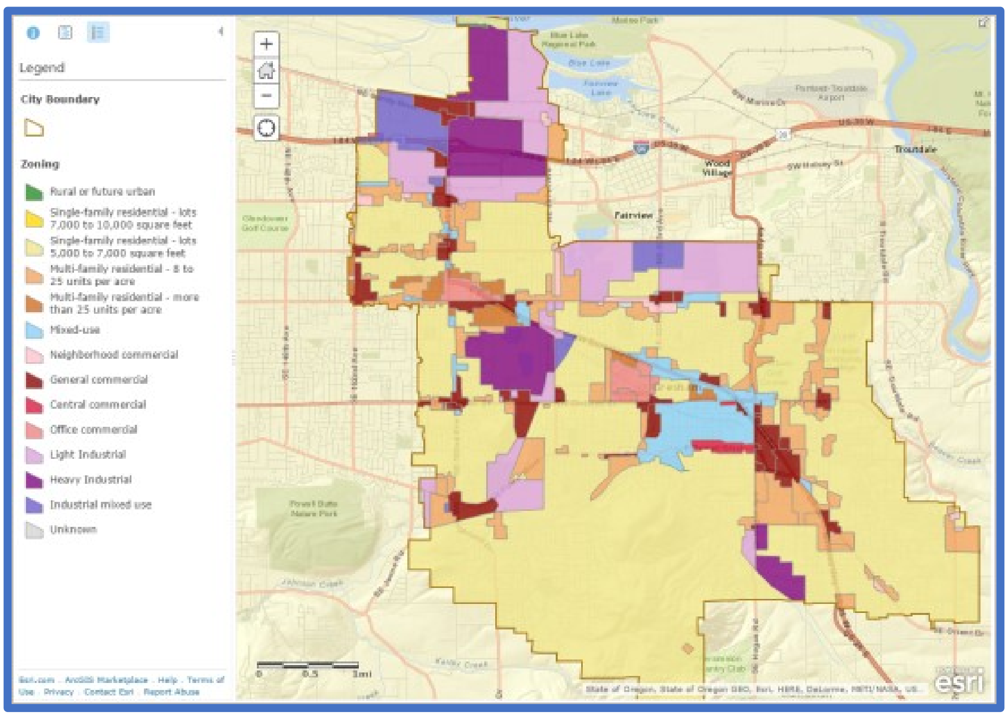

Figure 3. An example ArcGIS online web application displaying color-coded zoning within a city boundary. Users can enter an address or click on a zone for more detailed information. *Source:* ESRI, "Learn ArcGIS," https://learn.arcgis.com/en/projects/evaluate-locations-for-mixed-use-development/lessons/prepare-andvisualize-data.htm (accessed November 26, 2019

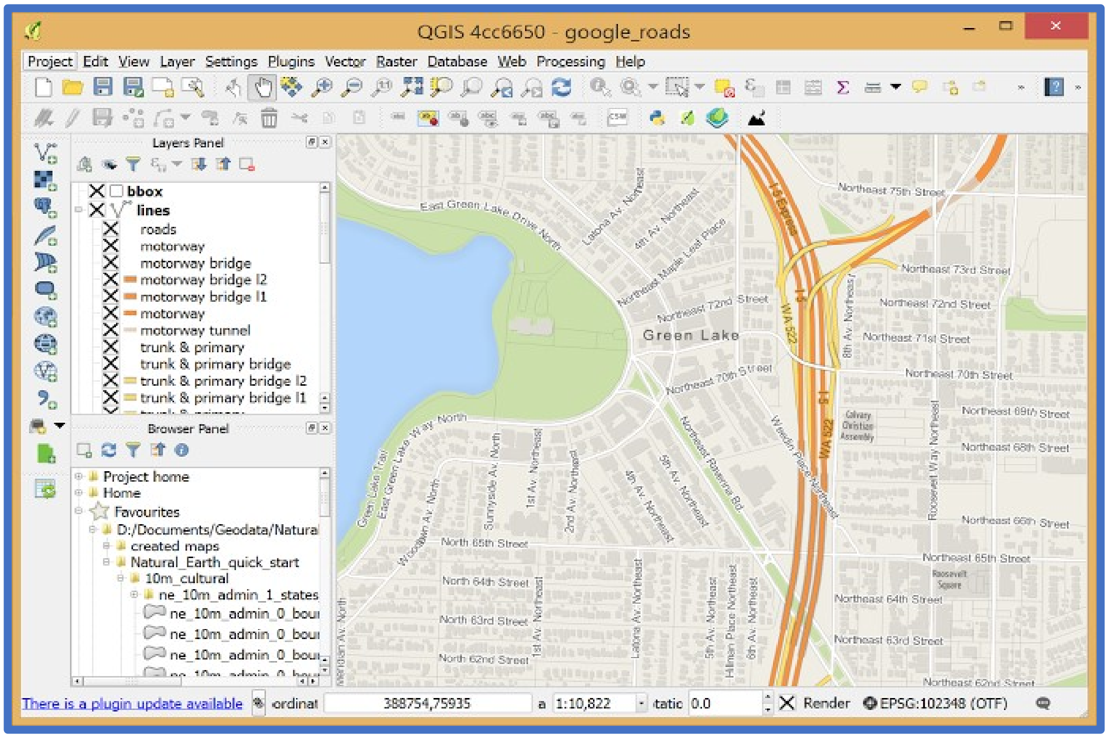

Figure 4. Local roads and land features displayed in QGIS. QGIS, "About QGIS," https://qgis.org/en/_static/images/about-screenshot.png (accessed November 27, 2019).

Interactive Land Use Visualization

Land use visualization software organizes satellite and terrestrial photography into searchable panoramas. Planners use interactive land use visualizations to quickly assess site context without physically visiting the parcel. Interactive land use visualizations are typically used alongside electronic plan review and permit management systems, both described below. *Example applications:* Google StreetView, Google Earth

Architectural Mockup

Architectural mockup software produces superficial virtual representations of structures, unlike computer automated design software that produce precisely detailed, functional models of structures. Planners versed in architectural mockup software may use this tool to demonstrate a design concept or plan set review feedback, or a visualize a proposed project for decision-makers.

Example applications: SketchUp, Sweet Home 3D

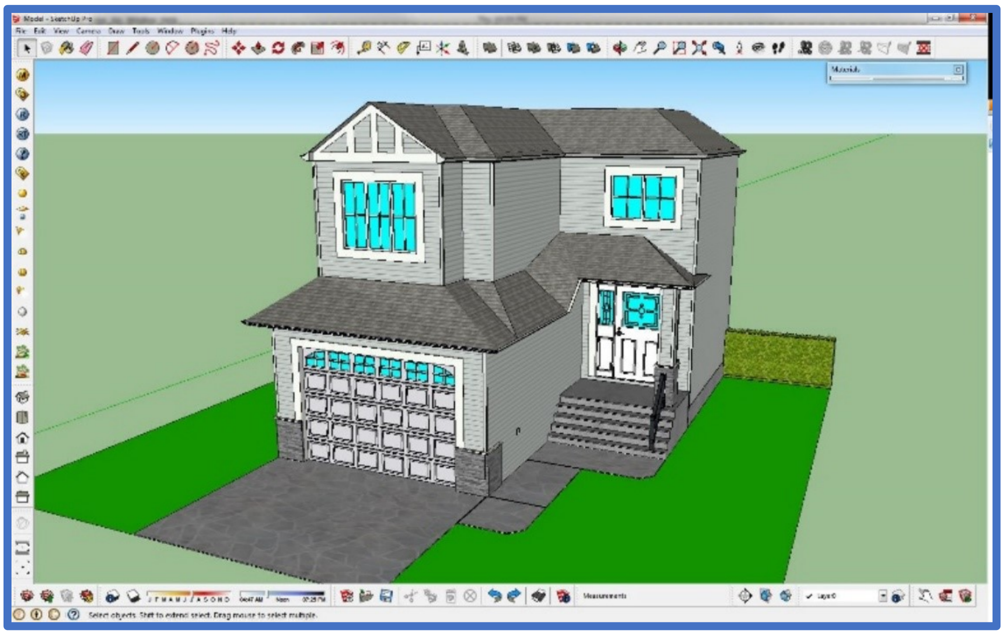

Figure 5. A two-story home rendered in Sketchup. *Source:* StackExchange, https://graphicdesign.stackexchange.com/questions/28761/painlessly-export-from-sketchup-pro-2013-to-cinema4d-r15-studio (accessed November 27, 2019).

Specialized Software

This section provides an overview of software intended for planners and their colleagues in building and public safety departments. Some of the software covered in this section are feature subsets of tools designed for architecture, construction, and engineering trades.

Permit Management Systems

Permit management systems organize and track information related to projects in development, such as supporting documentation, renewal dates, fees, and due dates. Many local governments adopt permit management systems for two key reasons: 1) centralized tracking and coordination of permitting data across planning, building, and fire, and other public works departments; 2) a web portal that closely reflects the real status of permits as they processed internally. Most permit management systems are extensively customized by IT staff and senior planners to facilitate local procedures for validating applications through a planning department. Many local governments integrate their permit management system with their GIS system for quick contextualization of available information on projects.

Example Applications: TRAKiT, Accela, Amanda

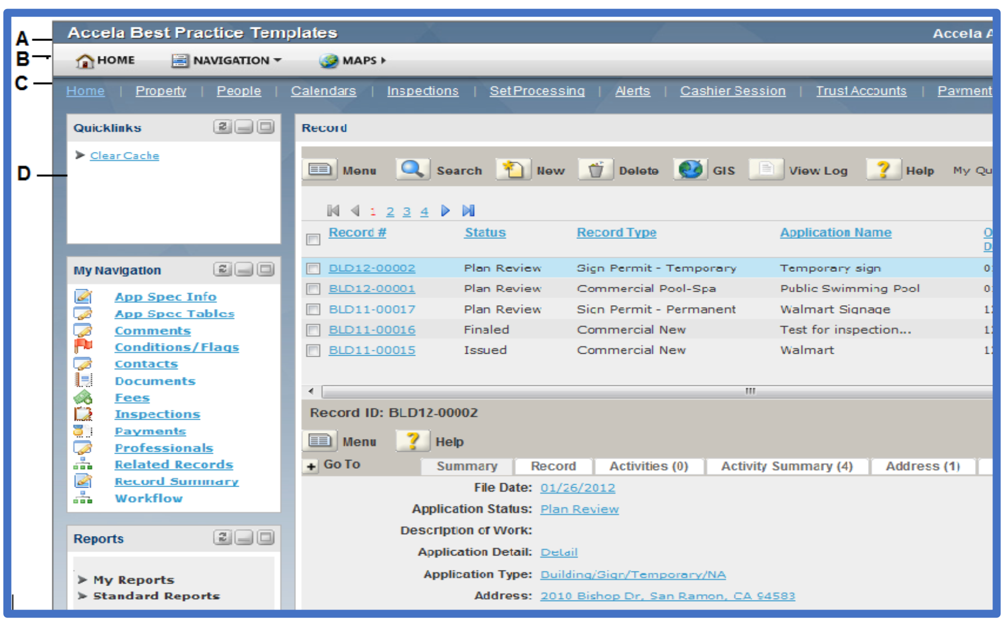

Figure 6. Sample Planning Department-Facing Screenshot of the Accela Permit Management System. *Source:* Accela, “Understanding the Civic Console Platform,” https://av.accela.com/docs/ConceptsGuide/1-understandingAccelaAutomationConsole.html#id88428514-ca90-4fea-be7c-94277755d24a (accessed November 25, 2019)

Electronic Plan Review (EPR) Software

Critically, EPR software facilitates parallel review of plan set documents by staff in different departments (i.e. planning, building, fire, and public works). Planners and building department officials use EPR to track comments and changes to plan sets throughout the application review process. Interoperability of data between asset inspection management software and electronic plan review is a desirable feature, since the functions of these software overlap in managing building applications.[26] Some asset inspection applications include extensions to specially manage Electronic Plan Review.

Example Applications: ProjectDox, BlueBeam, idtPlans

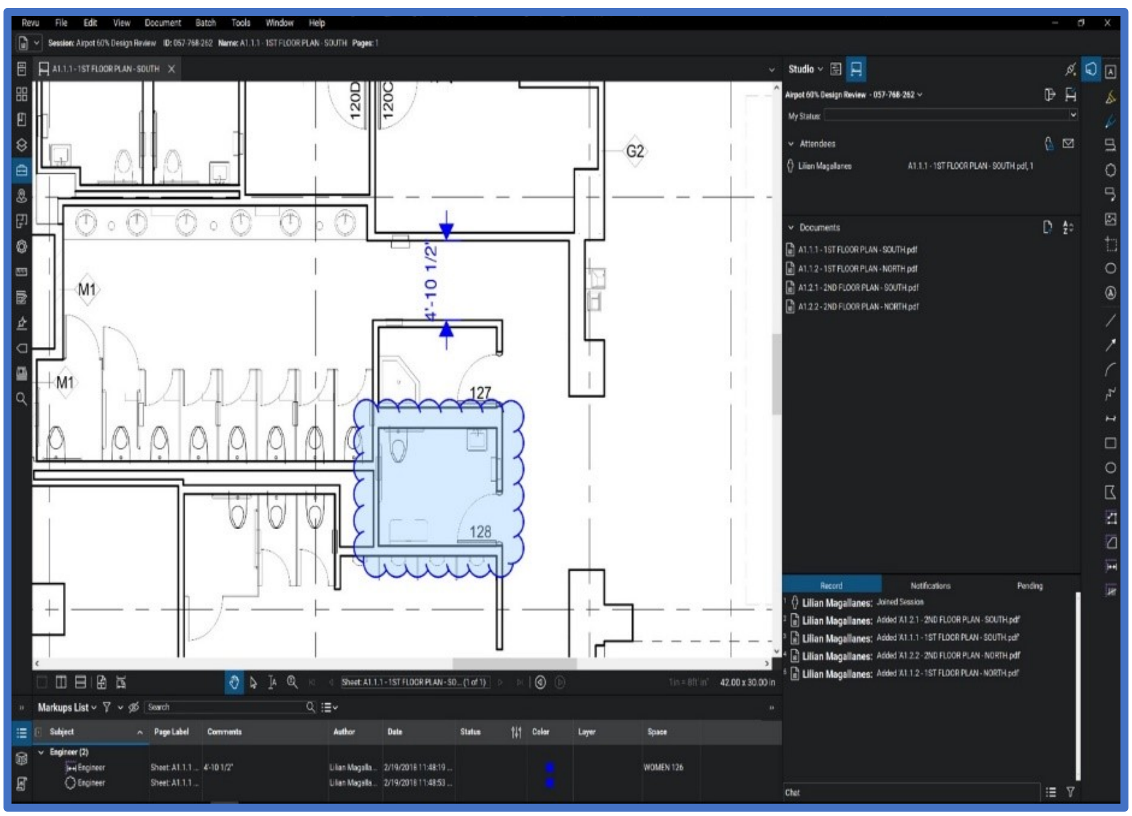

Figure 7. Bluebeam Revu for electronic plan review. The bubble indicates an area with a comment. *Source:* TrustRadius, "Product: Bluebeam Revu," https://media.trustradius.com/product-screenshots/gr/2u/TNOM63AWNS9Q.jpeg (accessed November 27, 2019).

[26] Avolve Software, "Interoperability" (n.d.). Retrieved from: https://www.avolvesoftware.com/interoperability/

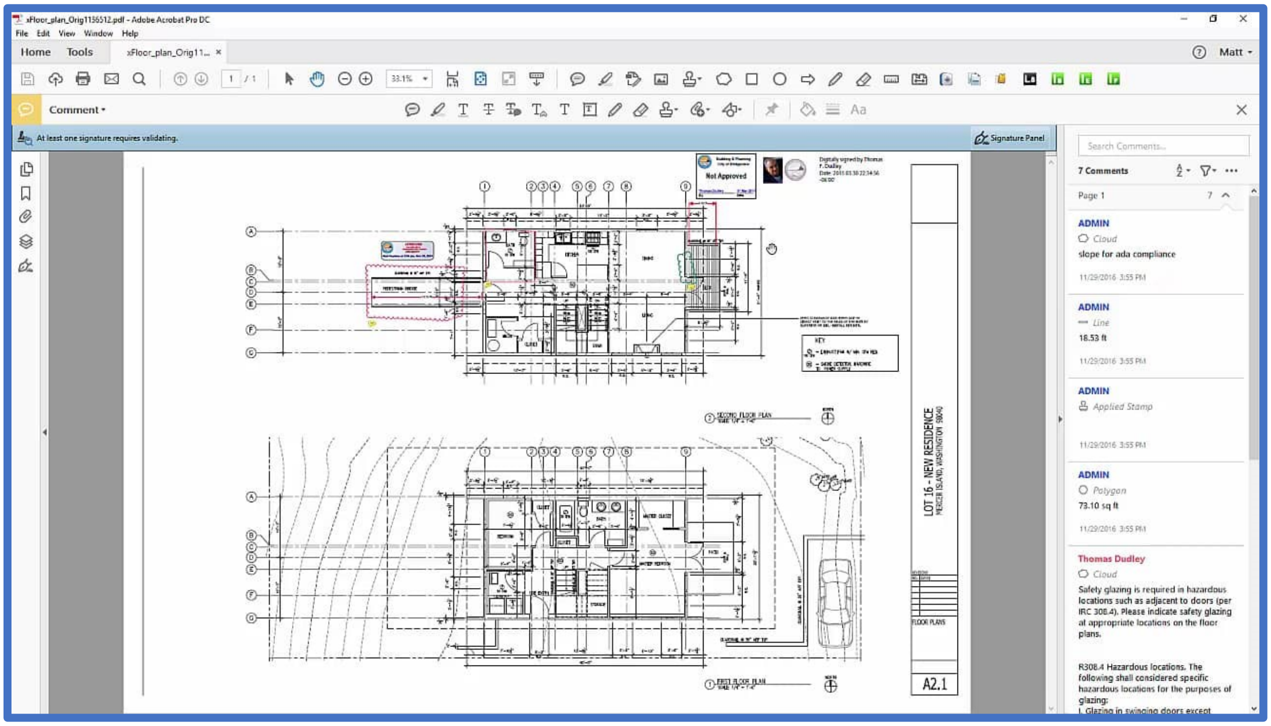

Figure 8. Accela Electronic Plan Review plugin for Adobe Acrobat Pro DC. *Source:* Accela Demo Library, "Permit Plan Review Using Accela Civic Platform and Adobe Acrobat Pro" https://vimeo.com/195533362 (accessed November 27, 2019).

Emerging Technologies

Building Information Modeling (BIM)

BIM is not a class of software itself, rather it a process involving Computer Assisted Design software for architecture, construction, and engineering that embeds information about a physical structure in a digital form. Broadly, the result of BIM is a data-rich representation (model) of the physical and functional characteristics of the structure that it represents. For municipalities, one of the primary advantages of receiving BIM submissions over 2D plan sets is more extensive automated code compliance checking through model-based inspections. BIM primarily benefits building departments, since they evaluate the technical conditions and performance of a structure that BIM can efficiently store and potentially simulate. Planning departments can evaluate a flattened 3D model as they would a 2D plan set, with the benefit of a 3D view for a better sense of massing and other salient design features.

Only a few governments worldwide have implemented a transition from 2D digital plan set intake to BIM. Singapore mandated the use of BIM for all new construction projects in 2015. Singapore has implemented partial automated building code compliance checking and basic checks for compatibility with land use type and allowable floor area ratio in that land use type. In the United States, as of October 2019, no local government has yet adopted BIM for plan review.[27]

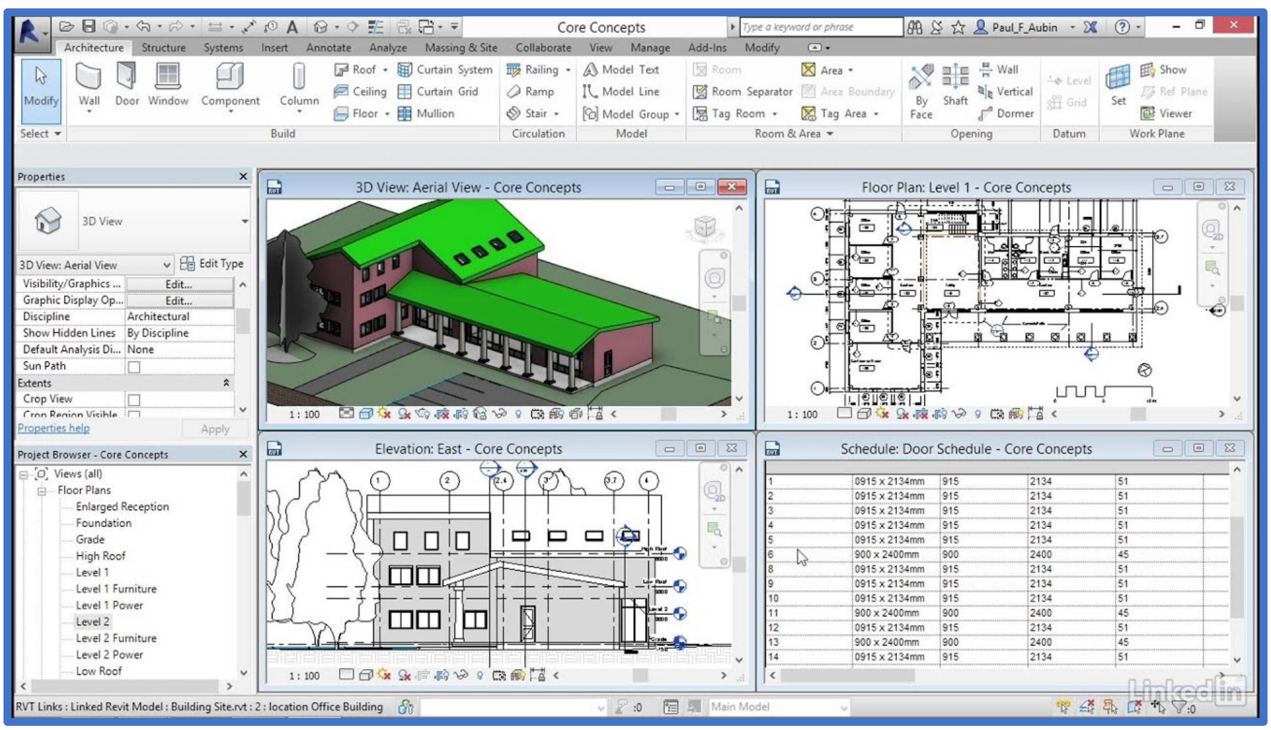

Figure 9. Screenshot demonstrating features of Autodesk's BIM design program REVIT. *Source:* LinkedInLearning (formerly Lynda), "Introducing building information modeling (BIM): Revit Architecture 2016 Essential Training," https://www.youtube.com/watch?v=ErGFP-2p6K0 (accessed November 28, 2019).

[27] Kamellia Shahi, Brenda Y. McCabe, and Arash Shahi, "Framework for Automated Model-Based e-Permitting System for Municipal Jurisdictions," Journal of Management in Engineering 35, no. 6 (2019): 3–5, https://doi.org/10.1061/(asce)me.1943-5479.0000712.

Machine-Readable Policies, Ordinances, Building, and Zoning Codes

Policies, ordinances, building codes, zoning codes exist as plain text in a document unless they are translated into a machine-readable format. Research has primarily focused on relevance to building, fire and energy codes, which are more easily translated into formal logic, than context-dependent planning ordinances and design criteria. Implementing machine-readable forms of a local government's policies and enforceable development standards makes introspective policies aware of overlapping or contradictory effects and automated code compliance possible.

One company, Symbium, has begun developing machine-readable forms of objective development standards for a few California jurisdictions. For example, Symbium provides automated online preliminary zoning review of accessory dwelling units for San José, San Francisco, Los Angeles, and San Mateo County.[28]

[28] "Symbium," 2019, https://symbium.com/press.

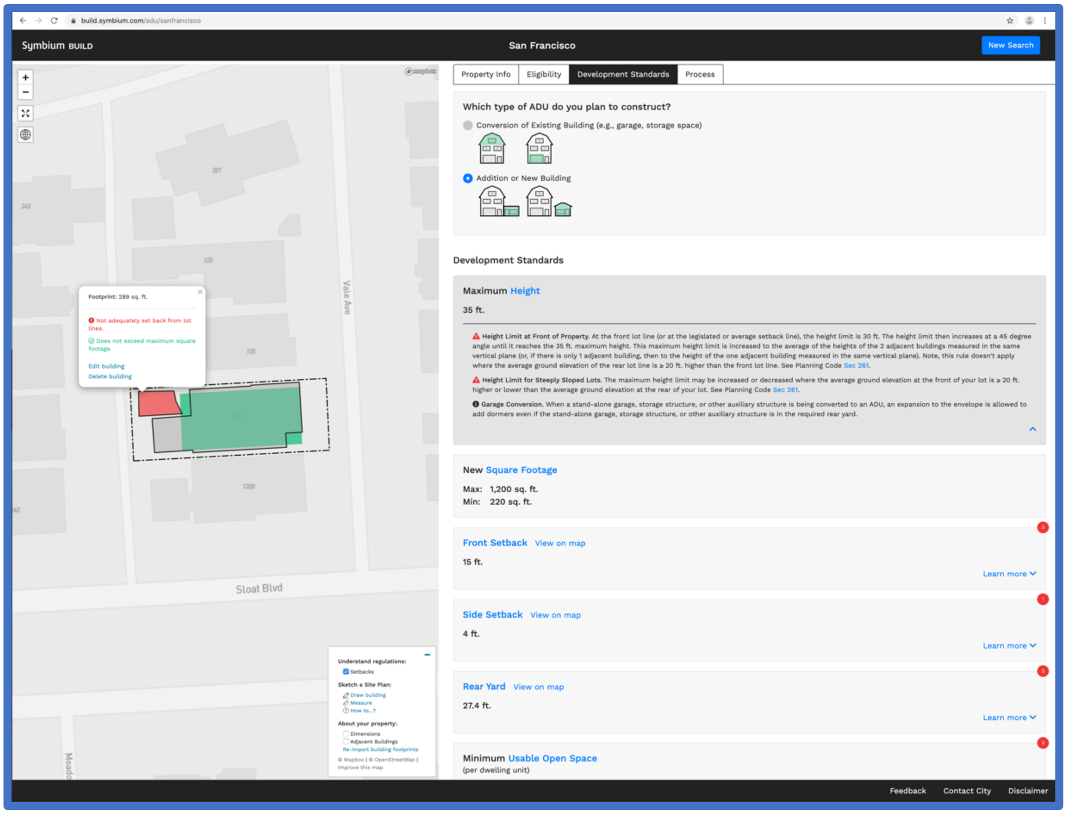

Figure 10. Screenshot from Symbium's online platform for determining legal compliance for an accessory dwelling unit (ADU). Symbium proposes to convert a city's legal code into machine-readable rules. *Source*: Symbium, "Symbium Build: San Francisco," https://assets.the-atlas.com/project_images/65c4ef57af600c1caf62dcc9646ab432.png (accessed November 17, 2019).

GIS Integrated with BIM

Academic and industry researchers have proposed the integration of GIS with BIM to provide environmental (macro-level) context to project-specific (micro-level) BIM information. The promise of BIM/GIS integration is a "transformative" tool to analyze spatial information through the full scale of the built environment, making project planning "more efficient, rational, and standardized."[29] BIM/GIS integration is considered an essential technology for

[29] Hao Wang, Yisha Pan, and Xiaochun Luo, "Integration of BIM and GIS in Sustainable Built Environment : A Review and Bibliometric Analysis," Automation in Construction 103 (2019): 42, https://doi.org/10.1016/j.autcon.2019.03.005.

more complete automation of the project review process.[30] However, the broader application of BIM/GIS integration to urban governance has not been extensively researched, and there have been few real-world applications. Realizing the potential of BIM/GIS integration involves capturing data about existing buildings in BIM and developing BIM-compatible data formats for relevant information outside of the scope of the construction industry, such as landscape water consumption.[31]

Figure 11. A still from architecture and design software company Autodesk's promotional video on the benefits of BIM-GIS integration. *Source*: Autodesk, "Uses for BIM-GIS Integration," https://www.viewstream-media.com/autodesk/bim-gis-integration/08/ (accessed November 27, 2019).

[30] Shahi, McCabe, and Shahi, "Framework for Automated Model-Based e-Permitting System for Municipal Jurisdictions."

[31] Wang, Pan, and Luo, "Integration of BIM and GIS in Sustainable Built Environment : A Review and Bibliometric Analysis," 49.

Chapter Takeaways

This chapter provided an overview of the types of software used in modern planning departments. This includes general productivity software, such as Microsoft Word, Excel, and Outlook, and specialized software for planners, such as electronic plan review and permit management systems. Many planners take advantage of spatial visualization tools, such as Google StreetView and Google Earth, to determine site context. Emerging trends in planning software technology include integrating Building Information Modeling (BIM) with Geographic Information Systems (BIM/GIS integrations) and encoding objective regulatory ordinances in machine-readable forms to automate and increase the speed of administrative decision-making.

Chapter 3. Literature Review: Present and Future Uses for Software and Data in Urban Planning

The purpose of this literature review is twofold: 1) provide a foundation of knowledge on the role of software and data in urban planning as a public sector entity; and 2) identify emerging theoretical understandings for the future role of software and data in the urban planning profession. For key terms and databases used in the literature review, refer to Appendix A: Literature Review Search Parameters. This chapter is divided in two parts: *Software* and *Data*.

Software

In 1987, planning theorist A. Gar-On Yeh divided software packages for urban planning into two categories: generalized and specialized.[32] Yeh predicted that the creation of specialized software would be slow, since the relatively small size of the planning field meant that the market for specialized software would be small. The review of the literature presented here follows the same two-part division: 1) generalized software in planning; and 2) planning specific software.

[32] A Gar-On Yeh, "Microcomputers in Urban Planning: Applications, Constraints, and Impacts," Environment & Planning B 15, no. 3 (1988): 245.

Generalized Software in Planning

Generalized software in planning has received little attention since the late 1980s when computerized systems were affordable to most planning departments. Only one comprehensive review of the role of generalized software appears in the urban planning literature, “Microcomputers in Urban Planning: Applications, Constraints, and Impacts” (1987) by the aforementioned A. Gar-On Yeh. In this review of the early literature on software in planning, Yeh identifies generalized “software packages” used in planning, treating word processing and spreadsheet programs in detail. Of the “commonly-used” packages Yeh lists for both word processing and spreadsheet production, only Word and Excel are still maintained.[33] In an analysis of the usefulness of generalized microcomputer functions to the planning profession, Yeh determines that word processing is the “most applicable” to the typology of tasks used in W. L. Whited’s 1982 APA report on the role of microcomputers in planning. Computer graphics are found to be the second-most applicable – not computer mapping, which is found to be equally applicable to programmatic modelling. GIS scholar and planning practitioner Richard Klosterman, writing in 1998, more than a decade after the publication of Yeh’s article, cited only Yeh as providing an overview of the function of software in planning.[34]

Since the 1990s, the study of generalized software within planning has shifted to collaborative, networked software. Robert Laurini’s book *Information Systems in Urban Planning* (2001) describes urban planning applications for collaboration tools, such as email and teleconferencing software. Generally, these collaboration tools expand computers from

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[33] Yeh, 245.

[34] R E Klosterman, “Computer Applications in Planning,” Environment and Planning B: Planning and Design Anniversary Issue (1998): 32.

cartographic or database systems to enablers of communication, either by face, voice, or text over simultaneous or asynchronous timeframes.[35] To the author's knowledge, there has not been a descriptive study of how collaboration software are used within urban planning departments, and whether or not they improve communications internally, with the public, or with policy makers. Riggs and Gordon (2017) expanded the study of collaboration software from the desktop to include smartphone-based apps. Their study, a survey of California planners assumed to be representative of planning departments nationwide, found that nearly 40% of planning departments had become entirely dependent on Internet technology. The majority of uses involved email and search engine use, with Google Earth, Dropbox, and note-taking apps as commonly used mobile applications.[36] This continued reliance on generic software confirms Yeh's prediction three decades later. Riggs and Gordon do not cite any precedent in the literature for assuming a sample of California is representative of national trends, suggesting that further surveys are necessary to support the findings of this study.

Despite the widespread recognition of word processing and spreadsheets as important computer applications within the planning profession, there are notable gaps in the planning technology literature about these two types of software. To the author's knowledge, no study has directly examined the role of word processing in urban planning departments. A search on the SJSU Articles database for the subjects "Urban Planning" and "Word Processing" yields no results. (A similar search for subjects "Urban Planning" and "GIS," which is less commonly used by the typical urban planner, yields many results.) Again, to the author's knowledge, no study

[35] Robert Laurini, Information Systems for Urban Planning (London: Taylor & Francis, 2001), 221-233.

[36] William Riggs and Kayla Gordon, "How Is Mobile Technology Changing City Planning? Developing a Taxonomy for the Future," Environment and Planning B: Urban Analytics and City Science 44, no. 1 (2017): 117.

has directly evaluated the role or function of the spreadsheet within the planning department. Numerous studies discuss the importance of spreadsheets as containers for spatial data useful in GIS analysis or land use modeling, but there is apparently no descriptive or qualitative study in the literature observing the use of spreadsheets in the planning department. There are other gaps in the literature on the role of generalized software in planning departments. The role of email and other collaboration software, as well as legal databases used in the planning context to manage ordinances, are unstudied.

Public participation-specific technologies, such as social media and community message boards, have been excluded from this review despite their recognized importance to public sector planning. A Delphi study of academics and government officials based in Western Europe, Canada, and the United States conducted by Anthopolous and Reddick found that urban planning was deemed *un-important* in the development of smart cities. Rather, citizen participation was found to be more important.[37] This echoes a sentiment by Laurini, who wrote in the preface to his analysis of computers in urban planning that, "Computers can help city-dwellers to extend their freedom, to impose their views to urban planners, to share their opinions about the future."[38] Ongoing public engagement mediated by specially designed software remains too limited in professional practice to be a subject of this report. For two decades, email has been the primary software used for public engagement, with its continued prominence indicated in Riggs and Gordon's study.

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[37] Riggs and Gordon, 110.

[38] Laurini, Information Systems for Urban Planning, xv.

Planning-Specific Software

Goodspeed (2016), in his systematic review of planning-specific software as an aid to planners as servants of the public interest, found four major software types in the literature: urban modeling, GIS, Planning Support Systems (PSS), and urban informatics.[39] Anthopolous and Reddick (2016), in their systematic literature review of planning-specific technologies involved in the development of smart cities, identified three software types: advanced GIS models, urban informatics, and urban management-centric databases. Anthopolous and Reddick have combined GIS and PSS into "advanced GIS models." All four of these systems are used by planning departments to assist policy making by modeling the effects of sprawl, economic development, city retrofitting, and land use changes.[40] Neither Goodspeed nor Anthopolous et al. provide descriptive context for how widely used these technologies are, although the extensive study of these four system types in the planning literature suggests their broad relevance to planners globally. A selection of the literature on the presence of GIS and PSS in urban planning offices follows.

GIS in Urban Planning

The literature surrounding the potential uses of GIS in urban planning is vast, but the literature examining the use of GIS in actual professional contexts is relatively sparse. Alrwais et al. (2016) conducted a survey of Southern California cities on their GIS use. Some cities were staffed with GIS divisions responsible for maintaining developing, maintaining, and updating

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[39] Robert Goodspeed, "Digital Knowledge Technologies in Planning Practice: From Black Boxes to Media for Collaborative Inquiry," Planning Theory and Practice 17, no. 4 (2016): 580.

[40] Leonidas G. Anthopoulos and Christopher G. Reddick, "Understanding Electronic Government Research and Smart City: A Framework and Empirical Evidence," Information Polity 21 (2016): 106.

key municipal maps and data with spatial attributes. They observed that cities without a GIS division were in a 'no-growth' mode or had not seen an advancement in their use of GIS. Only the extent that GIS was used within the planning department ("GIS maturity"), more than staff experience or a GIS evangelist on staff, was strongly associated with perceived value. Some cities were found to rely on only a single employee to maintain their entire GIS department.[41] Vishkaie et al. (2014), while focused on the potential for GIS and CAD to be combined in a public participation tool, interviewed a group of ten planners and academics about their experiences with both software types. Most participants mentioned that mapping, data management activities such as data acquisition and assembling data sets and developing modelling tools are the most challenging GIS tasks in their jobs.[42] Vishkaie et al.'s findings are anecdotal, but the same difficulties and barriers to use are reflected in the survey by Alrwais et al. Additionally, Vishkaie et al. note that, while a larger, multi-city, international sample would have provided greater confidence in the findings, the small sample in their ethnographic approach still generated a large quantity of data, sufficient to develop concepts and context.[43]

Planning Support Systems

Planning Support Systems (PSS) are the definitive planning-specific software, yet adoption by planning departments is rare[44], and the bulk of the literature focuses on potential or theoretical applications. Pelzer et al. (2015) found in their review of PSS literature that the

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[41] O. Alrwais et al., "An Organizational Perspective on GIS Payoffs for the Public Sector: Is Usage the Missing Link?," AMCIS 2016: Surfing the IT Innovation Wave - 22nd Americas Conference on Information Systems (2016): 8.

[42] Rojin Vishkaie, Richard Levy, and Anthony Tang, "Urban Planning Process: Can Technology Enhance Participatory Communication?," Urban Planning and Design Research 2 (2014): 24.

[43] Vishkaie, Levy, and Tang, 22.

[44] Patrizia Russo et al., "Adoption and Use of Software in Land Use Planning Practice: A Multiple-Country Study," International Journal of Human-Computer Interaction 34, no. 1 (January 2, 2018): 57.

usefulness of this type of software had only been observed quasi-experimentally, with the earliest study dating back only to 2013.[45] Pelzer et al.'s study applied a theoretical framework for "task-technology fit" to eight case studies from Dutch cities, with four case studies explored in detail. Directly, PSS served to facilitate communication between planners, stakeholders in a given project, and decision makers. Indirectly, PSS served to bring actors who were not used to talking to each other to physically stand around a table and collaborate, suggesting one indirect benefit. This act of standing around a table illustrates the limitations to this study – the PSS studied here (MapTable) used a tabletop displaying a digital map, which is unique among PSS.[46] Klosterman (1998) found that spreadsheets were by far the most used software for urban modelling,[47] twenty years later this continues to be true, with a relatively small amount of planning-specific modelling conducted within PSS.

Notable Absences in the Literature on Planning-Specific Software

There are significant gaps in the literature on urban management-centric software. A Google Scholar search for Magnet municipal management software yields zero results. ProjectDox, an electronic plan review software by the company Avolve, is also absent from the literature. Both of software products are widely used nationally, yet it appears that no descriptive or qualitative research has been conducted to examine the role of these software types within planning or development processes. Klosterman (1998) notes that the emphasis for planning-specific software has been on short-term management and code enforcement.[48] The

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[45] Peter Pelzer et al., "Planning Support Systems and Task-Technology Fit: A Comparative Case Study," Applied Spatial Analysis and Policy 8, no. 2 (2015): 156, https://doi.org/10.1007/s12061-015-9135-5.
[46] Pelzer et al., 170–75.
[47] Klosterman, "Computer Applications in Planning", 33
[48] Klosterman, 34.

profession-specific software mentioned by Klosterman does not appear elsewhere in the literature; an empirical evaluation of the effectiveness of these software products would have been relevant to this report.

Data

To provide a grounding in the wide variety of data used in public sector urban planning, data is broken up into three components: 1) conventional data, or traditional data used for administration and physical resource inventory (e.g. parcel tax income, general plan designations, water quality indicators); 2) big data, used to model and predict general behaviors; and 3) open data. A fourth sub-section summarizes the literature on the practical realities of data: data mismanagement, changes in public sector practice due to digitalization, and the presentation of data by staff to public officials through staff reports. Rather than describe administrative functions or technical uses for big data in the public sector, this review emphasized literature on current use of data in the public sector with a scholarly eye towards greater usefulness for public sector service.

Conventional Data

Christodoulou et al. (2018) conducted a systematic review of literature on data usage and innovation derived from data used in the public sector. Three categories of uses for data-driven administrations were identified: innovation, transparency (open data), and efficiency. It was clear from the literature that the proliferation of data has improved administrative efficiency in almost every case. Data also poses four types of challenges: cultural and political barriers to use, technical obstacles, privacy and security issues, and efficient data management.[49] The majority of data remains unstructured, as text, audio files, or photos, or other forms structured (tagged) for machine-readability. Supporting the purpose of this report, the researchers found that the user experience of data management should be further examined.[50]

Gil-Garcia & Ku (2018) performed an in-depth case study on data collection used in a single mid-size city government in New York state. They found that much of the data in local governments was socially constructed, rather than simply mechanically produced. Here, the social construction of data entails the collection of data affected by division of labor, forms of work processes, human factors such as leadership or employees' perceptions, and events happening external to the administration. Gil-Garcia & Ku note that a large portion of the data collected and created in local governments are non-digital. [51] This finding in conjunction with Christodolou et al. (2018)'s observation that the majority of government data remains unstructured suggests there are large quantities of machine-inaccessible conventional data. Gil-Garcia & Ku are explicit about the limitations of the single-city focus of their study hindering generalizability and the incidental fact that most of the interviewees participated in the same administrative projects[52], raising doubts on the theoretical value of their qualitative findings.

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[49] Paraskevi Christodoulou et al., "Data Makes the Public Sector Go Round," in EGOV 2018 (Springer International Publishing, 2018), 221–232, https://doi.org/10.1007/BF03251472.

[50] Christodoulou et al., 230.

[51] J Ramon Gil-Garcia and Minyoung Ku, "Ready for Data Analytics? Data Collection and Creation in Local Governments," in In Proceedings of the 19th Annual International Conference on Digital Government Research (Delft, The Netherlands: ACM, 2018), 1–10, https://doi.org/10.1145/3209281.3209381.

[52] Gil-Garcia and Ku, 9.

Contemporary Uses of Big Data

Rogge, Agasisti, & deWitte (2017) conducted a literature review on big data analytics in the public sector. The researchers identify five categories for the current use of big data. Their findings supplement the benefits and challenges for conventional data relayed in Christodolou et al. (2018). It was found that, "many managers believed that, for some policy areas, big data could result in the use of entirely new management models."[53] The researchers note that a widely accepted theory for the usefulness of big data has yet to be developed. They argue for a set of principles for big data-driven public policy to be codified into a theory of data-driven governance.[54] The study does not address the implications of uneven adoption of big data technology, or tiered, collaborative roles states and cities can play in big data process development.

Redden (2018) employs a countermapping approach, using interviews (n = 23, 16 public sector employees, 7 non-profit employees) and FOIA requests, to move beyond government rhetoric on the use of open data in the public sector. Her work focuses on Canadian public sector agencies. Generally, big data is associated with a variety of promises and benefits for the public sector, including, but not limited to, accelerated research, more precise evaluation of program success, cost savings through policy targeting, and better management of agricultural and natural resources.[55] A range of risks for using big data were identified in the interviews and policy documents. Technical infrastructure development and promoting secure access were the

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[53] Nicky Rogge, Tommaso Agasisti, and Kristof De Witte, "Big Data and the Measurement of Public Organizations' Performance and Efficiency: The State-of-the-Art," Public Policy and Administration 32, no. 4 (2017): 271, https://doi.org/10.1177/0952076716687355.

[54] Rogge, Agasisti, and De Witte, 276.

[55] Joanna Redden, "Democratic Governance in an Age of Datafication: Lessons from Mapping Government Discourses and Practices," Big Data & Society 5, no. 2 (2018): 6, https://doi.org/10.1177/2053951718809145.

most commonly raised risks. Concerns were also voiced about changing power dynamics and problematic debates around the culture of data-driven policy, reactions seldom discussed in previous literature.[56] Redden highlights a critical theme in the literature that recurs through the literature on the future of software in planning: datafication ("datafied public-private partnerships") may limit democratic systems, so it is critical to ensure humans continue to make important decisions and involve affected members of the public in those decisions.[57]

Open Data

Ganapati & Reddick (2014) conducted surveys (n = 107) and follow-up phone interviews (n = 14) with Chief Administrative Officers in municipalities with populations of 100,000 or more across the United States. The majority of CAO considered their achievement of Open Government, or the release of selected administrative data to the public, was "high" or "very high." [58] Open government was found to be a necessary process for maintaining democratic values. More effective local government operations were identified by 79.1% of respondents in a survey of open government benefits. 63.6% of respondents identified more efficient local government operations as a benefit.[59] This suggests a difference between the value of open data and data in general, which was overwhelmingly associated with efficiency by Christodolou (2018). Ganapati and Reddick do not appear to account for response bias in

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[56] Redden, 10.
[57] Redden, 10.
[58] Sukumar Ganapati and Christopher G. Reddick, "The Use of ICT for Open Government in U. S. Municipalities," Public Performance & Management Review 37, no. 3 (2014): 365–87, https://doi.org/10.2753/PMR1530-9576370302.
[59] Ganapati and Reddick, 374.

limiting their surveys only to officials likely in charge of implementing open government initiatives.

Practical Concerns with Data in the Public Sector

This review identified three papers on data as a practical reality in the public sector: one on the mismanagement of data by administrators, one on the transformation to digitized documents, and one on staff reports, a routine and profession-wide practice of communicating information to decisionmakers and the public, that is heavily reliant on desktop software and diverse forms of data.

A literature review conducted by Stone et al. (2018) determined that information (i.e. data) mismanagement is widespread in organizations. A four-type taxonomy of information mismanagement is produced, which describes the ways data can be suppressed or manipulated in public sector (and private sector) organizations.[60] The researchers highlight the value of analytics and big data as a safeguard or quality-assurance mechanism for decision making. Ultimately, they conclude that government transparency and public vigilance are necessary to combat data misuse.[61] Other studies focused on actual public sector activities, such as Gil-Garcia & Ku (2018) and Redden (2018), may identify but do not explore the role of information mismanagement, willful or accidental, in data-driven governance.

Plesner et al. (2018) conducted a systematic literature review on how digital technologies lead to changes in public sector organizations. The researchers hold that no systematic account existed prior to their study on changes specifically due to digitization in the

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[60] Merlin Stone et al., "From Information Mismanagement to Misinformation – the Dark Side of Information Management," The Bottom Line, 2018, 1–25, https://doi.org/10.1108/BL-09-2018-0043.
[61] Stone et al., 17–19.

public sector, despite digitization being a major change factor in contemporary organizations. Further, they found that bureaucratic structures, accountability, and "professionals," or the tendency of highly-skilled career employees to maintain certain practices, are not theorized in the literature as particular aspects of the public sector or the process of accommodating to digitalization.[62] Plesner et al. drew their conclusions solely from a literature review, without input from public sector change experts or digitalization specialists within public sector agencies.

Finally, this review could not find a study addressing the role of staff reports as an aggregation and presentation of data on routine and urgent issues. Instead, this review identified a study by Johnson & Lyles (2016) that developed criteria for staff report quality (where quality is interpreted as factual accuracy and effectiveness of communication) and evaluated a sample of staff reports gathered nationally. Johnson & Lyles observe that staff reports are "probably planners' most common, but least studied, work products."[63] All staff reports collected for the sample concerned a simple, noncontroversial zoning application. Generally, staff reports were found to be deficient on some traditional best practices and most modern or recently identified best practices, such as checking for consistency with plans from other local governments or arguing for a recommendation.[64] The sample collected in this study focuses on one type of staff report, leaving open further research into evaluation and national performance on the diversity of staff report topics.

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[62] Ursula Plesner, Lise Justesen, and Cecilie Glerup, "The Transformation of Work in Digitized Public Sector Organizations," Journal of Organizational Change Management 31, no. 5 (2018): 1176–90, https://doi.org/10.1108/JOCM-06-2017-0257.

[63] Bonnie J. Johnson and Ward Lyles, "The Unexamined Staff Report: Results from an Evaluation of a National Sample," Journal of the American Planning Association 82, no. 1 (2016): 22, https://doi.org/10.1080/01944363.2015.1109471.

[64] Johnson and Lyles, 33.

The Future Role of Software in Planning

Advances in the capabilities of computing over the past decade coinciding with increased urbanization has led to renewed interest in the potential of software to improve the urban planning process. Software is a multi-purpose category of planning tools; the literature review in response to this question sought a high-level overview of scholarly approaches to different aspects of software in planning, defined by the author as the following: 1) Urban Operating Systems; 2) Big Data; 3) GIS; 4) PSS; 5) automated administration (e.g. permit processing). Finally, the review conducted for this question included the future role of ICT in Policy Design.

Urban Operating Systems

Marvin & Luque-Ayala (2017) introduce the concept of the urban operating system, termed "Urban OS" to describe city operations that rely on a set of packaged hardware and software developed by private IT companies, an emerging phenomenon in urban governance. Drawing on policy documents produced by Microsoft, IBM, and Hitachi, a five-part framework for Urban OS is elaborated that describes the assumptions of computational logic in software products that govern urban systems. Crucially, the researchers conclude that the "progressive potential of the smart city" likely entails a public, discursive process that challenges corporate-led views of computational urbanism. Their analysis on the history and function of Urban OS is limited to a literature review, lacking direct input from other experts on the capacity or potential of these systems.[65] Urban geographer and planning scholar Michael Batty is skeptical of the urban operating system concept. He contends that a singular platform underlying urban operations implies broad consensus of how a city should function ("the focus of operation") that has never existed.[66]

Future Uses of Big Data

Big data, as applied to future potential urban planning, is closely linked to the broadly developed literature on "Smart Governance" or public-sector component of Smart City development. The literature review identified four papers: two systematic reviews on the potential for big data in the public sector, one on a new class of metrics for quality of life beyond surveys and basic environmental information, and one on a new class of APIs for access and manipulation of big urban data generated by a proliferation of sensors and smartphones. The literature on the potential theoretical applications for big data in urban planning is growing rapidly. Research rooted in big data in professional practice is much more limited.

As Rogge, Agasisti, & DeWitte (2017) indicated, there is, at present, no well-known theory for big data development[67], which has led to the current state of research exploring how big data might be realized technically and as an aid to policymaking. Durrant et al. posit that big data, to be used effectively for policymaking, requires a problem-oriented approach that incorporates political reality, through public dialogue or other social context-aware process. The researchers arrived at this conclusion through participatory action research, studying four

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[65] Simon Marvin and Andrés Luque-Ayala, "Urban Operating Systems: Diagramming the City," International Journal of Urban and Regional Research 41 (2017): 84–103, https://doi.org/10.1111/1468-2427.12479.
[66] Batty, Inventing Future Cities, 179.
[67] Rogge, Agasisti, and De Witte, "Big Data and the Measurement of Public Organizations' Performance and Efficiency: The State-of-the-Art," 276.

different big data driven policy implementations all located in the South West of England, spanning 2013-2018. None of the policy types covered in this study were directly associated with an urban planning topic (e.g. land use, transportation planning), although the primary finding of politics as a constraining factor on data-driven policy applies to planning. Varying levels of data analysis expertise or varying institutional capacities to access, process, and store big data were not discussed.[68] Costin & Eastman, examine the problem of the interoperability of big data between architecture, engineering, construction and operations companies as the primary barrier to broader use and adoption. After a holistic review of technical literature, the researchers found that "smart and sustainable urban systems" will require interoperability across domains (e.g. sewer maintenance and street maintenance), incentives for interoperability, and standardization for cross-domain organization.[69] This paper was identified as relevant because the lack of interoperability on the private sector side poses a problem for public sector agencies, particularly planning and building departments, that would benefit from integrating building data into their maintenance and management systems. The researchers do not address the role of the public sector in responding to the open challenges they identified.

McKenna (2019), using an exploratory case study evaluation, including interviews and an online survey (n = 73), approaches big data creatively, proposing innovative metrics for evaluating quality of life in data-rich urban areas. McKenna adopts a four-dimension framework for urban metrics: awareness, learning, openness, and engagement, with a defined number of metrics associated with each dimension. These metrics, based on Anderson's Body

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[68] Hannah Durrant, Julie Barnett, and Emily Suzanne Rempel, "Realising the Benefits of Integrated Data for Local Policymaking: Rhetoric versus Reality," Politics and Governance 6, no. 4 (2018): 18–28, https://doi.org/10.17645/pag.v6i4.1586.

[69] Aaron Costin and Charles Eastman, "Need for Interoperability to Enable Seamless Information Exchanges in Smart and Sustainable Urban Systems," Journal of Computing in Civil Engineering 33, no. 3 (2019): 1–14, https://doi.org/10.1061/(ASCE)CP.1943-5487.0000824.

Insight scale but applied to human-urban connectedness, are intended to mitigate an algorithm-driven separation between urban improvement and quality of life.[70] The integrity of McKenna's framework as an effective means to evaluate perceived quality of life was tested through an online survey conducted as a follow-up to the interview protocol. McKenna concedes that there is a small possibility for the generalization of the survey results to broader populations but follows Lee and Baskerville (2003) to suggest that there is a possibility for analytic generations of case study findings to theory.[71]

Access and manipulation of big data will be mediated through APIs, an essential technology of contemporary networked software. Raetzsch et al. (2019) proposes the concept of "City APIs" to describe software rules for interacting with the full diversity of networked urban objects, anything from a sewer line to a bus to the struts of a bridge. Raetzsch et al. caution that defining what an API can do "embeds crucial socio-political assumptions," because APIs can control what types of data are accessible and who has access to certain data.[72] This echoes the determination by Durrant et al. (2018) that the products of big data are subject to interpretation by groups with different levels of power. Further, the City API concept is complementary to the Urban OS, although the Urban OS as it is currently implemented is rationalist and corporate-led while the City API concept is intended to expand the capacity of the public to engage with their physical infrastructure. Raetzsch et al. elaborate the City API

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[70] H. Patricia McKenna, "Innovating Metrics for Smarter, Responsive Cities," Data 4 (2019): 1–25, https://doi.org/10.3390/data4010025.
[71] McKenna, 14.
[72] Christoph Raetzsch et al., "Weaving Seams with Data: Conceptualizing City APIs as Elements of Infrastructures," Big Data & Society, 2019, 1–14, https://doi.org/10.1177/2053951719827619.

entirely on the basis of a literature review. There are no expert interviews or descriptive study of APIs currently in use as predecessors to the technology described in the research.

Future Uses of GIS

Drummond & French (2008) in a perspective letter drawing from their decades of experience as urban planners and theorists of the profession, as well as a limited literature review, outline a long-term future for GIS as applied in planning departments. For Drummond & French, future planning departments will rely on web-based technologies and open-source software, augmented by applications developed in cooperation with universities and research institutions.[73] Contemporary GIS has been slow to adopt profession-specific features, such as support community negotiation and participation, data structures that facilitate quick sketching of developments or land uses, or immersive visualizations.[74] In a response to Drummond & French printed in that same issue, Klosterman (2018) counter-claimed that the corporate developers of GIS (i.e. ESRI) would continue to adapt to the immediate needs of the profession. Klosterman places the onus for the advance of GIS not on the software itself, but on improved organizational and communication skills from within the planning profession.[75]

Miller (2018) outlines a GIS philosophy for handling the increased flows of real-time data likely to occur in future spatial informatics. Based on his expert opinion, he claims that algorithmically determined real-time decisions may be lifesaving in some circumstances, but

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[73] William J. Drummond and Steven P. French, "The Future of GIS in Planning: Converging Technologies and Diverging Interests," Journal of the American Planning Association 74, no. 2 (2008): 161–74, https://doi.org/10.1080/01944360801982146.

[74] Drummond and French, 172–73.

[75] Richard Klosterman, "Comment on Drummond and French: Another View of the Future of GIS," Journal of the American Planning Association 74, no. 2 (2008): 174–76, https://doi.org/10.1080/01944360801982203.

too many decisions made on the basis of real-time data can lead to “an unsustainable urban system.”[76] As an alternative, he proposes that GIS should be practiced “at human speed,” taking into account participatory GIS and concepts like *slow data* that are amassed over a period of months or years to fill in the gaps of real-time sensor networks.[77] Miller’s assertion for a human turn in the analytical approach of GIS joins similar assertions by Raetzsch et al. (2019) and Durrant et al. (2018) for engagement by the public who are ultimately governed, in part, by the processes and projections of software. Miller does not claim specific political benefits for implementing human-speed GIS.

Future Uses of PSS

Planning support systems tailored towards urban design have been in limited use in several cities internationally. UrbanFootprint, a visually sophisticated urban design PSS has been offered in popular media as a tool in the future of planning.[78] Due to the recency of its release, the impact of UrbanFootprint on the few urban areas where it has been applied has not been evaluated by academics. A PSS that generates permutations of neighborhood building footprints based on criteria such as desired open space and setback has recently been produced by Alphabet-backed Sidewalk Labs.[79] Pettit et al. (2018) conducted a review of Australia's

[76] Harvey J. Miller, “Geographic Information Science III: Why Faster Geographic Information Is Not Always Smarter,” Progress in Human Geography, 2018, 2, https://doi.org/10.1177/0309132518799596.
[77] Miller, “Geographic Information Science III: Why Faster Geographic Information Is Not Always Smarter.”
[78] UrbanFootprint. "In the News," last updated June 19, 2019. Retrieved from: https://urbanfootprint.com/about/news/
[79] Sidewalk Labs. "A first step toward the future of neighborhood design," last updated December 11, 2019. Retrieved from: https://www.sidewalklabs.com/blog/a-first-step-toward-the-future-of-neighborhood-design/

applications of urban design PSS.[80] This study mentioned UrbanFootprint and UrbanSim, a population growth and land use simulator, among emerging urban design PSS.

Lagenheim et al. (2017) conducted a case study evaluation of two Australian planning cases applying several different types of PSS to urban disaster preparedness.[81] Based on their assessment of the two cases, they posit that planning support systems contribute to disaster resilience by synthesizing data and information from divergent disciplines, making it easier to plan for inherently complex, multi-disciplinary problems.[82] Replicability and iterative improvements of planning outcomes are considered to be a design goal for future PSS. Despite an evaluation of interdisciplinary data, Langenheim et al. does not address data interoperability, which Costin and Eastman (2019) identify as a major barrier to interdisciplinary big data-driven operations. Longitudinal studies that assess the impact of a policy or design intervention based on a decision informed by PSS have yet to be conducted. Thus, the actual effect of resilience plans based on PSS, such as those in this case study, are unknown.

Fertner et al. (2018) does not deal with PSS directly. However, this study is relevant to an understanding of the near-term potential of PSS because it reveals significant gaps in the literature on interpretation of digital plan sets, as well as inter-departmental collaborative policymaking informed by digital plan sets. The researchers find that it would be mistaken to prescribe future development based on existing databases of plan data. This is because plans describe intentions or aspirations, but, at least in the Danish case, do not necessarily reflect

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[80] Christopher Pettit et al., "Planning Support Systems for Smart Cities," *City, Culture and Society* 12, no. August 2017 (2018): 13–24, https://doi.org/10.1016/j.ccs.2017.10.002.

[81] Nano Langenheim et al., "Designing with Data for Urban Resilience," in Planning Support Science for Smarter Urban Futures: Lecture Notes in Geoinformation and Cartography, ed. S. Geertman et al. (Springer International Publishing, 2017), 113–33, https://doi.org/10.1007/978-3-319-57819-4.

[82] Langenheim et al., 113.

realistic development options or outcomes. Ultimately, the interrelationship between plans and land use change and the inverse effect of actual land use change on plans requires further research.[83] plan data observed in this study is limited to Denmark and several smaller Scandinavian databases of digitalized manuscripts.

Automated Administration

One study, by Eirinaki et al. (2018), proposed a solution to an administrative problem in urban planning departments using software. Reinforcing the observation that software used in planning is under-studied, the researchers note that there is no systematic review of the capabilities of online permitting platforms in the U.S.[84] The novelty of the proposed solution is its user-centered design, providing customized answers through a fully automated permitting process, recommendation engine, and data visualization.[85] Building Information Modeling or challenges with integration into existing inter-departmental IT infrastructure. Further, there is no discussion of the in-person "planning desk" component of permit management, which is the current standard for many types of permits the proposed solution seeks to address. This paper is notable for representing an attempt by academia to solve a public-sector problem, although the problem was not taken up from a request by the public sector, an approach advocated by Drummond & French (2008).

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[83] Christian Fertner et al., "Emerging Digital Plan Data–New Research Perspectives on Planning Practice and Evaluation," Geografisk Tidsskrift - Danish Journal of Geography, 2018, 1–12, https://doi.org/10.1080/00167223.2018.1528555.
[84] Magdalini Eirinaki et al., "A Building Permit System for Smart Cities: A Cloud-Based Framework," Computers, Environment and Urban Systems 70 (2018): 175–88, https://doi.org/10.1016/j.compenvurbsys.2018.03.006.
[85] Eirinaki et al., 177.

Although machine-readable law is an emerging body of technical research and the private company Symbium (established in 2019) already provides automated administrative services to a few urban planning departments, to the author's knowledge there has not been any scholarly study of the application of machine-readable law to urban planning, particularly the design of municipal codes.

Information and Communication Technologies in Policy Design

Capano & Pavano (2018) conducted a case study evaluation to observe how current digital communications technologies can contribute to the design of effective policies. They provided recommendations for Information and Communication Technologies (ICT) usage that can bypass or minimize political obstacles and discover public priorities earlier in policy design. The researchers term these ICT-informed policies as *anticipatory* policies.[86] According to the researchers' literature review, no systematic study had described the process used by policymakers to include software in policy packages, or how software would compound with other types of tools (e.g. an expert interview, a policy scan) in policy development.[87] The researchers found that ICT adoption and effective policy making is not linear, rather there are several factors that determine effectiveness, such as governmental use of contributions collected from the public and clarity of tasks assigned to citizens. Only three case studies were evaluated, all in wealthy European countries. Although public-outreach software (i.e. social media) is outside the scope of this report, public outreach or "e-government" software is an

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[86] Giliberto Capano and Elena Pavan, "Designing Anticipatory Policies through the Use of ICTs," Policy and Society, 2018, 1–22, https://doi.org/10.1080/14494035.2018.1511194.
[87] Capano and Pavan, 4.

important strain in the literature and relevant to the design of software intended to benefit the public interest.

Chapter Takeaways

The literature review presented an overview on the state of research into how the public sector uses software and data for its activities, and what we know about the future of urban planning software. The sample sizes of many of the qualitative studies identified in this literature review were small, reflecting the state of research on software and data used in the public sector (particularly urban planning) as emergent, emphasizing theory. There are still significant gaps in the literature, including a broad understanding of the way software is used in the planning practice, how data practices effect decisions, and how public participation can be meaningfully incorporated into software as a tool for urban governance.

The literature reflects that the software used by the planning profession has remained largely unchanged over the past twenty years. Many of the most commonly used applications of planners like word processors and email present in any white-collar office. Profession-specific software for permit management is absent from the literature, while Planning Support Systems, which have its roots in academic development, remain highly studied but rarely used by professionals. Recently, there has been an emphasis in public administration on using digitized data for public transparency and shaping policy with data analytics. The literature on data used in public administration, conventional and big, appears to be more optimistic about the creation of a new model of urban governance than the literature on the experimental uses for PSS or observed uses of GIS. Perhaps this is because the literature on data tends to focus on its use by decisionmakers within public sector organizations, while planners are primarily technicians and communicators within a public agency.

The future of software and data for planning points towards the necessity for an engaged public, or else they will be viewed in sweeping algorithmic processes as mere inputs to be managed. In practice, this requires a much greater change in the structure and practice of governance than the relatively flexible task of software design. New technologies, such as City APIs and increased amounts of real-time spatial information, need to be developed through public dialogue in a manner that considers tools as extensions of public servants who should uphold the public interest.

This literature review serves as a theoretical grounding to develop the interview protocol and interpret the findings from the interviews. The review of research into the future of planning software will form the theoretical basis for the framework presented in this report.

Chapter 4. Methodology

The lack of research on planners' perceptions on software generally reveals a gap that this report addresses through new empirical research. This chapter outlines the methodology for the study at hand, including the interview protocol, the instrument for collecting planners' perceptions about their software, and a description of how the interviews were arranged and conducted.

Research Design

Study Area

Santa Clara County, better known as Silicon Valley, was selected as the study area for research due to the range of city sizes and stereotypical expectation of local governments to provide modern digital services. Whether this area's reputation for high-tech prowess extends to local governance may be of general interest to planners nationally. The County contains the tenth largest city in the United States, San José, along with several mid-sized, affluent suburban communities (city populations ranging from 31,000 to over 1 million). The experiences of planners in this study may be comparable to those of other affluent metro areas renowned for high-tech industry elsewhere in the U.S, such as Seattle's King County or Boston's Suffolk and Middlesex counties.

Sample Selection

2018-2019 City Budgets and organization charts (if available) were collected for Los Altos, Campbell, Palo Alto, Sunnyvale, Saratoga, Los Gatos, Mountain View, and San José. These were used to analyze Silicon Valley local governments for their staff size and enterprise software in use. Interviews were sought from mid-career and upper-level planners in the study area. Referrals for other available planners were requested at the end of each interview. A broad selection of planning staff at different levels of seniority with different job roles sought to capture the differences and similarities of using the same applications and what data, if any, was used most frequently across roles.

In total, eleven planners from six different local governments were interviewed. The sample size in this study is small, with no claim to general validity. The responses from these interviews do not represent the experiences of all urban planners with their software. There are many confounding factors in how planning departments experience their software: task burdens on staff, levels of training or expertise within staff, number of staff, and funding for requested software or equipment.

The purpose of these interviews is to ascertain real-world planning issues that might be addressed through a theoretical framework for the future of planning software. On that basis, a qualitative study that seeks input from a few subjects is sufficient for conceptual and contextual clarity on the strengths and shortcomings of software in planning departments. This approach is similar to the semi-structured in-depth interview approach used by Kuller et al. (2018) in their study of Planning Support Systems for urban green water infrastructure[88] and the semi-

[88] Kuller et al., "Building Effective Planning Support Systems for Green Urban Water Infrastructure—Practitioners' Perceptions."

structured field interview approach used by Caulkins et al. (2007) in their study of the impacts of spreadsheet errors on decision making[89].

Subject Recruitment

Interviews were requested by email using a standardized template with customization regarding the relevance of the planner's job to the project. Recruitment emails also included a formal consent document that stated the nature of the project and that the interview would be recorded. If needed, up to three follow-up emails were sent periodically until the subject replied with their willingness to participate. A four-question survey (see Appendix B: Interview Protocol) regarding software used on a weekly basis was sent after consent for the interview was received. The brief survey guided adjustments to the interview protocol to align the questions with the software used by the interviewee. To reassure the interviewee about the non-controversial nature of the interview, and help the interviewee prepare their responses, sample questions were sent in advance, if requested. If the subject agreed to participate, a request to record the interview for transcription was sent along with sample questions and scheduling information.

Conducting Interviews

Interviews were held either in-person (usually in a conference room at or near the interviewee's place of work) or over the phone, depending on the interviewee's availability. Recordings over the phone were made by using a laptop to record a conversation playing over

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[89] JP Caulkins, Erica Layne Morrison, and Timothy Weidemann, "Spreadsheet Errors and Decision Making: Evidence from Field Interviews," Journal of Organizational and End User Computing 19, no. 3 (2007): 1–23, https://doi.org/10.4018/joeuc.2007070101.

speakerphone. Live recordings were made using a laptop and phone in voice-memo mode. Manual notes were recorded in a notebook during the interview with highlights and minute timecodes to refer to during interview transcription and analysis.

Compiling Interview Data

Interview recordings were listened to and relevant responses were transcribed. Key reactions to software's role in planning department operations or perceptions of the effectiveness of software in performing planning tasks were recorded for each interviewee. In the next chapter, responses are aggregated and summarized, and organized by relevant software.

Chapter 5. Interview Findings

This chapter presents a summary of findings from interviews with eleven planners of various professional titles from Silicon Valley. Findings are organized by software, generally in the order that planners indicated the importance of that software to their daily tasks. Software associated with the most common tasks are presented first, software used less often are presented last. For the wide range of software that planners reported that they use, refer to Appendix C: List of Software Used by Urban Planners (Self-Reported).

Survey Findings

Responses from the entrance survey were generally consistent across job titles and levels of experience (for the text of the entrance survey, refer to Appendix B). The eight planners who completed the entrance survey considered software "essential" to the profession[90]. The unanimous ranking of software as essential to the profession may be an indicator of selection bias, since planners most willing to respond to an interview request about software may be those who deem it especially important. Planners were asked to rank the top three software that they use most often (Table 1). Most planners ranked their email as their most-used application, followed by either Microsoft Word or a permit management system. Several planners did not initially recognize Microsoft Outlook as a software that they use, even if it was discovered during the interview that responding to email preoccupied much of their

[90] Planners were asked: "On a scale of 1 (irrelevant) to 5 (essential), how important do you think software is in your everyday tasks as a planner?"

workday. Of the planners responsible for plan set review in their current roles, two planners listed Adobe Reader as their electronic plan review application, while others listed a specialized electronic plan review application. The eleven planners interviewed spent most of their day with a computer, either at their desk or with a laptop as a reference tool at a meeting.

Table 1. Urban planners' top-three most used software (self-reported)

Planner	Most used	Second most used	Third most used
A	Outlook	Word	ArcGIS Online
B	Outlook	Google Chrome (online resources)	Internal GIS
C	Serena (project management)	Office Suite (Word, Excel, PPT)	Adobe PDF Reader
D	Trakit (permitting)	ArcGIS Online	BlueBeam Revu (EPR)
E	Outlook	Amanda (permitting)	Acrobat PDF
F	Outlook	Word	Excel
G	Amlegal (city code)	Word	Adobe PDF Reader
H	Accela (permitting)	ProjectDox (EPR)	ArcGIS Online
I	ArcGIS Online	InSite (permitting)	Outlook

The Role of Software in Daily Practice

Most planners, across seniority levels and roles, spent most of their workday using a computer (several planners used the phrase "screen time"). Expressed as a rounded percentage, several planners said they spent 90 percent of their time in front of a computer, occasionally with days where only 70 percent would be spent at a computer if they were particularly busy with in-person meetings. While many planners are away from their desks for meetings or at the planning counter talking with an applicant, a laptop may be present for reference to ordinances or the record about the site.

Email

Unanimously, planners stated that Microsoft Outlook was their most used software for managing email. Typically, email might be used for setting up a meeting, laying out an analysis of an issue, or explaining findings about a project or application in writing, even if there will be a meeting later (for public record, as opposed to an unrecorded phone conversation). Email functions as the point of contact for applicants, destination for questions from the community, and an inter-office collaboration tool. Occasionally, the phone serves as the most convenient way to convey information or respond to a question. "For virtually everyone, it's the primary way to communicate, nowadays," one planner remarked. However, email can "dehumanize and depersonalize" conversations, and according to one planner, "meeting in person can help to convey information so everyone's on the same page." Other planners described certain thresholds in email conversations after which either a telephone call or in-person meeting became necessary. Such thresholds included the number of questions asked in an email and the extent of explanation required for a question.

Planners described email as "overwhelming," the only software to elicit that reaction. "Before we had this tool, we could go to sleep," one planner remarked. When asked about the impact of email in their department, one planner remarked, "We've become a lazier society with regards to technology." It was also noted that both the public and planners needed to be respectful and conscientious about the tone and content of emails. "People are expecting instant responses. That's unrealistic for me," the same planner said. Another planner found that applicants and the public used email "nonstop, almost using it as a chat." Tactics to deal with the deluge of messages internally and from the public included: telling insistent emailers to wait for a reply, directing frequent emailers to the city website, "punting" or forwarding a message to staff for a response, responding with a timeline where a *response* – not necessarily an answer – would be received, or simply marking an email as unread after a quick scan and attending to it eventually. One planner suggested that improving their web resources and educating the public about how to use those resources would be one way to stem the "barrage" of emails.

As an internal collaborative tool, most planners perceived that email worked well, though some planners strongly caveated potential issues with inter-office email. One planner noted that she would receive emails that could have been avoided if the sender stopped by her office to simply say "thank you." Planners developed their own email etiquette over time.

Conversations and Archiving

Generally, planners acknowledged that information could be lost in the course of a long email thread, however this was considered rare. Planners were asked how well Outlook was suited to finding information needed to respond to a question. Planners found Outlook's basic keyword search and folders suitable for most information retrieval. In an example instance where information might be lost, a respondent on an email chain would forget to copy senior staff that the issue had been resolved.

Planners were asked how automation or integration with other software could improve their email experience. Several planners cited Outlook's ability to organize emails into folders as one of the most useful features of the software. One planner recognized that automated filtering and sorting of emails by creating "rules" could perform some manual sorting tasks, but she felt no urgency to learn how to create these rules. A planner who focuses on policy and ordinance development found email *less* onerous for the detailed back-and-forth involved in that role than using Google Docs' simultaneous writing feature. According to this planner, emailing drafts prevented the occasional writing-over of collaborators that happens with shared documents. A participant copied ("cc'd") in a conversation dropping off a long thread was noted as a potential issue with email for this type of collaboration. This planner was asked if GIS-integration with email would be helpful for sorting conversations by topic location. Because of the broad application of policies to many locations, the planner considered this less relevant. Asked if automatically grouping email by project would be useful, the planner thought it could be, since this would save the step of manually organizing emails into project folders.

Legal Implications

Under the Brown Act and California Public Records Act, two major California public records laws, most emails sent by planners regarding land use and development enter public record. When messaging with the city attorney, confidential email may be exchanged. One planner described a practice where, to indicate confidentiality, the subject line will read "CONFIDENTIAL: [SUBJECT]" in plain text. This planner had established a disclosable and non-disclosable folder for emails in potentially sensitive conversations where litigation is likely. While the planner noted that there are "no great tools" for tracking potentially sensitive conversations, carefully separating emails by confidentiality was only occasionally needed.

Several planners offered the dictum "Don't write anything you wouldn't want to see on the front page of the Mercury News," as guidance for appropriate content for emails should they accidentally be disclosed. Additionally, several planners noted the importance of deleting older emails out of the program's recycle bin after the date necessary to keep the communications in compliance with public records laws.

Calendar Integration

Planners relied on Outlook's integrated calendar feature to organize the various staff meetings they might need to attend throughout the week. The basic features that Outlook provides, such as the ability to create an event from an "invitation" embedded in an email, were sufficient to manage department meetings. Planners had no issue with the scheduling assistance that Outlook's calendar provided. However, one planner mentioned the need to create a spreadsheet to track project timelines, a purpose-separated parallel timekeeping system for medium- and long-term deadlines.

Voicemail Integration

Several planners found Outlook's voicemail integration to be a useful feature. The integration allowed them to view and manage communications from both sources in one place. It was noted that Outlook has minimal features for managing voicemail, but this was not perceived to be an inconvenience. One planner described voicemail integration as "unbelievably helpful." This planner perceived voicemail messages as being easier to respond to compared to email messages, which tended to require time consuming research and preparation of a written reply.

Permit Management Systems

All planners acknowledge the efficiencies that were gained by digital permit management for coordinating the permit process across many governmental departments, including building, fire, and public works, among others. This emphasis on safety and security justified investing significant financial resources in customizing the new system and dedicating staff time to training for the new system. Planners in this department were in the beginning of a transition phase, with most staff not yet adapted to the workflow of the new permitting system. There was commitment from department leadership to continue to train staff and work with consultants to expand the features of the system and improve integration with other data sources.

Planners were enthusiastic about the benefits of transitioning their practice to permit management systems. One planner noted, “My understanding of it is that it has tremendous capacity that we’re not using yet.” This planner considered the goal of transitioning to permit management software, from the planner’s standpoint, to be an automatic linking of data between a permit management system, generation of project status emails, and archival scans of relevant documents (such as a letter of incompleteness indicating missing elements from a plan set or prior draft plan sets). Permit management systems also facilitated a concurrent review process between the planning and building departments, where previously a four- to five-week delay would occur. According to this planner, managers were now able to easily check on the progress of their staff as they handled plan sets, although this was likely not an intended purpose for adopting the system. From the applicant’s standpoint, the goal would be immediate access to a project’s status through the activation of a web portal that reflected the city’s internal status. This same planner perceived the web portal as a “tremendous savings of time” because many applicant questions pertain only to a project’s current status. However, this planner found that at the current state of their department’s implementation, permit management systems created, “another layer of something else we have to do.” Project documents and notes on plan sets needed to be manually uploaded, a new administrative task. The planner noted that within his department, not all staff had adapted yet to the same protocol for managing documents through the software, because no expectations or requirements had been established. For example, a member of the public could ask for an incompleteness letter, and this planner would be able to access it through their system for his own projects, because he had taken the time to upload it, but he might not be able to do the same for a project managed by another planner. Ultimately, this planner felt that the expectation for the permit management system was to make the development process easier for the public, not necessarily to save time for staff. Another planner who had worked previously at a local government outside Silicon Valley remarked that they had long standing procedures for inputting permitting data, the expectation of taking time to enter permit data already existed.

Several planners noted that data entry tasks when using permit management systems had been a cause of incomplete or incorrect information about some properties. In an example scenario, a permit management system would stop a planner from progressing to the next step in a process unless she had input certain information. This hypothetical planner might input "Null" or a numeric code representing "no information" as a quick way to bypass information requirements. Although inputting incorrect information had no immediate ramification, it might cause an issue later when information about many similar projects would be needed, or when another department needed to access information about the property. Null inputs were considered a flaw in digital permit intake that could be corrected through an overhaul of the "standard operating procedures" or steps a planner would follow to enter permit information into the system. "Standard operating procedures" could be encoded in the permit management system with detailed written explanations describing why other planners and staff in other departments would need certain information. Planners acknowledged that inputting information could be cumbersome but avoiding data entry voided the purpose of implementing a permit management system.

File Tree-Based Permit Management Systems

Some planners mentioned FileMakerPlus as a previous generation of project management software. In their experience, another planner or member of the technical staff would create a custom project structure in FileMaker to track the progress of all applications in process. These custom project structures suffered from poor maintainability and a lack of integrated inter-departmental project status tracking. One planner described a project tracking software, not a fully featured permit management system, as an interim solution within the planning department to store pertinent project documents and generate agendas automatically. Each urban development department (Planning, Building, Fire, and Public Works) relied on a separate software to manage documents despite working on the same projects.

Code and Ordinance Archives

Most planners affirmed that they consulted with a code and ordinance archive, such as MuniCode, very frequently throughout the day. One planner noted that MuniCode is "our bible," while another said she was "constantly referring to it." As an essential tool, code and ordinance archives are closely associated with every other software that planners use. Several planners noted that they use MuniCode's export feature to download a chapter of ordinances into Word, then use Track Changes feature to make revisions or comment on a draft of a new ordinance in context.

Planners remarked that they use the same ordinance archives that the public has access to with minor changes to the interface. Planners interviewed had no special way of navigating these archives, relying primarily on their experience with the local code. The most common way to navigate through code and ordinance archives was the browser's built-in keyword search tool.

Several planners were asked if code and ordinance archives could be better integrated into other software, such as Word or a permit management system, since they were a constant reference. These planners had no perceived need for integration, since many planning departments have either acquired dual monitors or would use a keyboard command to switch between a plan review application and a web browser with the code reference.

Electronic Plan Review

Similar to permit management systems, several planners recognized the potentially transformative benefits of electronic plan review. These planners felt their departments were in the middle of a transition phase where beneficial features were not yet fully implemented or adopted by their department.

One planner initiated the transition for his department. He said, “I [tested] Adobe by myself and it was worthless.” Then, on advice from several architects, he tested an industry standard EPR software and convinced his department to purchase it. He also received a 45-inch monitor dedicated to reviewing projects. “It’s very limited in scope if we use it to review plans, mark them up, and email applicants. That’s just such a limited view of how you could use it. Because the reality is that it can be a tremendous savings of time for employees, for both planning, building, and engineering.” One of the most crucial time saving features is the capacity to compare two successive plan set drafts and catch the differences automatically. However, this feature has not been implemented. “Half the battle is trying to find out the differences between plan sets,” since developers may make code-violating changes in the plan set between drafts without notifying the planner, “intentionally or unintentionally.” Using EPR, discrepancies identified between submissions could be reviewed against the completeness letter sent for the previous submission, and a letter listing code-violating changes could be prepared. Catching changes that slip through between plan set drafts is especially important since, “once you issue the building permit, they’re vested, there’s nothing you can do.” To implement this feature, staff time would need to be dedicated to establishing consistent formatting guidelines and setting these parameters within the EPR software. In this planner's office, however, the building department has opposed adopting EPR over the possibility of fraudulent digital signatures.

Several other planners expressed concerns about developing a standardized page labeling convention for intaking digitized plan sets for automated comparison. Ideally, all site plans would appear on page A, all elevations would appear on page B, and applicants conform to one standard for titling their submissions. Other departments would follow these naming conventions, such that A through F in planning would correspond with X and Y in engineering. Instead, planners described receiving plan sets that were labeled and arranged differently depending on the applicant. The software itself cannot correct these formatting inconsistences. Consistently labeled plan sets would allow EPR to perform an automatic comparison for all submittals. Moreover, establishing a standardized naming convention would aid in cataloging and assessing thousands of plan sets across several departments and responsible agencies. One planner described electronic plan review as "tremendously underutilized," in the absence of a convention for plan set intake.

One planner noted that EPR offered the ability to create separate layers for comments, such that several parties could collaboratively comment on the same document. He felt that the projects handled by his department were not complex enough to fully take advantage of this feature, though it could be helpful to local governments with land for larger projects. Another planner who has worked on larger, more complex projects, considered the capability to view the project itself as a series of layers to be useful. A planner who currently uses Adobe Acrobat for plan review, which lacks specialized EPR features, was indifferent to navigating different lengths of plan sets.

Planners may have a choice whether to use EPR or traditional paper markups (with digital scanning) in their departments. For one planner, the choice of review method depends on the needs of the applicant, rather than a preference for one method or the other. “[S]adly, I use [our EPR software] more for single family [residence projects] and I revert back to letter format for these larger projects,” such as multifamily residential developments. The primary advantage of EPR in an incomplete implementation is, for this planner, to precisely locate needed changes on the plan as instructions (or “hand holding”) for the architect. Despite the length of plan sets for larger projects, review has been faster writing a traditional letter and taking a meeting with the architects. Architects on larger projects tended to be able to address comments on the project itself completely but needed detailed explanations of policies or regulations that would be difficult to express in an EPR comment. Pushback from large-project developers on certain comments were perceived to be easier to address through means of review outside of EPR, such as a phone call or meeting. The “sad” fact of working with architects or designers on some residential projects is that they tended to have difficulty making specified changes over successive plan versions. Features of EPR, such as bubble-shapes to highlight certain parts of a design that needed to be altered or arrows pointing to elements that needed adjustment, provided guidance for architects working on smaller projects that architects on larger projects simply did not need.

Several planners commented that EPR provided an opportunity to reduce the paper clutter that crowds planning department workspaces. However, this transition to a paper-less office was a long-term prospect. There was a legal need to keep a backlog of paper plan sets for public records request purposes.

Occasionally, older architects bringing in hand-drawn plan sets prevented the use of EPR. “You just work with those people,” one planner said. He would print plan sets and mark his comments on paper, working with these applicants the traditional way. Other planners remarked that paper plan sets would never entirely be phased out of practice, since, “in some cases it is easier to annotate certain projects on paper.”

Word Processing

Most planners found Word satisfactory, having no complaints when asked if the software was suited to their needs. However, it was recognized that Word has changed little over the past decade even as planner’s word processing needs have evolved. Letters, staff reports, policy memos, and other text products made in Word have become longer and more detailed over the years as elected officials recognize that research can be performed more quickly. Permit management systems may be able to automatically generate certain letters, if the correct information has been entered into the database, reducing the need for some Word documents. One planner noted that the form and content of staff reports is dictated in part by what city council finds useful (and in part by standards for a legally defensible public record). As new generations of council members hold office, they may desire more visual presentation of information from staff, and the form of the staff report may change accordingly.

Spreadsheets

As suggested by the literature on spreadsheet errors, planners typically found erroneous numeric and text data in spreadsheets. Over a range of local government sizes (31,000 to over 1 million population), planners found that the data they used was generally correct. Planners typically rated the occurrence of data errors a “2” for both GIS and spreadsheet-based data, with only a few instances of a planner rating “3” for GIS errors and one “4” for spreadsheet errors (Table 2). The planner that declined to respond directly to the question stated that occurrence of erroneous data was context dependent and could not be generalized. Planners were asked a follow-up question about how data errors (in either spreadsheets or GIS) were uncovered. Circumstances of discovering and correcting errors were similar regardless of the error frequency rating. Typically, errors were found informally, such as a parcel number search returning an obviously incorrect location, not as part of an internal audit or data inventory.

Table 2. Urban planners' perceptions of errors found in spreadsheet and GIS data

Planner	Spreadsheet	GIS
A	2	2
B	Declined to respond	Declined to respond
C	3	3
D	1	2
E	2	3
F	2	2
G	4	2
H	2	2
I	1	2

Note: Respondents were asked the following question: "On a scale of 1 (never) to 5 (daily), how often do you find an error in: a) a spreadsheet; and b) GIS data?"

Planners typically discovered errors in spreadsheets by manually checking through the data when they needed it to respond to a question or perform an analysis. One planner mentioned a frequent source of errors comes data that they may receive from a third party, typically an applicant: “It may be purposeful, maybe not, either way we have to check it.” Error discovery happened manually, typically because a result did not make sense or fit with a general impression of the data. No planner could recall a time when Excel had automatically helped them discover an error or inaccuracy in data. Several planners felt confident that there were very few errors in their department’s data, because the small size of their local government’s inventory meant staff had reviewed and corrected data thoroughly over time.

Most planners used Excel for compiling information using simple formulas and basic calculations. No planner that used Excel regularly used it for complex economic or land use projections. One planner recounted how they would need to instruct staff to tabulate data in Excel rather than present numbers as text in Word with calculations done on a physical calculator. “That’s one less thing for me to check.” Another planner remarked how Excel assisted planners as communicators by allowing them to simplify complex concepts into a table or graph. “If we needed a map, we would include it,” one planner said, finding that tables and graphs created in Excel are often sufficient, and there is no unmet need for more maps or visualizations in staff reports or presentations to council.

Excel was viewed by one planner as a complementary program to the permit management system. “[Our permit management system] is only as good as the data in the database,” so other tools may be needed when that data has not (or cannot be) imported into a permit management system.

A GIS technician may be needed to retrieve certain data for cleaning and analysis in Excel. Working on an analysis of accessory dwelling units (ADUs), one planner needed specialist GIS staff to retrieve relevant records in the city’s geodatabase. The permit management system had not been sufficiently integrated with records available through GIS for the planner to perform the search herself. The planner remarked that she had to spend significant time cleaning and compiling data in spreadsheets because it had not been entered correctly into a permit management system or geodatabase initially.

Customized Project Calendar

One policy-focused planner used a spreadsheet to track timelines on various internal projects, including staff reports related to projects effected by streamlining timelines specified in state law. The planner searched the web for a generic spreadsheet calendar template and customized it as needed. This calendar is not standard to the department or the local government. Excel facilitated the creation of this ad-hoc calendar and has basic functions that support it, such as color-coding for cells and the ability to sort text by an associated number value (e.g. days until due). For this planner, a customized spreadsheet in Excel tracked tasks and project timelines, while Outlook's integrated calendar tracked meetings.

ArcGIS Online

All planners used their department's ArcGIS Online implementation to access basic information about parcels. For many planners, analyses of land use and policy impacts used spreadsheet models in Excel. Planners in departments that had adopted permit management systems found integration with spatial information presented in ArcGIS Online to be a significant convenience feature. One planner noted that some applicants would use the local government's interactive ArcGIS Online map to find information about their project's zoning and General Plan designation, then bring the same question to the planning counter so it could be explained to them in conversation, supplemented with hand-drawn pictures.

One planner felt that ESRI, the creator of ArcGIS, had too much market-share in planning departments. QGIS, an open source alternative, could be used more widely, reducing dependence on contracts with ESRI.

Spatial Analysis and Visualization Systems (Google Street View/Google Earth/ArcGIS Online/SketchUp)

Planners frequently use Google Street View alongside Word, email, or EPR, to better understand the surrounding uses (or "context") of a parcel. Pre-interview survey results indicated that Street View and Earth are widely used accessory software. Planners referred to Street View as a tool for supporting an understanding of site context.

When asked about how existing software could better depict zoning codes, one planner imagined an improvement to Google Street View. "In my mind it would be super cool if I could show a push and pull," of the 3D rendering of the property, demonstrating for the applicant with a real-time visualization of what development would be allowed in a given zoning.

PowerPoint

Senior planners described using PowerPoint as a visualization tool in presentations to elected decisionmakers. When asked if they found the visualization capabilities of PowerPoint to be sufficient for their needs, one planner noted that PowerPoint graphics "had come a long way," and could be intricately detailed, if needed. Several planners could describe instances where well-designed informative figures in PowerPoint had supported a recommendation to decisionmakers where oral arguments and written statements alone were insufficient.

SketchUp

Two interviewees that worked with applicants directly on design review were asked if they, or someone they knew in their department, had used a 3D visualization tool such as SketchUp to help explain local codes or design guidelines to an applicant. Neither of the interviewees reported using SketchUp, citing the learning curve on the software. One planner admitted that although he did not know SketchUp, another staff member had occasionally used the software to illustrate design review comments rather than write them in detail, reducing some of his review times. The other planner said that, at the counter, the public typically want a direct answer to their question, “either yes, no, or a number,” and do not need a visualization.

Advanced Technology in Planning

Most senior-level planners were asked about the possible role of big data in the future of planning department operations. Respondents perceived no immediate use for big data. One planner recognized that the transportation department could use big data to manage traffic operations but did not see how it would apply to near-term urban planning. Many planners felt they had an appropriate amount of data available to them for analyzing projects.

Most senior-level planners were asked if they had used a planning support system. Only one was familiar with the term; none had used a planning support system professionally.

General Perceptions and Expectations for Planning Software

Planners were asked to make one wish for their department’s software. Generally, planners tended not to focus on the software itself as much as a change in how software is supported. Several planners dedicated their wish to more effectively dealing with consultants to customize their software to their department's needs. Other planners wished they had more time for staff training on new software. One planner wished cloud-based deployments of Outlook and Adobe Acrobat crashed less.

All planners asked about the potential impacts of automation suggested that the task of planning could never be entirely automated away by software. Several planners pointed to design review as an aspect of oversight in the development process that required a professional's input, both to work with the client interpersonally and negotiate a suitable design solution with respect to the interests of elected decision-makers. One planner said, "I work in things that require a hearing. If I automated it, it would defeat the purpose of why my department exists, which is for discretionary review," one planner said. Many planners recognized that objective ordinances existed, and that it might be possible for some level of automated verification, although objective requirements appeared to be more prevalent in the building department than planning. One planner noted that even with automatic verification for objective ordinances, there would still need to be a planner to verify the accuracy of the computer-generated model of the proposed project against the reality of the project site or existing structure. "The problem with an automated process is that you're trusting that the person applying it know what they're doing." Rather than check the ordinances, this planner speculated that automation should emphasize reducing manual data entry or record keeping. Only one planner expressed concern with the possibility that objective ordinance checking that she does could be automated.

Planners perceived that software alone would not be able to replace the role of the planner as a communicator and mediator between the public and elected officials. One planner noted that elected officials would watch body language carefully to assess a presenter's intentionality about a project: “They are watching how confident you are in what you’re saying, listening to your intonation, if you’re sure about what you’re saying…that speaks a lot to what a screen can’t do, relative to the truth of the project that you’re presenting. So, they’re watching us, not just watching the screen and listening.”

Critical Findings from the Interviews

This interview study intended to capture first-hand impressions from planners about their software. Three premises underpinned the interview protocol: 1) planners can interpret the usefulness of their software; 2) planners have a negative view of some of their most frequently used software; and 3) planners find communicating existing data more cumbersome than retrieving data.

Confirming the first hypothesis, planners were able to describe the role of software in the planning process in detail. This amounted to planners recounting how they perform routine tasks, such as entering permitting information or searching for local zoning code. Crucially, the inadequacies of software were rarely revealed by a perception of a missing software feature or lack of integration with other software. Instead, the flaws of software were implied through remarks about incidental institutional demands around the software itself. For example, planners discussed working with consultants on implementing software, difficulty with staff training and accommodation on new software, and dysfunctional communication with the public or applicants regarding their projects through email or the city website. Planners’ tendency to comment on the institutional aspect of their software could reflect their domain of expertise. They have much more familiarity with their consultants and staff than they do with the design of the software itself. Some of the inadequacies that planners perceived in their software were an artifact of when these interviews were conducted. Many public agencies in Silicon Valley appear to be transitioning to new permit management software, new electronic plan review software, or both. Several planners described their department's specialized software as "underutilized." Automation features that existed were not fully activated yet, or members of the department had not yet adopted the software. In effect, the interviewees could not perceive what the current state of software, fully implemented, has to offer. Disproving the stereotype, planning departments in Silicon Valley have years ahead of them to take full advantage of their technological tools.

Contrary to the second hypothesis, planners had a generally positive view of their most frequently used software. Only the activity of email itself was viewed negatively. Unanimously, planners found email a nuisance and occasionally a counterproductive format for dialogue with staff and the public. A broader literature supports the notion that email has become a source of anxiety for its users.[91] Surprisingly, all other software, whether specialized software for electronic plan review or general productivity software like Word, Excel, and Outlook, were viewed positively, even defensively. Interviews were limited to mid-level and senior planners, in part because interviews were not granted with lower-level staff, so there is no data on how entry-level planners perceive specialized software that comes with a learning curve. Word and Excel were viewed as sufficient as designed, no new features or integrations with other software were considered necessary. Despite this, one planner complained that some staff would enter numeric data as text into a Word document. This highlighted a clear flaw in

[91] Jean Francois Stich et al., "Appraisal of Email Use as a Source of Workplace Stress: A Person-Environment Fit Approach," Journal of the Association of Information Systems 20, no. 2 (2019): 132–60, https://doi.org/10.17705/1jais.00531.

productivity software that remained substantially unchanged over decades of superficial improvements.

The desire to keep general productivity software as-is may be due to a number of factors. Mid- and senior-level planners interviewed may not see a need for additional support from their software due to their existing base of expertise. They may be accustomed to the sources of issues, like incorrect spreadsheet data, and how to overcome them, such that new features might be an interference. There might be an aversion to the institutional time lost to setting up new features or a distrust of breaking with established operating practice. More likely, planners could not imagine how their productivity software might be redesigned or extended to better serve them. Word and Excel have changed little over the past twenty years. PowerPoint has changed little over the past ten years. The acceptance of existing software suggests that, despite the complexity of the planning processes they are engaged in, they felt confident mentally managing the context, design principles, laws, and data with the minimal support provided to them by Word, Excel, Adobe PDF Reader and other generalized tools.

Notably, planners differed on the perceived value of online resources as communication tools with the public. Planners cited improved web portals for accessing permitting statuses were a key reason for adopting permit management systems. Simple status requests were highly valued. Many planners received emails from the public about questions that were answered by the online local code, yet there was no stated interest in altering or simplifying the presentation of the local code. There are several possible explanations for this. One is that the public prefers an explanation of the code from a planner (statements from several planners suggest this). This offers the assurance of a person to blame if the process is later derailed. This could also be because a single presentation of the local code in its authoritative, legal form prevents confusion over multiple codes. The framework developed in Chapter 6 will attempt to reconcile the desire to simplify the planning experience for the public with the opacity of local codes.

Interviews confirmed the third hypothesis. Communicating permit status and comments on submitted building applications appeared to be the most pressing reason for adopting new software. Retrieving data appeared to be a negligible concern.

None of the hypotheses anticipated or could explain the most salient finding for the future of planning software: planners interviewed were not familiar with how big data or planning support systems might be used for their long-range planning goals. Despite a growing body of literature on both these topics, professionals asked about possible applications for advanced technologies had no immediate use for them. This reflects the theory-practice gap and should be expected – planners focus on their day to day tasks, not frontiers of research. Further, adopting new technology may be difficult to envision, due to institutional constraints around acquiring and training staff to use new software. This finding should underscore the importance of involving professional planners early in the design and development of new software, particularly when it will take advantage of new techniques with major policy implications like big data.

Significant findings from the interviews for the development of the framework for the future of planning software will be discussed in the next chapter.

Chapter Takeaways

Key findings from the interviews include:

- Most planners spend their day using a computer. Responding to emails take up the bulk of screen time and impacts planners' ability to focus on other tasks. "Before we had this tool, we could go to sleep," one planner remarked. Significant portions of the day are also spent using electronic plan review and permit management software for routine planning tasks.
- Many planners interviewed expressed displeasure with the volume of email that they received daily. Some felt that they received needless emails, either from communications that could have happened in person or questions that could have been answered from their local government's online resources.
- Adoption of Electronic Plan Review (EPR) systems is relatively recent, if a subject government has even adopted it at all. All planners recognized that EPR systems would have time-saving potential, both for staff and applicants, and were eager to see technical staff integrate data between plan review and permit management systems. Several planners noted that key features of EPR were underutilized because rules for intaking plan sets had not yet been developed. These rules would be aligned with parameters set in the EPR software to automate certain checks that were performed manually. Many planners used several different applications while using an EPR system, particularly their local government's code and Google StreetView.
- Like EPR, planning departments are still adapting to permit management systems. Although all the planners interviewed understood the value of with their local government's permit management system, several planners noted that there are

inconsistencies and omissions with data entries that limit the full potential of these systems. One planner noted that their department justified the adoption of a permit management system to share information across departments concurrently and share status of permits more efficiently, with the goal of making the development process easier for the public, despite added burdens on staff to enter data manually into the system. Planners generally found GIS integration in permit management systems an important convenience feature.

- No planner asked about the potential role of "big data" (city-scale, data analytics) felt that their department had an immediate use for big data. Several planners felt that their local government was too small to take advantage of big data, although their transportation planners might have some use for it.
- Most planners were asked if they had used a planning support system. None of these planners had used a planning support system, and only one had heard of this type of software and could explain how it might be used.

Chapter 6. Framework for the Future Planning Software

This chapter proposes a framework for future planning software that aims to ameliorate gaps in communication and recover time wasted from manual retrieval of correct data or decisions made based on incorrect or missing data. The features of the framework proposed here are fundamentally informed by findings from this study, including from the interviews summarized in Chapter 5. This does not mean, however, that every feature of the new framework should be construed as being in direct response to the opinions of any one interviewee. Nor is the proposed framework intended as a criticism of any existing software or any particular planning department's practices.

The Value of a Framework

The proposed framework interprets a broader mandate from several planning scholars for academic planning researchers to become involved in the future of planning software. Drummond and French (2008) called for research universities to engage with local planning departments on developing and targeting their GIS services.[92] Eirinaki et al. (2018), working as inter-disciplinary academics, developed a prototype for a cloud computing-based, open source permit management system for municipal use.[93] The role of research universities in supporting local communities has been established in the literature, sometimes under the "Triple Helix" label for university-community-private sector partnerships, sometimes under university-

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[92] Drummond and French, "The Future of GIS in Planning: Converging Technologies and Diverging Interests," 173.
[93] Eirinaki et al., "A Building Permit System for Smart Cities: A Cloud-Based Framework."

community partnerships for institutional collaboration on community challenges. For example, Notre Dame University in South Bend, Indiana[94] and Carnegie Mellon University in Pittsburgh, Pennsylvania[95] both regularly partner with the municipal governments of their hometowns. The development philosophy advanced by this report champions universities as collaborators with local planning departments to solve urban planning problems through inter-disciplinary exchange.

The purpose of defining a framework is to integrate seemingly disparate components of software used in planning into a unified platform that reflects the multi-faceted role of planners. This framework encompasses the related sub-duties that form a municipal planning department. Ideally, this framework can be extended to a socio-technical system that integrates administration, public works, and financial duties within a municipal government. Developed as an initial provocation, a framework can then be critiqued and improved, as well as used to position a smaller prototype in a larger context. A framework can also be used as a structuring element for a future research agenda. The voice of planners has been sought to include them as early participants in the user-centered design of this proposed framework. As a framework, the discussion of software will be conceptual, meaning there will not be any concrete descriptions of the proposed software as if it were implemented. Descriptions of user interfaces, for example, are absent. Hardware support for this framework, such as the type and configuration of server infrastructure, is outside the scope of this report, but would serve as a technically sophisticated, companion to this report. It should be noted that public sector procurers should

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[94] Zack Quaintance, "South Bend, Ind., Could be a Glimpse at the Future of Mid-Sized Cities" (January 8, 2018). Retrieved from Government Technology (April 29, 2019): https://www.govtech.com/civic/South-Bend-Ind-Could-be-a-Glimpse-of-the-Future-for-Mid-Sized-Cities.html

[95] Carnegie Mellon University, "Metro21 Partners" (n.d.). Retrieved from Carnegie Mellon University: https://www.cmu.edu/metro21/partners/index.html

be careful before contracting with public cloud providers like Amazon and Microsoft, such that public data can be retrieved without having to pay an onerous fee at the termination of a contract.[96]

Relevant Insight from Planners

Several key challenges identified from interviews with planners to be addressed in a future generation of planning software include:

- An inundation of email, both internally and from the public, takes time away from critical activities.
- Inconsistencies between plan sets submitted for EPR prevents some automated features from being used. Automated checking of objective ordinances has been shown to be a time-saving feature and if that capacity can be expanded, it should.
- Manual data entry tasks incumbent in permit management systems have been viewed by some planners as a waste of time. However, this impacts the work of other departments and planners who analyze permitting information.
- Planners frequently check their local government's codes and ordinances for reference. Some planners have adopted two monitors so they can view documents and ordinances together. Many planners are preoccupied with explaining relevant code to applicants as part of the EPR process, even after applicants read the local code.
- Planners have to manually identify errors in spreadsheets, either from data provided by a third party or created internally. In practice, this may only occasionally develop into a

[96] DSM, "Hotel California: Can the Public Cloud Hold Your Data Hostage?" (July 5, 2018). Retrieved April 30, 2019 from: https://www.dsm.net/it-solutions-blog/hotel-california-can-the-public-cloud-hold-your-data-hostage

serious issue, however staff time is taken in carefully inspecting spreadsheets for errors and catching them before they make their way into the public record or inform a decision-making process.

- Word processors have not substantially changed despite noted increases in the length of documents and the greater demand for evidentiary data in documents. Some planners still manually tabulate data using a calculator before entering it into a document, and word processors lack features to prevent this behavior or make users aware of best practices.
- Presentations to decision-makers benefit from visual aids. Generations of decision-makers to come may prefer information presented visually as a complement to text.
- Staff may not be properly trained to use permit management systems, electronic plan review, or other general productivity software for spreadsheets or presentation design.

These insights form the foundation of the Framework described in this chapter.

Sketching a Software Framework for Urban Planning

Naturally, software has limitations within the planning process. Software may be able to perform complex, rule-based processes more efficiently and consistently than manual work, but it cannot interpret a local government's guiding development principles or communicate on an inter-personal level with the public. Therefore, the framework to be described in subsequent sections is socio-technical – combining technical elements (new software capabilities) organizational changes (modified planning practices). Organizational changes are highlighted in the last section, dealing with email and calendars.

The purpose of this framework is to simplify common tasks and reduce or eliminate redundancies or inefficiencies that arise from separate, context-insensitive software in use today. This framework describes an inter-connected set of applications. Together, these applications mutually benefit each other by creating data about built and environmental assets, managing tasks and projects through defined rules, and minimizing information lost during internal and external communications. Automation is critical to this framework, but the automatization is focused on *assisting* planners through information retrieval, organization, and presentation. Automated decision-making is specifically excluded, with respect to the distinct political and organizational problems of identifying administrative tasks to automate and making automated decision-making processes transparent to the public.[97] The framework involves the following components, ordered by their potential service scale, from multi-state regions down to individual planners (Figure 12):

[97] Jan Etscheid, "Artificial Intelligence in Public Administration," in Electronic Government - 17th IFIP WG 8.5 International Conference, EGOV, ed. Ida Lindgren et al. (San Benedetto Del Tronto, Italy: Springer Nature, 2019), 248–61, https://doi.org/https://doi.org/10.1007/978-3-030-27325-5_19.

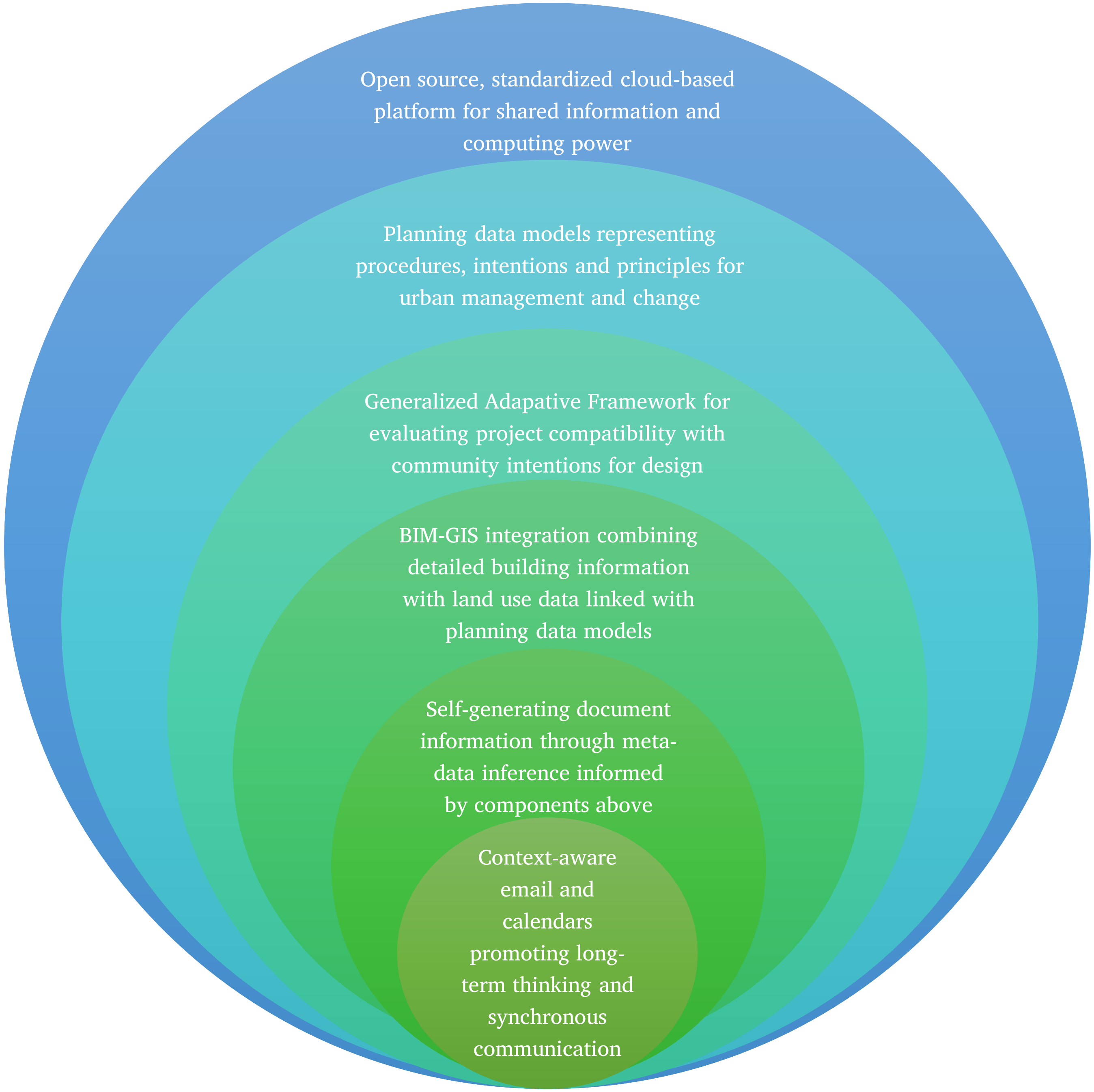

Figure 12. Framework for the future of planning software. The nesting position of each circle represents the service scale of each component. Cloud-based platforms serve multi-region areas, potentially several states. Planning data models serve states all the way down to neighborhoods. Generalized Adaptive Frameworks encompass state building codes and local design guidelines. BIM-GIS integration is attained at the county and city level. Metadata inference may be tailored to a department's specific corpus of documents. Context-aware email and calendars serve individual planners, but the rules are created using information from the larger nested circles and exchanged on the cloud-based platform.

As determined by findings from the literature review, a framework for future planning software must be capable of accepting and manipulating textual data and diverse sources of big data from the following inputs:

- Local code and economic development policy: text data with objective standards and requirements for land use;
- Land use plans: spatial data with corresponding text data collected in a planning document.
- State and federal policy: text data with objective minimums and requirements for municipal actions;
- Embedded sensors in the built environment: "Internet of Things," i.e. infrastructure and asset data reporting on the status of transportation conditions, water and sewer systems, and electric grids, among other infrastructure;
- Environmental sensors: including, as illustrative examples: location-precise air quality, pollinator populations, urban heat and shade;
- Internal and external communications: Text data related to tasks and projects, such as policy analysis or project feedback, some of this text may require time sensitive replies;
- Public engagement: real-time responses, either emotional or physiological, to public services in the built environment, e.g. accessibility conditions at curbs, pavement maintenance conditions, street shade at transit stops;

The following sections discuss the function of each component of the framework for the future of planning software in detail, ordered by their service scale.

Open Source and Standardized Platforms for "Government 3.0"

The software adopted by the local governments examined in this report could broadly be referred to as "Government 2.0," while the framework described in this chapter consists of "Government 3.0" or "Smart City" software. Under the Government 2.0 paradigm, public administrations transition from analog (paper) processes to digitized processes, although the procedure and workflow of the paper process remains essentially the same. Efficiencies may be gained through more inter-departmental coordination using a digitally managed process, but information silos or barriers between departments remain. Open data, or the release of public data digitized in the computer-adoption era of Government 1.0, is another hallmark of Government 2.0. Many public agencies nationally have yet to determine policies and practices for regularly updating and releasing their public data.[98] Negotiating data sharing and open data agreements with private partners remains a challenge. Much of the software used in the Government 2.0 paradigm is proprietary, compelling public agencies to pay private companies and consultants for the use and maintenance of essential government functions. Additionally, a hybrid cloud-based system, part public (off-site) cloud managed at a state or inter-state level with a private (generally, on-site) component for highly-sensitive data, could provide less-well-resourced local governments the ability to access compute-power intensive software with the benefits of lowered maintenance costs and greater system reliability for larger, relatively well-resourced local governments. As pressure to modernize increases, government service risks becoming entangled with costly proprietary systems that pressure budgets and put smaller, less financially sound communities at a competitive disadvantage for offering similar services. As a Government 3.0 framework, the software described here is assumed to be integrated across

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[98] Kevin Desouza and Kendra Smith, "Big Data and Planning" (Chicago, 2016), 64.

department data sources, oriented towards releasing open data for transparent public service, and open source for standardization across local governments and lowered maintenance costs.[99]

It falls outside the scope of the framework to describe policies or organizational strategies that may improve the likelihood of a government committing to investment in enterprise software and cloud hardware, but it is worth noting political conditions that underscore the framework. Non-technical barriers present the greatest challenge to adopting new government technology, chiefly institutional or organizational leadership.[100] Staff may be aware of technology that would make their work easier, but executive leadership may be unable to justify the expense of procurement or the risk of training and deploying systems that will disrupt established practices. At the top of a department, executives may recognize the need for modernization, but local elected officials may disagree. This framework assumes willing leadership and justifies this in two ways: 1) Regardless of political position of decision-makers, open-source software is consistent with broadly accepted principles of public transparency for algorithmic decision-making, standardization of data formats, and fiscal responsibility[101]; and 2) public agencies could cooperate on the development of software within the framework, based on the notion that public agencies create public value (as opposed to competing for tax revenue), so larger local governments could lead development while smaller local governments could share their solutions mutually.[102]

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[99] Yannis Charalabidis et al., "Three Generations of Electronic Government: From Service Provision to Open Data to Policy Analytics," in Electronic Government - 17th IFIP WG 8.5 International Conference, EGOV, ed. Ida Lindgren et al. (San Benedetto Del Tronto, Italy: Springer Nature, 2019), 3–17.

[100] Kuno Schedler, Ali Asker Guenduez, and Ruth Frischknecht, "How Smart Can Government Be ? Exploring Barriers to the Adoption of Smart Government," Information Polity 24 (2019): 3–20, https://doi.org/10.3233/IP-180095.

[101] Albert Jacob Meijer et al., "Open Governance : A New Paradigm for Understanding Urban Governance in an Information Age," Frontiers in Sustainable Cities 1, no. 3 (2019): 1–9, https://doi.org/10.3389/frsc.2019.00003.

[102] Ralf-martin Soe and Wolfgang Drechsler, "Agile Local Governments : Experimentation before Implementation," Government Information Quarterly 35, no. 2 (2018): 10, https://doi.org/10.1016/j.giq.2017.11.010.

Building the Public Record – Integrating Digital Plan Data with the Framework Components

Planners tended to be satisfied with the current forms of word processing, spreadsheets, and ordinance archives. For most, the track changes feature in Microsoft Word and basic formulas with simple functions and conditional statements were sufficient for most tasks. Planners did not identify a need for additional visualization tools to supplement documents of record, such as staff reports. Fundamentally, the expertise of planners as interpreters of complex plans and communicators of a local government's evolving development policies to the public cannot be replaced by software. However, software can improve discovery times for information, both for planners and for the public, and it can provide structure to promote adherence to best practices within a department. This portion of the framework groups three tools – word processors, spreadsheets, and code and ordinance archives – because planners use them to analyze policies and projects. In other words, these tools are used in building the public record (not to mention everyday administrative tasks). This framework posits an expansion of these tools through context-awareness within a local planning process. Subsequent parts of the framework build on this context-awareness.

Policies, whether regulatory ordinances or intentional land use development guidelines, are generally represented as plain text without external content annotation. Urban development plans, their related policies and ordinances, are intrinsically more difficult to make machine-readable than objective ordinances. Development plans vary by local government, using non-standardized spatial representations, describing intentions qualitatively or quantitatively depending on local politics, and may suffer from to internal contradictions within plans, with state law, or with changing local politics.[103] Literal translations of policy to machine-readable forms create overwhelming complexity, while simplified or representational translations may be too abstract to represent a useful model. A best practice for systematically encoding policies as data is unknown.[104] A method for representing land use rules spatially has been developed to assist urban land use change modelers, but this method has not been automated and assumes equal weighting of the applied rules.[105] Standardized technologies for defining interrelationships among natural language terms represent one possible set of tools for specifying spatial norms.[106] Despite major technical gaps, at the conceptual level of a framework, land use policies and regulations could be machine-readable.

Machine-readable policies and regulations could be encoded using a planning data model.[107] In brief, a planning data model encodes relationships between actors in the built environment (e.g. the public, the planning commission), urban assets (e.g. homes, streets), and decisions (e.g. width of a sidewalk, height of a building, setback in a densely zoned area).[108] Planning data models could be applied to the vague, sometimes contradictory policies and regulations that comprise city plans, since they are descriptive rather than deterministic. How the planning data model extends to form-based codes, which emphasize physical form of

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[103] Anna M. Hersperger et al., "Urban Land-Use Change: The Role of Strategic Spatial Planning," Global Environmental Change 51 (2018): 36, https://doi.org/10.1016/j.gloenvcha.2018.05.001.
[104] Hersperger et al., 36–37.
[105] Gaëtan Palka et al., "Visualizing Planning Intentions: From Heterogeneous Information to Maps," Journal of Geovisualization and Spatial Analysis 2, no. 26 (2018): 1–14. https://doi.org/10.1007/s41651-018-0023-9.
[106] Rinke Hoekstra, Radboud Winkels, and Erik Hupkes, "Reasoning with Spatial Plans on the Semantic Web." *ICAIL-2009 Barcelona, Spain*, 2009, 185–93.
[107] Lewis D. Hopkins, Nikhil Kaza, and Varkki George Pallathucheril, "Representing Urban Development Plans and Regulations as Data: A Planning Data Model," Environment and Planning B: Planning and Design 32, no. 4 (2005): 597–615, https://doi.org/10.1068/b31178.
[108] For Hopkins et al.'s illustrative example of a planning data model, refer to Appendix D, **Error! Reference source n ot found.**.

structures, instead of land use, remains unstudied.[109] Despite technical uncertainties, there are four conceptual reasons to support a planning data model: 1) the potential for the public, developers, researchers, and entry-level planners to access complex interrelationships between policies and regulations that might be familiar to an expert; 2) create generalizable, programmable planning support systems (PSS), overcoming one of the fundamental flaws with that class of software[110] and providing built environment simulation and land use tools with greater flexibility[111]; 3) expedite finding similar policies and regulations in other local governments through "deep" rule-level search, rather than "shallow" word-level search; and 4) allow relevant changes across agencies, stakeholders, and state and federal law to more quickly coordinate on intentions of policies and regulations.[112] One of the most immediate benefits of a planning data model would be to describe algorithms used in urban planning in a form closer to plain language. Algorithmic decisions for investment and urban planning can be used to obfuscate political decisions as objective or abstract.[113] By using a relatively simple, natural language form that describes relationships between actors and elements in the built environment, planning data models could provide a basis for discussing the variables used in algorithmic planning. Making the variables of a planning algorithm explicit, describing the data

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[109] Ajay Garde and Cecilia Kim, "Form-Based Codes for Zoning Reform to Promote Sustainable Development: Insights From Cities in Southern California," Journal of the American Planning Association 83, no. 4 (2017): 346–64, https://doi.org/10.1080/01944363.2017.1364974.

[110] Hopkins, Kaza, and Pallathucheril, "Representing Urban Development Plans and Regulations as Data: A Planning Data Model," 614.

[111] Monica Billger and Liane Thuvander, "In Search of Visualization Challenges: The Development and Implementation of Visualization Tools for Supporting Dialogue in Urban Planning Processes," Environment & Planning B: Urban Analytics and City Science 44, no. 6 (2017): 1012–35, https://doi.org/10.1177/0265813516657341.

[112] Lewis D. Hopkins and Gerrit Jan Knaap, "Autonomous Planning: Using Plans as Signals," Planning Theory 17, no. 2 (2018): 274–95, https://doi.org/10.1177/1473095216669868.

[113] Sara Safransky, "Geographies of Algorithmic Violence: Redlining the Smart City," *International Journal of Urban and Regional Research*, November 24, 2019, 15, https://doi.org/10.1111/1468-2427.12833.

inputs for a decision, politicizes planning algorithms and allows for more direct comparisons.[114] Planning data models are also well suited to experimenting with alternative forms of land use governance. For example, planning codes, which are abstract, general, and a-spatial unlike zoning, can be described in a planning data model.[115] Making these codes accessible in visualizations or simulation software might make experimentation easier. Questions of transparency in land use planning remain for scholars; a planning data model cannot resolve these questions, but it can be used to describe transparency requirements and describe outcomes for transparent processes as a standard for accountability.[116] The increasing complexity of governance across agencies also underscores the need for a planning data model.

Crafting policy already consumes significant staff time. Therefore, the representation of policy and regulation as machine-code should not add to staff tasks. How staff could encode policy and regulation with minimal effort remains an open question. A comprehensive planning data model has not yet been implemented in software and no assistive technology to translate existing policies to such a model has been devised. It is possible that the rule-language developed for managing email, building checklists for discretionary review, automating or semi-automating plan checks, and creating content-aware permit management systems could be integrated with a planning data model.

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[114] Safransky, 16–17.

[115] Nurit Alfasi, "The Coding Turn in Urban Planning: Could It Remedy the Essential Drawbacks of Planning?," *Planning Theory* 17, no. 3 (2018): 377, https://doi.org/10.1177/1473095217716206.

[116] Nicholas J. Marantz and Nicola Ulibarri, "The Tensions of Transparency in Urban and Environmental Planning," *Journal of Planning Education and Research*, 2019, 8–9, https://doi.org/10.1177/0739456X19827638.

Staff Reports

Although staff reports are one of the most commonly produced written products by planners, they are rarely examined by researchers.[117] Johnson and Lyles (2016) developed a staff report evaluation tool based on presence of structural, organizational, and content best practices relative to page count. Their proposed tool is not definitive, since there has been a dearth of comprehensive research on what constitutes a good staff report, or how staff reports should effectively provide information to elected officials and enhance transparency in decision-making for the public.[118] Still, this evaluation tool could serve as a basis for a template for writing staff reports. Planners interviewed did not specifically request augmentations to their word processors to support writing staff reports or other detailed, public-facing communications. It was recognized that Microsoft Word, the word processor used by all planners interviewed, had changed little over the past decade. Planners did not use templates to define best practices for their staff reports, although they often used staff reports (or other documents) with similar content as a starting point. The evidence from Johnson and Lyles' (2016) national evaluation of staff reports shows, however, that generally report quality lacks many of the characteristics of effective staff reports.[119] The framework builds upon the planning data model and introduces formalized templates for staff reports to promote data integration and standards-based report quality.

In this component of the framework, staff reports and other documents begin with a standards-based template with generic links to data stored in spreadsheets, permit management systems, email, and other digital sources. Additionally, a dynamic checklist system could assist

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[117] Johnson and Lyles, "The Unexamined Staff Report: Results from an Evaluation of a National Sample," 22.

[118] Johnson and Lyles, 33.

[119] Johnson and Lyles, 23.

the planner in filling out the template. The benefits of this system would be greatest for the entry-level planner. Potentially, it could also improve consistency for the expert planner and reduce review time. Data-typed links would control the origin of the data – tables with numbers could not be composed as plain text within the word processor, the data would need to be sourced from a spreadsheet. For example, a table-typed link in a staff report on housing could be pointed to a citywide housing allocation table connected to relevant spreadsheets within the local government and accessible (permission- or transparency-marked) data from neighboring local governments. The text of the report would not be automatically generated as a derivation from the data. Planners would still have the latitude to analyze, reason, and provide context. Templates annotated in the same language as the planning data model could be linked to the relevant policy, providing a traceable public record of the applied history of a policy through its existence. The purpose here goes beyond usability for the planner towards greater regulatory transparency, in line with the scholarly view that urban futures should involve more direct public participation.

Electronic Plan Review – Machine-Readable Ordinances and BIM Integration

Planners interviewed in this report welcomed the potential of increased automation to relieve them of the numerous time-consuming checks required of plan sets under review. Many were positive about the very basic automatic comparisons that could be performed on two successive plan sets for unreported inconsistencies. Future generations of software could perform complete, automatic checks of objective municipal codes, allowing applicants to verify compliance instantly, rather than attempt to interpret the municipal code themselves.

One of the key benefits of Building Information Modeling is the potential for automated code compliance – code is shorthand here for municipal code and applicable building codes. In automated code compliance, information contained in the Building Information Model[120] that represents the proposed project is checked against machine-readable legal standards. These legal standards are described using a programming language that represents a formal logical expression of a regulation or building code. Since some local government codes, particularly zoning codes, are characterized by ranges with exceptions and may be ambiguous (e.g., using terms such as "some" or "large"), machine-readable representations must be generalizable, rather than one-to-one encoded for each allowable development configuration.[121] Some automatic or semi-automatic code compliance exists in contemporary use by the Architecture, Construction, and Engineering trades, but the rulesets used are non-adaptive. Non-adaptive frameworks are proprietary, domain-specific (e.g., energy or water code only), or hard-coded to a particular region. This framework incorporates the Generalized Adaptive Framework (GAF) for representing local government zoning and building codes developed by Nawari (2020). GAF supports an open data standard, allowing local governments to avoid using proprietary or domain-specific mechanisms.[122] Besides Nawari (2020), other implementations of the structured rule language approach are emerging, and this framework seeks to highlight the relevance of these novel technologies to planners.[123] It is technologically feasible for electronic

[120] Technically, the information contained in BIM is a separate data format. One open-source standard for describing information in BIM is called Industry Foundation Class (IFC).
[121] Nawari O. Nawari, "Generalized Adaptive Framework for Computerizing the Building Design Review Process," *Journal of Architectural Engineering* 26, no. 1 (March 1, 2020): 13, https://doi.org/10.1061/(ASCE)AE.1943-5568.0000382.
[122] Nawari, 6.
[123] One example of a similar generalized rule-based model checking approach similar to Nawari's is Christoph Sydora and Eleni Stroulia, "Towards Rule-Based Model Checking of Building Information Models," Proceedings of the 36th International Symposium on Automation and Robotics in Construction (ISARC) (2019): 1327–1333.

plan review (EPR) to perform automated checks on local codes and many design guidelines, significantly assisting planners on a complex and time-consuming task. Furthermore, local government rules and principles for development are non-proprietary, unlike some international building codes, providing all applicants the opportunity to perform a pre-review for objective and discretionary standards.[124]

Discretionary Review Assistance

Subjective standards for General Plan policies and design review criteria cannot be easily automated or semi-automated since their application requires expert evaluation. Even clearly defined formal rules for urban green infrastructure raise questions of human stewardship.[125] Appropriate design varies by site context, street by street, and cannot be practically represented in formal logic. However, software for creative knowledge work[126] could assist both experienced and entry-level planners with making the routine checks that they perform during a design review process. Additionally, inscribing the subjective design review process of planners in a publishable, open-source dynamic form could add transparency to the administrative aspect of planning.

Bharadwaj et al. (2019) conducted an observational study with a prototype software for creative knowledge work with three components: dynamic checklists, automated quality

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[124] One startup for an online building code search application, UpCode, has been sued by the International Code Council (ICC) for infringing their copyright by making portions of the ICC's building code available for free. UpCode claims that they provide search tools for ICC's building code and that the code is often a legal requirement but not available for free unless a local government pays for the license. Local government codes, ordinances, and design guidelines, the subject of this report, are in the public domain and immune to the same legal challenge. Bill Millard, "The International Code Council Goes to Court over Free Access to Building Codes," The Architect's Newspaper, July 9, 2019, https://archpaper.com/2019/07/international-code-council-start-ups/.

[125] Natalie Marie Gulsrud et al., "'Rage against the Machine'? The Opportunities and Risks Concerning the Automation of Urban Green Infrastructure," Landscape and Urban Planning 180 (2018): 85–92, https://doi.org/10.1016/j.landurbplan.2018.08.012.

[126] This is an emerging type of software with no concise or broadly recognized name.

assurance checks, and a feedback manager for comments from a reviewer.[127] Dynamic checklists are characterized by a hierarchy of elements (i.e., more and less important elements) and self-pruning, or elimination of element in response to particular needs. Automated quality assurance could perform basic checks on the first phase of performance guided by the dynamic checklist. These basic checks would be encoded in a machine-readable format for guidelines that could not automatically checked using the GAF (e.g., 'window material should not appear as a backsplash'). Feedback managers allow from input from a peer reviewer, which may be another planner or a counterpart in another department. Under a current full implementation, EPR software helps planners evaluate objective elements of a plan set and detect changes between versions, but it cannot assist planners through the design review process. There are basic collaborative features in the form of callout-bubbles or text-based notes that may be appended to a document and viewed in layers from different parties, but no tools to ensure consistent review among planners. A Critter-like guidance tool is not intended to replace the personal expertise of planners, but rather promote consistent review. The features described here could be expanded or modified for committees and decision-making bodies that make discretionary judgments, allowing individuals without the same training as planners to receive software-based support.

Design Review and Visualization

Computer-assisted visualization currently plays a limited role in the subjective process of design review. Many planners already use Google Earth and Google StreetView to assess site context, and a few who are versed in SketchUp may use it to illustrate design concepts. A

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[127] Aditya Bharadwaj et al., "Critter : Augmenting Creative Work with Dynamic Checklists , Automated Quality Assurance , and Contextual Reviewer Feedback," in CHI 2019 (Glasgow, Scotland, UK, 2019), 1–12, https://doi.org/https://doi.org/10.1145/3290605.3300769.

future generation of software could supplement design review through more detailed, complete geographic models and displays of site-specific metrics on people's perceptions of the site.

Especially promising is the role that visualization technology, particularly augmented reality and virtual reality, might play in facilitating better communication and dialogue between planners and community members.[128] For instance, design review often involves a conversation between planner and applicant with possible characteristics of negotiation, education, and even consolation in the event a preferred design is rejected (a reality for some homeowners).[129] One planner thought a 3D customizable visualization of allowable projects based on the parcel's zoned floor area ratio and density might be useful. In real time, the planner could expand, reduce, or partition the 3D visualization of the proposal to demonstrate project redesign possibilities within the local code. This would be possible on a conventional flat monitor, and it could be enhanced in a virtual reality setting where planner and applicant could "walk through" virtual models.[130] Using augmented reality, the planner and applicant would view the proposed project as a digital diorama on a physical surface with the same affordance for real-time manipulation. Technical challenges abound for designing augmented and virtual environments that accurately construct relevant environmental impacts, such as sight lines, light, and scale (or bulk) while recognizing the capacity for photorealistic computer imagery to limit a viewer's critical awareness.[131]

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[128] Billger and Thuvander, "In Search of Visualization Challenges : The Development and Implementation of Visualization Tools for Supporting Dialogue in Urban Planning Processes."

[129] Joongsub Kim, "The Four Roles in the Context of Difficult Challenges Faced by Reviewers," in What Do Design Reviewers Really Do? Understanding Roles Played by Design Reviewers in Daily Practice (Springer Nature Switzerland, 2019), 99–109, https://doi.org/10.1007/978-3-030-05642-1.

[130] Yifan Liu et al., "Evaluating the Impact of Virtual Reality on Design Review Meetings," *Journal of Computing in Civil Engineering* 34, no. 1 (2020): 7–8, https://doi.org/10.1061/(ASCE)CP.1943-5487.0000856.

[131] Billger and Thuvander, "In Search of Visualization Challenges : The Development and Implementation of Visualization Tools for Supporting Dialogue in Urban Planning Processes," 1025–26.

For analytical review of a project in its site context, virtual geographic environments that combine geographic information systems with BIM vastly expands the level of detail possible on Google Earth or StreetView. Previously in this chapter, BIM was discussed at the level of a single structure. Multiple BIM can be positioned and contextualized in a virtual environment using GIS, a system simply referred to as BIM/GIS integration. Future electronic plan review should allow progressive visualization, such that planners could explore models of projects from the macro sub-area scale to the meso building scale, to the micro inner details of room size, accurate window positions.[132] Consultants could provide visual and auditory representations of their technical analyses for sight lines, acoustics, and lighting in a more interactive format for more engaging public disclosure. The capacity for immersive interactive visualizations of projects and their environmental impacts to persuade or mislead remains an open question. Technical challenges for accurately representing these impacts in sufficient detail also exist. Potentially, planners could view social and emotional metrics for a site within a project visualization.[133] Complex, quantitative data from ambient sensors could also be layered on to a BIM/GIS site visualization.[134]

Permit Management Systems – BIM/GIS Integration and Metadata Inference

Several planners interviewed described their department either transitioning to full implementation of a new permit management system or upgrading and refining the implementation of an existing permit management system. Planners mentioned that the

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[132] Ying Shen et al., "Using Focus + Context Techniques to Visualize Building Information Model in Virtual Geo-Environment," International Cartographic Association, 2019. https://doi.org/10.5194/ica-abs-1-422-2019.

[133] McKenna, "Innovating Metrics for Smarter, Responsive Cities," 5.

[134] Beata Stahre Wästberg et al., "Visualizing Environmental Data for Pedestrian Comfort Analysis in Urban Planning Processes," in 15th International Conference on Computers in Urban Planning and Urban Management (Adelaide, Australia, 2017), https://www.researchgate.net/publication/318340921.

accuracy and completeness of data entered in to permit management systems varied. Proposed reasons for potential data quality variance included uncertainty over the importance of system-requested information and as perceived low priority relative to plan set review. According to planners, permit management systems received acceptance from department leadership because the systems facilitate inter-department coordination on the status of permits and provide a faster, more efficient information pipeline to an online portal for connecting applicants with the status of their permits. Research into permit management systems (hereafter, e-permitting) has emphasized potential efficiencies for the building, fire and public works departments. Planning departments, however, coordinate with these departments on concurrent plan reviews and rely on e-permitting systems as a source of data to inform broader land use policy discussions. The successor permit management system described in this framework integrates features of electronic plan review (described above) and addresses perceived issues with existing permit management systems.

Principally, an advanced permit management system contextualizes urban asset data with integrated spatial data.[135] E-permitting today brings automation or semi-automation, depending on the level of implementation, to tracking permits through a local government's review process and managing supplementary documentation.[136] More advanced e-permitting augments automated process management with analytical features that support site visits, inspection during construction, and trend analysis.[137] Through BIM, e-permitting can store

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[135] Shahi, McCabe, and Shahi, "Framework for Automated Model-Based e-Permitting System for Municipal Jurisdictions."

[136] For Shahi et al.'s diagram of the levels of e-permitting, combining electronic plan review and permit management as a life-cycle urban asset management system, refer to Appendix D, Figure 14.

[137] Francesca Noardo et al., "Opportunities and Challenges for GeoBIM in Europe: Developing a Building Permits Use- Case to Raise Awareness and Examine Technical Interoperability Challenges Opportunities and Challenges for GeoBIM in Europe," Journal of Spatial Science (2019): 1–25, https://doi.org/10.1080/14498596.2019.1627253.

granular information about the real conditions of a building, rather than static facts about the building as permitted. This may seem more useful for the building department, but planners could leverage this information to perform complex analytics on changes in land use over time and real-time ambient conditions in the built environment. Further, the permit itself could be embedded in the BIM model maintained by the applicant, so they can track compliance continually. However, the ability to share BIM data back and forth with applicants entails cross-platform, open data formats for software systems.[138] By analogy, PDF has become the cross-platform, de facto standard for exchanging documents. Additionally, substantial research gaps for BIM visualization exist. This framework emphasizes research directions in BIM visualization for temporal evolutions of BIM data sets for managing changes in plans through project life cycles and intelligent user interfaces that adapt to the task requirements and goals of the user.[139]

Manual data entry could be substantially reduced by linking BIM and related digitized documents more closely with the e-permitting workflow itself. For new plans submitted as BIM, the necessary permit information could be extracted from the model and related GIS data based on a local government's requirements as expressed in machine-readable code.[140] Descriptions of permitted building functions could be written as natural language sentences and programmatically translated to objective rules.[141] These rules could be developed alongside the

[138] Huahui Lai, Xueyuan Deng, and Tse Yung P. Chang, "BIM-Based Platform for Collaborative Building Design and Project Management," Journal of Computing in Civil Engineering 33, no. 3 (2019): 3–4, https://doi.org/10.1061/(ASCE)CP.1943-5487.0000830.

[139] Paulo Ivson et al., "A Systematic Review of Visualization in Building Information Modeling," IEEE Transactions on Visualization and Computer Graphics, 2019, 13–14, https://doi.org/10.1109/TVCG.2019.2907583.

[140] Giuseppina Vacca and Emanuela Quaquero, "BIM-3D GIS: An Integrated System for the Knowledge Process of the Buildings," Journal of Spatial Science (2019): 1–16, https://doi.org/10.1080/14498596.2019.1601600.

[141] Qingsheng Xie et al., "Matching Real-World Facilities to Building Information Modeling Data Using Natural Language Processing," IEEE Access 7 (2019): 119465–75, https://doi.org/10.1109/ACCESS.2019.2937219.

Generalized Adaptive Framework used in EPR. Under an open source paradigm, these rules could be shared across local governments and customized as needed. While the savings on manual data entry may be easiest for new permits, the vast majority of urban assets do not exist as BIM since they were built during paper or 2D-digital plan review processes. Attaining data parity with existing permit records and identifying and correcting existing inaccuracies is a necessary complementary feature. Using accurate permit records as a training corpus, a language inference[142] based system could identify erroneous or incomplete data and suggest a replacement.[143] As an automated system that relies on prediction, or inference, based on a corpus of previous accurate entries, there will still be a role for manual inspection of the data. Overall, metadata inference could result in a time savings and accuracy enhancement over manual entry.

Finally, the applicant portal experience could be improved through the implementation of a cloud-based e-permitting with an urban-analytics powered recommendation tool for guiding the applicant through the permitting process. Eirinaki et al. (2018) elaborate their own framework for such a system. The recommendation engine guides the applicant through the permitting process through a self-improving chatbot that acts as the user-facing side of a decision-tree for determining the correct permits, documents, or information an applicant needs. The chatbot and associated decision-tree self-improve using predictive analytics and data mining techniques that draw on the repository of request histories, request trends, and

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[142] Language inference is a computational technique that uses large quantities of content-tagged or annotated sentences as training data to derive an abstract model of the general features of these sentences. Sentences that are expected to be similar to the training data are fed into the abstract model and automatically tagged – the characteristic attributes of the content are inferred.

[143] José María González Pinto et al., "Can Language Inference Support Metadata Generation?," in Digital Libraries for Open Knowledge: 23rd International Conference on Theory and Practice of Digital Libraries (Oslo, Norway: Springer Nature, 2019), 253–264.

manual analysis of permit process outcomes.[144] The aforementioned automated annotations on documents and BIM metadata could provide useful supporting information to this decision-tree system. As a cloud-based system, information could be (voluntarily) shared between local governments to expand the training set for the recommendation tool. As more governments adopt BIM, data from embedded sensors in buildings and infrastructure could update on-file BIM continuously. As groups or neighborhoods of buildings become BIM-enhanced, planners could quickly grasp environmental impacts, such as urban heat island effects or energy usage. It could also benefit coordinated scheduling and verifying in-person inspections for the building department.

Email and Collaborative Communication

Although planning literature has not addressed it specifically, a clear theme emerged during the interviews: email adds a significant cognitive burden to the daily tasks of urban planners. “Before we had this tool, we could go to sleep,” one planner said. Organizational practices in conjunction with software could be developed to alleviate the stress of email.

Emerging evidence, largely anecdotal, suggests that the best organizational practice to deal with email overload is to formally structure expectations when email will be used. Email works well for delivering documents, definite communications with clear endpoints, but it breaks down when it mediates indefinite, collaborative communications. For planners, email is poorly suited to handle on-going, complex conversations with staff, developers, and the public. Instead of an open-door policy for email, planners could establish a preference for in-person communication through brief, periodic meetings or set “office hours” for questions. Similarly,

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[144] Eirinaki et al., “A Building Permit System for Smart Cities: A Cloud-Based Framework.”

the public could be required to schedule a time to talk to a planner over the phone or in-person by default, just as they sign up for consultations or bring questions to the planning desk, rather than send an email.[145] These in-person consultations could be pushed out for weeks or months, particularly in cities with small staffs, putting a greater emphasis on online public-facing informational tools to answer questions about policy and regulations. These processes are intended to substantially reduce the volume and unpredictability of email exchanges, not eliminate email entirely. Email remains an effective tool for collaborative communication on discrete projects with analytical purpose.

Email systems, particularly Outlook which was universally used by the planners in this study, could benefit significantly by implementing more accessible and more powerful automation. Automatic organization, attention management, prioritization of email by context, among other features would address the 'hacks' that many planners have devised to manage their inboxes, such as marking a message unread as a reminder to return to it later. Outlook includes limited automation features, such as rule-based sorting of incoming messages into folders, but interviewees perceived these features as unnecessary or too cumbersome to activate. A future email client could intertwine the concept of folders and email threads with rule creation, deemphasizing manual management. Planners would not need to learn a special programming language-like set of descriptors to create filters or processes for organizing their inboxes. Instead, a graphical interface featuring conversation-flow arrows, timers representing frequency, and icons representing recipient groups could provide a simple way to tweak, or

[145] Computer scientist and productivity theorist Cal Newport finds anecdotal evidence for email best practices from tech companies with experimental attitudes towards workplace culture. In an August 2019 New Yorker article, he cites one company's "professor-style office hours" that allow employees to give their "undivided attention" to internal questions instead of an unpredictable flow of emails. Cal Newport, "Was Email A Mistake?," The New Yorker, August 2019, https://www.newyorker.com/tech/annals-of-technology/was-email-a-mistake.

occasionally make, new rules. Most rules could be imported as templates and tweaked, since the generic sorting actions needed by planners are similar. For example, if a homeowner attaches a document to be added to their project's record, the attachment could be automatically sent to an appropriate cloud folder. While the recipient addresses or timing may change, the basic rules remain the same. However, there is a fundamental limitation with contemporary email systems that prevent many automated features from being implemented.[146]

Currently, the computer implementation of email itself lacks 'self-awareness,' or a digital model of attributes that contextualizes the content and circumstances of a conversation. Information could be extracted from an email and used to update a long-term calendar intended for projects, separate from the short and medium-term calendar used to track meetings or tasks. Creating self-aware email systems requires an automated annotation of rule-corresponding ideas, such as, "progress (e.g., pending, done), deadline, topic, priority, or task."[147] Planning-specific annotations might associate emails with particular projects, policies, or locations. Managing legally sensitive messages, a concern that emerged during interviews with planners, could be handled through context-aware emails. Rather than sending check-in messages on the status of questions, a rule could be created to silently sort or delete the conversation. Deriving information about the time-sensitivity of a message automatically could help automatically manage attention, fitting emails into scheduled times or delegating emails to staff better suited to respond. Some of the automation features described in this chapter could be useful in transitioning staff and the public to an expectation where fewer emails need to be sent and the rhythm of response on emails has become more predictable.

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[146] Soya Park, Amy X Zhang, and Luke S Murray, "Opportunities for Automating Email Processing: A Need-Finding Study," in Conference on Human Factors in Computing Systems Proceedings (Glasgow, Scotland, UK, 2019), 1–12.
[147] Park, Zhang, and Murray, 4.

Process-Integrated Calendars

Planners often use digital calendars to manage their time, such as Outlook's calendar feature and customized Excel spreadsheets. However, these systems lack contextual awareness for projects and tasks. Some of the same principles of context awareness that apply to email could be extended to digital calendar management. A process-integrated or process-aware digital calendar builds itself automatically based on the content of email, direct entry to the calendar from an invited collaborator, or planning data model-encoded administrative rules for project deadlines (e.g., CEQA procedural filings, internal deadlines for staff reports).

More advanced calendar management software should not micromanage or minimize the autonomy of planners. Meetings, appointments, and project timelines that could log and track themselves should replace menial input and improve coordination between involved parties. Digital calendars can "materialize a particular orientation to time," in other words the way time is segmented and marked in a software's logic impacts the user's perception of time. With an engineer's emphasis on efficiency, digital calendars can prompt workers to relentlessly allocate time to short-term tasks.[148] There should not be an impetus to squeeze more productivity by calculating average task completion times or discovering hours to take additional meetings. Instead, a process-oriented calendar could provide planners an opportunity to view past and present projects on long time scales outside the range of a typical work task. For example, long-range calendars spanning years or decades could be designed as a tool for thinking about complex, long-term changes in the built environment set out in specific plans and regional transportation improvement plans.

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[148] Judy Wajcman, "The Digital Architecture of Time Management," Science Technology and Human Values 44, no. 2 (2019): 323, https://doi.org/10.1177/0162243918795041.

Significance of the Framework for the Future of Urban Planning

This chapter presented a novel framework for the future of planning software that unifies research in the technology of planning, construction, and creative professions. If urban planners wield influence in the development of urban spaces, then the software that planners use to understand urban conditions and communicate their findings with the public deserves special attention. The generalized productivity software that planners have been using for over thirty years is inadequate for the coming big data era of urban environments. For example, planners could benefit from incorporating real-time data into their local growth management plans.[149] Excel is not designed to support real-time analytics, Word is not designed to assist in describing or associating analytics with textual information, and no application has yet been designed to visualize or organize such data for engaging the public. This framework gives planners and researchers of planning technology insight into the range of software used by planners and develop an innovative class of software fit for stewarding the cities of the coming century.

There are several lessons from the past thirty years of planning software to be applied in the next thirty: 1) powerful software for urban planning should be available to local governments without endless dependency on consultants or subscription plans; 2) planning data models and detailed permit information systems should be an invitation to heighten transparency in urban development processes and prune regulatory complexity, favoring

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[149] John D. Landis, "Fifty Years of Local Growth Management in America," Progress in Planning, 2019, 21, https://doi.org/10.1016/j.progress.2019.100435.

simplicity[150] and supervised deliberation[151]; and 3) robust automation should create time for plan crafting and public dialogue, not merely shorten permitting times. The framework presented in this report affirms these important findings.

[150] Stefano Moroni et al., “Simple Planning Rules for Complex Urban Problems: Toward Legal Certainty for Spatial Flexibility,” Journal of Planning Education and Research, 2018, 1–12, https://doi.org/10.1177/0739456X18774122.
[151] Alfasi, “The Coding Turn in Urban Planning: Could It Remedy the Essential Drawbacks of Planning?”

Chapter Takeaways

This chapter presented a framework for the future of planning software, informed by Silicon Valley planners' perceptions of their current planning software. Key features of the framework include:

- Land use development policies (e.g. local General Plan and Climate Action Plan) are encoded through a planning data model. This allows local governments to more easily track interactions among policies regionally and at the state level. Word processors, which are typically structureless, are augmented to include a templating system that lets staff reports and other written products be described using rules based in best practices. Generic links to data stored in spreadsheets or in permit management systems ease information retrieval and prevent numeric information from being recorded as plain text.
- Electronic plan review systems use Generalized Adaptive Framework based on formal logic to interpret the flexible language of local zoning ordinances. As a generalized framework, rules could be shared and customized among local governments using a common platform. Design review is augmented through 3D visualization tools that express encoded rules in an immersive environment.
- Time consuming manual data entry by planners into permit management systems is reduced through digital intake of plans as BIM and automatic tagging of permit content through natural language inference technology. A cloud-based backend allows large and small public agencies to take advantage of computationally intensive BIM/GIS integrated systems and potentially share interrelated urban asset data.

- Email requires a social/organizational overhaul. Planners need to make a predictable, structured time to retrieve email from applicants and the public. An automated, rule-based system is implemented as a primary feature of the next generation of email systems to filter and manage the volume of email that requires a response.

Chapter 7. Conclusion

This report introduced a framework for the future of planning software based on a synthesis of cutting-edge research and interviews with planners about their current software. Eleven experienced planners in several different local governments in Silicon Valley were interviewed. Generally, planners found that software was essential to their everyday tasks but were resistant to the possibility that more robust automation could replace their skills as policy analysts and communicators. Planners desired more fully implemented automated features of the software that they were already using. Awareness of emerging paradigms in analyzing urban assets, such as BIM and big data, and the role that these technologies might have in the future of urban planning appeared limited. This may seem surprising in the context of Silicon Valley, or it may be a natural reflection of planners as technical professionals interested mainly in information directly relevant to their responsibilities.

The software framework developed in this report addresses the concerns expressed by planners along with long-term opportunities for time saving and enhanced customer service developed through the architecture, construction, and engineering literature. Essentially, the framework proposes three key features: 1) open-source, cloud-based systems that are accessible across local governments regardless of budget, rely on standardized data formats, and include built-in features to share data and resources that reflect common problems across local governments; 2) generalized adaptive rule-based systems and planning data models that make complex and sometimes contradictory policies more accessible and transparent to the public and decision-makers, as well as promote the broad use of automated plan set checking. These rule-based systems extend to email management and a novel checklist system designed to provide consistency and transparency in the plan review process; 3) implementation of integrated BIM/GIS with 3D visualization tools for organizing complex interrelationships between structures, both for planners and building departments, as well as demonstrating development possibilities for applicants. BIM/GIS integration in conjunction with machine-encoded policy and regulatory models and urban big data could lower the barrier for local governments to perform complex environmental analytics and land use modeling.

Reflecting on the Interview Protocol

The academic literature on planners' perception of the software that they use for their daily tasks is limited. One novel contribution of this report is interviewing planners about the perceptions of their software. Planners gave in-depth responses with little prompting on a wide variety of questions. Two types of questions stood out for producing thoughtful, in-depth responses: 1) What advice or training would the interviewee give to an entry-level planner? and 2) If the interviewee had one wish for anything software related, what would it be? Planners were also candid in discussing instances of issues with data correctness within their department and practices to handle these issues. The exploratory interview methodology used in this study prompts more targeted observational studies on efficiency or actual use patterns of their range of software.

At the outset of this study, the concept of a "workflow" was considered to describe how planners use several different software in the course of a single task and that this might be a lens to find efficiencies or ways to integrate several software into one. Permit management systems use the term "workflow" to describe rigid steps of permitting processes. However, the workflow concept was discarded after the first interview and not developed in this report. According to the first planner interviewed, planners, like many modern information workers, do not handle their tasks "one at a time" in the same sense as a workflow forces a strict pattern of behavior. Attempting to foist a definition of a workflow different than the one that planners already know would have been counterproductive.

Limitations of this Study

Broad Similarities Within the Study Area

The study area focused on Silicon Valley, a geographically large area with many local governments that share common characteristics, the most prominent being that they are relatively well-resourced. Generally, these authorities possess the financial resources to support long-term upgrades to planning department software. Planners' perceptions of their software and the reliability of their data may differ significantly in less well-resourced local governments in California or elsewhere in the country.

Narrow Interviewee Focus

Commissioners, council members, lower-level planners, plan check engineers, as well as developers and the public, were excluded from interview selection to maintain a focus on practitioners' perceptions. Testing the validity of the framework for the future of planning software in this report should involve the perceptions of these critical stakeholders.

Public Participation Technologies Omitted

Although public participation technologies, particularly social media and public participation GIS, have been a rich and ongoing subject of planning literature[152], public participation technologies were excluded from this report. The typical planner has not used

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[152] Renee Sieber, "Public Participation Geographic Information Systems: A Literature Review and Framework," Annals of the Association of American Geographers 96, no.3 (2006): 491-507

social media[153] or public participation GIS within a land use planning process[154]. The interview protocol developed in this report could be adapted to include or focus on planners' perceptions of social media applications for public engagement in the land use planning process.

Opportunities for Future Research

Research on the perceptions of personal information space of knowledge workers, a class of professional worker that includes planners, is still emerging.[155] Findings from the interviews conducted for this study suggest that planners develop their own personalized strategies to save and manage information that depends on their role and the exigencies of the local governments where they work. Perceptions of the personal information management strategies used by planners could be studied with much larger sample sizes, with near-term implications for organizational best practices and long-term implications for developing software to handle the growing volume of urban information. Similarly, how more deeply integrated information systems – with an awareness of the real-world procedures they reflect – can be designed to better inform decisionmakers and the public remains an open question.[156]

Several planners noted that software adoption is constrained by leadership, due to concerns either with usefulness or budget impacts. The move towards Government 2.0 software

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[153] Riggs and Gordon, "How Is Mobile Technology Changing City Planning? Developing a Taxonomy for the Future," 112.

[154] Maarit Kahila-Tani, Marketta Kytta, and Stan Geertman, "Does Mapping Improve Public Participation? Exploring the Pros and Cons of Using Public Participation GIS in Urban Planning Practices," Landscape and Urban Planning 186, no. February (2019): 46, https://doi.org/10.1016/j.landurbplan.2019.02.019.

[155] Lilach Alon, Sharon Hardof-jaffe, and Rafi Nachmias, "How Knowledge Workers Manage Their Personal Information Spaces: Perceptions , Challenges and High-Level Strategies," Interacting with Computers, 2019, https://doi.org/10.1093/iwc/iwz021.

[156] Capano and Pavan, "Designing Anticipatory Policies through the Use of ICTs."

for permit management systems and electronic plan review has been, in part, motivated by decisionmakers' desire to reduce time spent in review and improving transparency with applicants on project statuses. A strong trend in planning literature, particularly in smart city discourse, suggests that enhanced public participation mediated by software will be a distinguishing feature of future urban land use planning. How the rule-based systems and planning data model proposed in the framework could be joined with public participation in the information systems of urban governance, such as public participation GIS, remains an open question.

The framework developed in this report assumes willingness from decision-makers and posits lowered costs from adopting open-source technologies as a persuasive factor. Additional research is needed to determine how public agencies, including state, federal, and international organizations, in coordination with universities, could coordinate on standardized, open-source rule-systems and information formats for BIM-GIS integration and planning data models.

As a conceptual overview, the framework draws on the perceptions of planning software users and needfinding studies for desirable features of email[157] and code checking assistance[158]. The software features here provide a conceptual overview and basic technical description of an integrated suite of tools tailored to urban planners. Future needfinding studies that engage planners with prototype software derived from the components outlined in the framework could build upon this report.

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[157] Park, Zhang, and Murray, "Opportunities for Automating Email Processing: A Need-Finding Study."

[158] Bharadwaj et al., "Critter: Augmenting Creative Work with Dynamic Checklists , Automated Quality Assurance , and Contextual Reviewer Feedback."

Finally, focusing on the software used in public sector urban planning risks an uncritical assumption that digital technologies can support sustainable urban development.[159] By encompassing the range of software planners use, the framework developed in this report offers a system-level view into planning software. Research building upon this framework could continue to apply system thinking and consider how "analog" planning practices can supplement or provide redundant alternatives to digitally mediated planning practices.[160] Planning data models provide a language to codify the actions of such analog planning processes. The goal of any successor generation of planning software should be to simplify complex planning processes, expedite the process whenever possible, and broaden the base of people participating in the development of their communities.

Towards Urban Planning for Simplicity and the Whole Life Cycle of Structures

In conclusion, I would like to consider the next evolutionary step of the framework for the future of planning software. If the components of this framework were achieved within the next fifteen or twenty years, what would the next step look like and how can this framework be realized with that future step in mind? Given the planning profession's aspirations for inclusive public participation and sustainability, the goals of this next step should be: (1) planning processes that involve simple rules that lower barriers to public participation and yield places that people feel connected to; (2) planning processes that promote sustainable design,

[159] Johan Colding, Stephan Barthel, and Patrik Sörqvist, "Wicked Problems of Smart Cities," Smart Cities 2 (2019): 512–21, https://doi.org/10.3390/smartcities2040031.
[160] Colding, Barthel, and Sörqvist, 516–17.

distinguished by a minimal need for computational activity in construction and optimal efficiency during operation, and a maximum use of renewable materials.[161]

The first criterion, simplicity, could be achieved through an urban design theory that emphasizes clear guiding rules, dialogue, and toleration for an unfolding design process. The organic, unselfconscious urban design approach of architect and urban theorist Christopher Alexander offers one such approach.[162] The second criterion, cognizance of the whole life cycle of structures, evaluates the material and energy cost of development. This approach is elaborated in design theorist Christina Cogwell's monograph *Toward a Living Architecture? Complexism and Biology in Generative Design* (2018). According to Cogwell, computer-enabled design based on algorithms (parametric or generative design) involves mineral resources and energy that precludes it from any holistic determination of sustainability.[163] This also contradicts the popular vision, both in academia and the IT sector, that the energy and mineral-intensive creation of an Internet of Things can ultimately reduce a city's environmental impact.[164] Both of these criteria can be satisfied in a future where software is unnecessary for urban-scale development.

The next evolutionary step in the design of planning software should allow, as much as possible, for the scaling down of legal and technological complexity in urban development. The

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[161] The American Planning Association has enshrined the pursuit of social justice and promotion of sustainability planning in its Code of Ethics, Section 1. Our Overall Responsibility to the Public, subsections f) and g), respectively. The APA Code of Ethics can be found at: https://planning-org-uploaded-media.s3.amazonaws.com/document/AICP-Ethics-Revised-AICP-Code-Professional-Conduct-2016-04-01.pdf (last revised April 1, 2016, accessed November 30, 2019).

[162] David Seamon, "Christopher Alexander's Theory of Wholeness as a Tetrad of Creative Activity: The Examples of A New Theory of Urban Design and The Nature of Order," *Urban Science* 3, no. 2 (2019): 8, https://doi.org/10.3390/urbansci3020046.

[163] Christina Cogdell, *Toward a Living Architecture? Complexism and Biology in Generative Design* (Minneapolis: University of Minnesota Press, 2018), 52, https://doi.org/10.5749/j.ctv9b2tnw.

[164] Cogdell, 44.

framework described here can accommodate, for example, BIM-enabled design (energy and resource intensive) of a housing block made of renewable materials like earthbags.[165] A planning data model and a General Adaptive Framework could specify the housing block's compatibility with a neighborhood's planning process and a BIM-GIS system could help integrate the block of earthbag houses with local buildings the natural setting. The next evolutionary step of planning software could extract years of such software-informed decisions into heuristics, or guiding rules expressed in natural language. Gradually, certain software features or specific algorithms could be retired altogether in favor of heuristics. Achieving sustainability, where demands for natural resources and energy decrease, means computer-enabled development cannot be the default. The near future of planning software could bring insight to a vast amount of urban data. The next horizon transforms these insights into dialogue-centered processes aligned with planetary constraints.

[165] Deborah M Santos and José Nuno Beirão, "Integration of BIM and Generative Design for Earthbag Projects," in *Progress in Digital and Physical Manufacturing*, ed. Henrique A Almeida and Joel C Vasco (Cham: Springer International Publishing, 2020), 102–9, https://doi.org/https://doi.org/10.1007/978-3-030-29041-2_13.

Appendix A: Literature Review Search Parameters

Databases used: Google Scholar, Web of Science, and the SJSU Library Database

Keywords: Scopus, Web of Science, and Google Scholar (using the 'Cited By' and 'Search Within Citations' features) were used to retrieve supporting literature. The literature review used combinations of the following key phrases: "planning support system" "urban planning" "public administration" "word processing" "spreadsheet" "Microsoft Excel" "Avolve" "Computer Software, Inc." "Chief Technology Officer" "Urban Informatics" "software workflow" "workflow" "local planning" "municipal planning" "collaboration" "urban data". Conference papers, published journal articles, and books were included in the literature review.

Appendix B: Interview Protocol

Pre-Interview Survey Protocol

A name-associated pre-interview survey will consist of several questions seeking basic quantitative information about the software used by a staff member, with one Likert-type question on data quality:

- *The following is a list of software commonly used in urban planning:*
  - *Electronic Plan Review: ProjectDox, BlueBeam, Adobe PDF*
  - *Land Use/City ordinances: American Legal Publishing's City Ordinance Library (online)*
  - *Visual Databases: Microsoft Excel, Magnet, ArcGIS*
  - *Public/Departmental Communications: Microsoft Word, Microsoft Outlook, smartphone messaging software*
  - *Permitting software: TRAKiT, CitizenServe, GovPilot*
- *Are there any software you use regularly that are missing from this list?*
- *From the software that you use regularly, what are the top three that you spend the most time in?*
- *On a scale of 1 (never) to 5 (daily), how often do you find an error in:*
  - *A spreadsheet*
  - *GIS data*
- *On a scale of 1 (irrelevant) to 5 (essential), how important do you think software is in your everyday tasks as a planner?*

Interview Protocol

Interviews are intended to last between 30-45 minutes and will consist of four question types outlined in the subchapters below. Each question type will be allocated 5-10 minutes, depending on the detail of response by the interviewee. See Table 3 for example allocations of question types linked to job description. If time remains, the interview will be opened to other issues related to planning and software.

Satisfaction with the quality of decisions aided by software (e.g. “good” or “better” decisions) will not be possible to assess qualitatively, due to response bias, and the positive influence of user interfaces on use satisfaction[166]. Instead, interviewees will describe how they use their software, how software helps them do their jobs, and the role different kinds of urban data plays in communications and decisions – all related to dimensions of software usefulness.

Introductory questions, asked to all interviewees, include: Please describe your role at the City. What projects do you spend most of your time doing?

Table 3. Sample interview protocol grid for planners

Job Title	**Associate Planner**	**Senior/Executive Planner**
Question Type	Collaboration	Collaboration
	Electronic Plan Review	Microsoft Word
	Effectiveness of Software	Permit Management Systems
	Practical Management of Data	Data Prospects

[166] James Schaffer, John O’Donovan, and Tobias Holler, “Easy to Please: Separating User Experience from Choice Satisfaction,” in UMAP’18: 26th Conference on User Modeling, Adaptation and Personalization, July 8-11, 2018, Singapore: 177. The paper itself focuses on recommender systems (like Netflix’s movie recommendation engine) but makes a general point about the potential for user interfaces to bias self-reported satisfaction with software.

Question Types

Types of questions to be asked are listed alphabetically. Potential follow-on questions pursuant to the main question are listed below in bullet points. The protocol format used below is adapted from Caulkins (2007).[167] Questions are influenced by Calo's (2014) research paper on Government Information Sharing[168] and the APA's Big Data and Planning Report[169].

<u>*Collaboration*</u>

- Do you have boilerplate (standardized) responses for certain kinds of communications?
- What other software do you tend to rely on for information when writing a reply [for a specific kind of request relevant to the interviewee's job]?
- How often do you refer to old emails? How do you feel about retrieving the information you need?
- Do you ever feel like information gets lost between parties in your communications?
- How often do you talk directly with the people who you rely on for field data?
- Do you feel like your software helps you manage the volume of emails and phone calls that you must answer?
- Do you think software makes it easier to communicate with other public agencies in Santa Clara County that could provide helpful data?
- Is there an expert in your office who, if they left, would slow down your daily tasks?
- Are there particular features of email or other software that you use regularly?

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[167] "Spreadsheet Errors and Decision Making: Evidence from Field Interviews": 22-23.
[168] Karla Mendes Calo et. al., "Government Information Sharing - A Model for Classifying Benefits, Barriers and Risks," ICEGOV 2014, October 27-30, 2014, Guimaraes Portugal: 208.
[169] Kevin C. Desouza and Kendra L. Smith, Big Data and Planning, Chicago, IL: American Planning Association, December 2016.

Practical Management of Data

- What data sources do you typically rely on when contributing to a staff report? Do you think the software you use makes writing the report faster?
- Have you ever accessed or manipulated the same data, say information about a parcel, using different software?
- Do you feel like your data is standardized? Do you think a neighboring city uses the same format as you for storing the same kind of data (e.g. about tree cover, streetlights, retail vacancies)?
- How do you identify legacy or outdated data?
- What software do you use when making a CEQA determination? Do you feel like that software is suited to helping you write replies to questions about CEQA and projects under CEQA review?
- Does the software make sharing data across departments easier?
- Is there data that you rely on that has not been digitized?
- Do you ever have security concerns about the data that you use?
- Describe your experiences with spreadsheets that were known to contain errors.[170]
- How were the errors fixed?[171]

Data Prospects

- What applications do you see yourself using more in the future of your career?
- If ministerial processes or by-right development becomes more common, do you think that will change what your software needs?

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[170] Adapted from "Spreadsheet Errors and Decision Making: Evidence from Field Interviews": 23.
[171] Ibid.

- Does the department have any plans for its legacy data?
- Do you think software could make it possible to do certain kinds of mitigation fee studies in-house?
- Have you personally thought about or discussed as a team the role big data might play in your workplace?
- Has your department ever talked about ethical standards for open data, or the ethical use of data to make planning decisions?
- Do you ever find information presented as text to be a limitation or a hindrance?

Effectiveness of Software

- Describe some tasks that are easier now than they were five years ago.
- Describe some tasks that are more difficult because of the increased pace of development.
- Have you used any new software since you started your job? How has this (or these) software changed the way you do your job?
- Describe a time using software where you felt you were doing extra work because of the way the software was designed.
- Describe something you felt was overly complicated about your software.

Electronic Plan Review (Ministerial Review/Land Use Law/City Ordinances)

- Please describe your experience with <EPR software currently used> with large projects (e.g. multi-family residential, mixed-use commercial) and with smaller projects (e.g., single family residential redevelopment). What makes <EPR software currently used> useful for you?
- How has the switch to EPR changed how you communicate with developers?

- Does <EPR software currently used> make it any easier to catch changes between versions of a plan that should be flagged?
- How do you use the City's code database in relation to plan review? What are some features of the code database that makes your job easier?
- Have you or the staff discussed the role of BIM in electronic plan review?
- How has the way you used <EPR software currently used> changed with experience?
- Do you have experience with any other EPR software before (or besides) <EPR software currently used>?

Long Range Planning

- Have you, or your department, used a planning support system (or spatial decision support system) for long range planning?
- What software do you use when involved in a long-range planning process? (Email, Word, anything else?)
- Could you describe any software that you use that are different from what you normally use specialized for collaborating in a long-range planning process?
- Do you feel you have access to the information you need during the long-range planning process?
- Do you think there is an expanded role for annotated maps or interactive maps instead of text? Is software a limitation here or are there other limiting factors?
- Has the planning department discussed a role for big data in long range planning? (transportation planning data, precise detection and 3D-building reconstructions using satellite imagery, potentially aggregated real-time indicators on mood or heart rate at population scale)

Permit Management Systems

- Did you have experience with any other permitting software like <permitting software currently used>?
- Do you use any other applications while using <permitting software currently used>, like an ordinance data base or Excel spreadsheets?
- Do you feel like your permit management system helps you retrieve information?
- Do you ever feel like you are doing extra work because of <permitting software currently used>?
- If you were to give someone new some advice on using <permitting software currently used>, what would be the first thing you would tell them?

Process Improvement

- Do you have an inventory of digital information <your local government> has available to make decisions about land use?
- How has software made you more independent? How has it made you more collaborative?
- Are you ever concerned about the impact of technological change on the profession?
- Do you think there are barriers to information sharing across municipalities?
- Are you ever concerned about entrusting third parties with <your local government's> data?
- Is there anything you wish software could help you do (through a new feature or automated process)?
- What are some of your least favorite things about the software you use?
- If you had one wish for anything software-related in your department, what would it be?

<u>*Software Specific Questions*</u>

Microsoft Word

- Tell me about the different types of documents you make using Word.
- Do you think it would be helpful if there was better integration between AmLegal and Word? For example, you could access text from AmLegal within Word, or access other Word documents where you had written previously about an ordinance without leaving the document?
- Have the requirements for the documents that you make in Word changed significantly over time, for example, officials have requested more use of bullet points or longer documents with more background.
- How has the way you have used Word changed over time? (For example, are there certain features you use more? Do you spend more time manually proofreading? Do you use Track Changes more or less?)
- Tell me about some other websites or desktop applications you tend to use while writing (a policy memo, a staff report, a letter, etc.)
- Does Word help you find information within a document? (Are there any techniques you use to sort or categorize information? Do you rely on memory and experience or are there features in the software that are helpful?)
- Have you used Word to create templates or record best practices for the documents that you and your division write?
- Are there occasions where you feel another format, such as an annotated map or PowerPoint, would be more effective than a Word document for a point you want to make?
- Do you use Adobe PDF to only to view documents or do you comment on PDFs as well?

Zonar 3D

- Could you tell me how you learned to use the Zonar3D?
- Are there any other applications you use alongside Zonar3D?
- Do you or your department want to use Zonar3D more than you are currently using it? Are there features of the software that are not yet implemented for your department's use?

Appendix C: List of Software Used by Urban Planners (Self-Reported)

Table 4. Software used by professional urban planners (self-reported) provides a list of software reported as used by the eight urban planners (out of a total eleven interviewed) who completed the entrance survey. Respondents received the following question:

The following is a list of software commonly used in urban planning:

- *Electronic Plan Review: ProjectDox, BlueBeam, Adobe PDF*
- *Land Use/City ordinances: American Legal Publishing's City Ordinance Library (online)*
- *Visual Databases: Microsoft Excel, Magnet, ArcGIS*
- *Public/Departmental Communications: Microsoft Word, Microsoft Outlook, smartphone messaging software*
- *Permitting software: TrackIt, CitizenServe, GovPilot*

Are there any software you use regularly that are missing from this list?

Responses were compiled into a single list and organized alphabetically. This list does not include web browsers or general online resources (e.g., local government webpages, information about historic structures, local news). Specific web resources, such as code and ordinance archives and public agency document management, are included.

Table 4. Software used by professional urban planners (self-reported)

Software type	Software name
Appointment manager	Fullslate
Building visualization	Sketchup
Code and ordinance archive	AmLegal
	MuniCode
Public agency document management	ApplicationXtender
	Google Drive
	Granicus
	Microsoft OneDrive
	Superion LaserFiche
Electronic plan review	Adobe PDF Acrobat
	Adobe PDF Reader
	Bluebeam Revu
	PlanGrid
	ProjectDox
GIS	ArcGIS Desktop
	ArcGIS Online
	Custom GIS/Interactive web map
Government agenda manager	Granicus govMeetings
Land use visualization and analysis	Zonar3D
Permit management system	CentralSquare

	CitizenServe
	CSDC Amanda
	Superion TRAKiT
Productivity	Microsoft Excel
	Microsoft OneNote
	Microsoft Outlook (Desktop)
	Microsoft Outlook 365
	Microsoft PowerPoint
	Microsoft Word
Project tracking	Serena
Publishing and graphics	Adobe InDesign
	Adobe Photoshop
	Microsoft Publisher
Remote meetings	Cisco WebEx
	MicroSkype
	RingCentral
Site/land use visualization	Google Earth
	Google StreetView
VPN software	Unspecified

Appendix D: Supplemental Figures

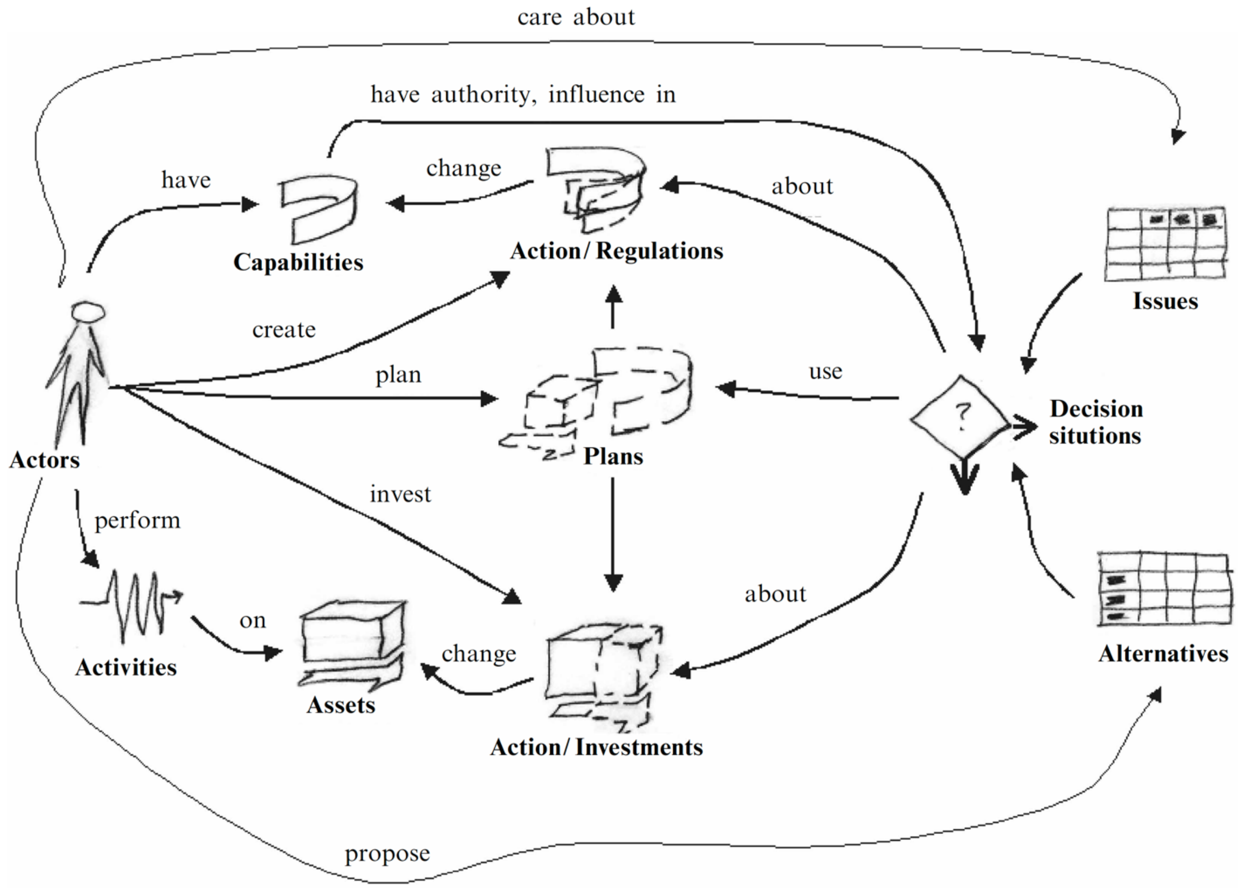

Figure 13. Conceptual illustration of the elements of a planning data model
Source: Reprinted from Hopkins, et al., "Representing Urban Development Plans and Regulations as Data: A Planning Data Model." *Environment and Planning B: Planning and Design* 32, no. 4 (2005): 603.

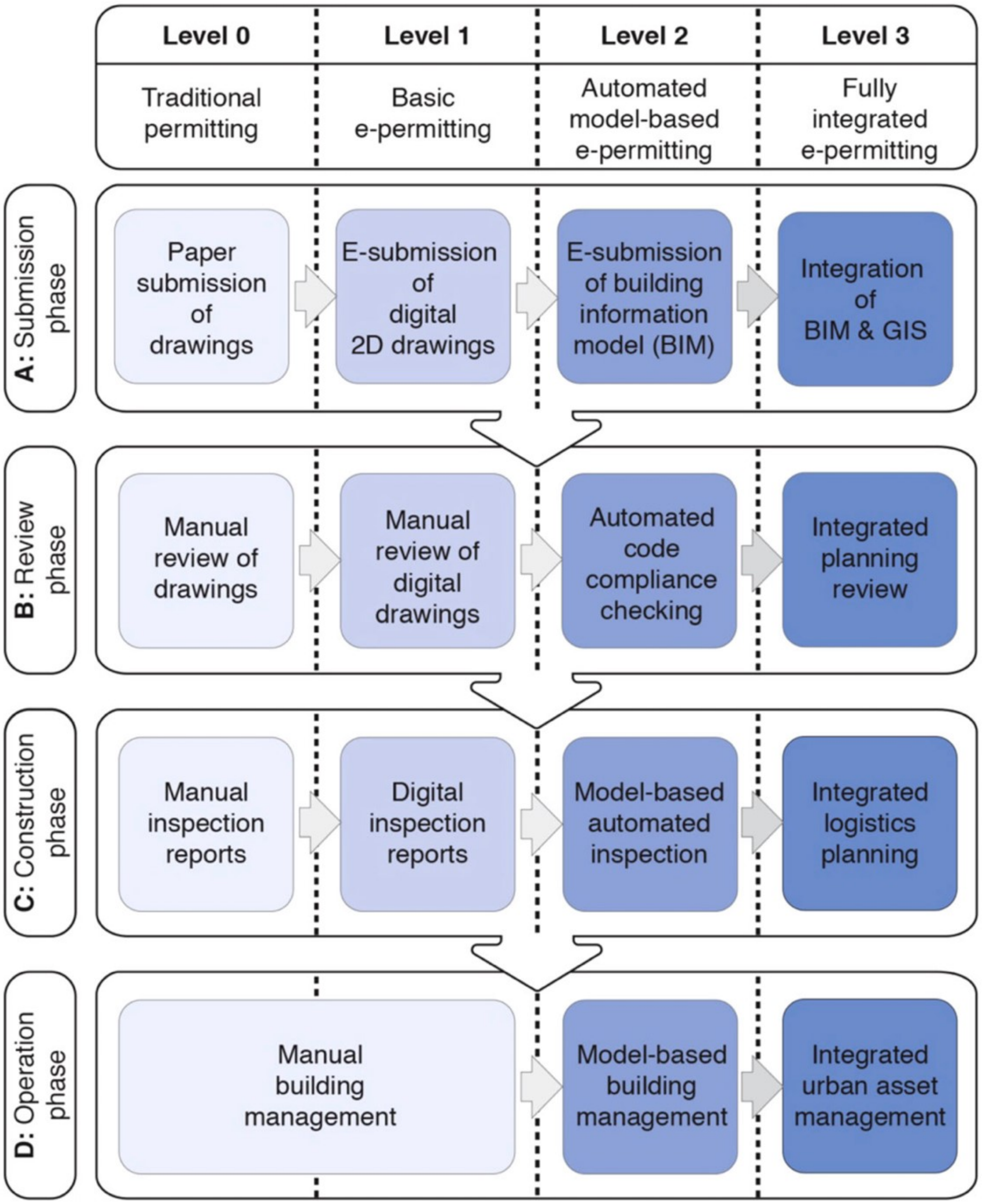

Figure 14. Framework for data-integration and continuous urban asset management through the building life cycle

Source: Reprinted from Kamellia et al. "Framework for Automated Model-Based e-Permitting System for Municipal Jurisdictions." *Journal of Management in Engineering* 35, no. 6 (2019): 4.

Note: The authors refer to the entire urban asset management process as "e-permitting." Phases A and B are directly relevant to electronic plan review.

Bibliography

Akbar, Fatema, Ayse Elvan Bayraktaroglu, Pradeep Buddharaju, Dennis Rodrigo, Da Cunha, Ge Gao, Ted Grover, et al. "Email Makes You Sweat: Examining Email Interruptions and Stress with Thermal Imaging." In CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4 - 9, 2019, Glasgow, Scotland UK., 1–14, 2019.

Alexander, Ernest R. "'Planning' or e-Planning?" International Journal of E-Planning Research 3, no. 1 (2014): 1–15. https://doi.org/10.4018/ijepr.2014010101.

Alfasi, Nurit. "The Coding Turn in Urban Planning: Could It Remedy the Essential Drawbacks of Planning?" Planning Theory 17, no. 3 (2018): 375–95. https://doi.org/10.1177/1473095217716206.

Alon, Lilach, Sharon Hardof-jaffe, and Rafi Nachmias. "How Knowledge Workers Manage Their Personal Information Spaces : Perceptions, Challenges and High-Level Strategies." Interacting with Computers, 2019. https://doi.org/10.1093/iwc/iwz021.

Alrwais, Omer, Brian Hilton, Thomas Horan, Tamir Bechor, Brian Hilton, and Tamir Bechor. "An Organizational Perspective on GIS Payoffs for the Public Sector: Is Usage the Missing Link?" AMCIS 2016: Surfing the IT Innovation Wave - 22nd Americas Conference on Information Systems, 2016, 1–10. https://doi.org/10.1023/A:1017055812457.

Anthopoulos, Leonidas G., and Christopher G. Reddick. "Understanding Electronic Government Research and Smart City: A Framework and Empirical Evidence." Information Polity 21, no. 1 (2016): 99–117. https://doi.org/10.3233/IP-150371.

Batty, Michael. Inventing Future Cities. Cambridge, MA: MIT Press, 2018.

Bertrand, Thomas, Laurent Moccozet, and Jean Henry Morin. "Augmented Human-Workplace Interaction: Revisiting Email." Information Visualisation - Biomedical Visualization, Visualisation on Built and Rural Environments and Geometric Modelling and Imaging, IV 2018, 2018, 194–97. https://doi.org/10.1109/iV.2018.00042.

Bharadwaj, Aditya, Pao Siangliulue, Adam Marcus, and Kurt Luther. "Critter: Augmenting Creative Work with Dynamic Checklists, Automated Quality Assurance, and Contextual Reviewer Feedback." In CHI 2019, 1–12. Glasgow, Scotland, UK, 2019. https://doi.org/https://doi.org/10.1145/3290605.3300769.

Billger, Monica, and Liane Thuvander. "In Search of Visualization Challenges: The Development and Implementation of Visualization Tools for Supporting Dialogue in Urban Planning Processes." Environment & Planning B: Urban Analytics and City Science 44, no. 6 (2017): 1012–35. https://doi.org/10.1177/0265813516657341.

Boulange, Claire, Chris Pettit, Lucy Dubrelle Gunn, Billie Giles-Corti, and Hannah Badland. "Improving Planning Analysis and Decision Making: The Development and Application of a Walkability Planning Support System." Journal of Transport Geography 69 (May 1, 2018): 129–37. https://doi.org/10.1016/J.JTRANGEO.2018.04.017.

Brömmelstroet, Marco te. "Towards a Pragmatic Research Agenda for the PSS Domain." Transportation Research Part A: Policy and Practice 104 (October 1, 2017): 77–83. https://doi.org/10.1016/j.tra.2016.05.011.

Capano, Giliberto, and Elena Pavan. "Designing Anticipatory Policies through the Use of ICTs." Policy and Society, 2018, 1–22. https://doi.org/10.1080/14494035.2018.1511194.

Caulkins, JP, Erica Layne Morrison, and Timothy Weidemann. "Spreadsheet Errors and Decision Making: Evidence from Field Interviews." Journal of Organizational and End User Computing 19, no. 3 (2007): 1–23. https://doi.org/10.4018/joeuc.2007070101.

Charalabidis, Yannis, Euripidis Loukis, Charalampos Alexopoulos, and Zoi Lachana. "Three Generations of Electronic Government: From Service Provision to Open Data to Policy Analytics." In Electronic Government - 17th IFIP WG 8.5 International Conference, EGOV, edited by Ida Lindgren, Marijn Janssen, Habin Lee, Andrea Polini, Manuel Pedro, Rodríguez Bolívar, Hans Jochen, et al., 3–17. San Benedetto Del Tronto, Italy: Springer Nature, 2019.

Christodoulou, Paraskevi, Stefan Decker, Aikaterini-Vasiliki Douka, Charalampia Komopoulou, Vasilios Peristeras, Sofia Sgagia, Vaios Tsarapatsanis, and Dimosthenis Vardouniotis. "Data Makes the Public Sector Go Round." In EGOV 2018, 221–232. Springer International Publishing, 2018. https://doi.org/10.1007/BF03251472.

Colding, Johan, Stephan Barthel, and Patrik Sörqvist. "Wicked Problems of Smart Cities." Smart Cities 2 (2019): 512–21. https://doi.org/10.3390/smartcities2040031.

Costin, Aaron, and Charles Eastman. "Need for Interoperability to Enable Seamless Information Exchanges in Smart and Sustainable Urban Systems." Journal of Computing in Civil Engineering 33, no. 3 (2019): 1–14. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000824.

Czerwinski, Mary, Eric Horvitz, and Susan Wilhite. "A Diary Study of Task Switching and Interruptions." In CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2004), April 24-29, 2004, Vienna, Austria., 6:175–82, 2004. https://doi.org/10.1145/985692.985715.

Davoudi, Simin. "Planning as Practice of Knowing." Planning Theory 14, no. 3 (2015): 316–31. https://doi.org/10.1177/1473095215575919.

Desouza, Kevin, and Kendra Smith. Big Data and Planning. Planning Advisory Service Report 585. Chicago: American Planning Association, 2016.

Drummond, William J., and Steven P. French. "The Future of GIS in Planning: Converging Technologies and Diverging Interests." Journal of the American Planning Association 74, no. 2 (2008): 161–74. https://doi.org/10.1080/01944360801982146.

Durrant, Hannah, Julie Barnett, and Emily Suzanne Rempel. "Realising the Benefits of Integrated Data for Local Policymaking: Rhetoric versus Reality." Politics and Governance 6, no. 4 (2018): 18–28. https://doi.org/10.17645/pag.v6i4.1586.

Eirinaki, Magdalini, Subhankar Dhar, Shishir Mathur, Adwait Kaley, Arpit Patel, Akshar Joshi, and Dhvani Shah. "A Building Permit System for Smart Cities: A Cloud-Based Framework." Computers, Environment and Urban Systems 70 (2018): 175–88. https://doi.org/10.1016/j.compenvurbsys.2018.03.006.

Etscheid, Jan. "Artificial Intelligence in Public Administration." In Electronic Government - 17th IFIP WG 8.5 International Conference, EGOV, edited by Ida Lindgren, Marijn Janssen, Habin Lee, Andrea Polini, Manuel Pedro, Rodríguez Bolívar, Hans Jochen, et al., 248–61. San Benedetto Del Tronto, Italy: Springer Nature, 2019. https://doi.org/https://doi.org/10.1007/978-3-030-27325-5_19.

Fertner, Christian, Andreas Aagaard Christensen, Peter Stubkjær Andersen, Anton Stahl Olafsson, Søren Præstholm, Ole Hjorth Caspersen, and Julien Grunfelder. "Emerging Digital Plan Data–New Research Perspectives on Planning Practice and Evaluation." Geografisk Tidsskrift - Danish Journal of Geography, 2018, 1–12. https://doi.org/10.1080/00167223.2018.1528555.

Ganapati, Sukumar, and Christopher G. Reddick. "The Use of ICT for Open Government in U. S. Municipalities." Public Performance & Management Review 37, no. 3 (2014): 365–87. https://doi.org/10.2753/PMR1530-9576370302.

Gar-On Yeh, A. "Microcomputers in Urban Planning: Applications, Constraints, and Impacts." Environment & Planning B 15, no. 3 (1988): 241–54. https://doi.org/https://doi.org/10.1068/b150241.

Garde, Ajay, and Cecilia Kim. "Form-Based Codes for Zoning Reform to Promote Sustainable Development: Insights From Cities in Southern California." Journal of the American Planning Association 83, no. 4 (2017): 346–64. https://doi.org/10.1080/01944363.2017.1364974.

Gil-Garcia, J Ramon, and Minyoung Ku. "Ready for Data Analytics? Data Collection and Creation in Local Governments." In In Proceedings of the 19th Annual International Conference on Digital Government Research, 1–10. Delft, The Netherlands: ACM, 2018. https://doi.org/10.1145/3209281.3209381.

Goodspeed, Robert. "Digital Knowledge Technologies in Planning Practice: From Black Boxes to Media for Collaborative Inquiry." Planning Theory and Practice 17, no. 4 (2016): 577–

600. https://doi.org/10.1080/14649357.2016.1212996.

Gulsrud, Natalie Marie, Christopher M. Raymond, Rebecca L. Rutt, Anton Stahl Olafsson, Tobias Plieninger, Mattias Sandberg, Thomas H. Beery, and K. Ingemar Jönsson. "'Rage against the Machine'? The Opportunities and Risks Concerning the Automation of Urban Green Infrastructure." Landscape and Urban Planning 180 (2018): 85–92. https://doi.org/10.1016/j.landurbplan.2018.08.012.

Hersperger, Anna M., Eduardo Oliveira, Sofia Pagliarin, Gaëtan Palka, Peter Verburg, Janine Bolliger, and Simona Grădinaru. "Urban Land-Use Change: The Role of Strategic Spatial Planning." Global Environmental Change 51 (2018): 32–42. https://doi.org/10.1016/j.gloenvcha.2018.05.001.

Hoekstra, Rinke, Radboud Winkels, and Erik Hupkes. "Reasoning with Spatial Plans on the Semantic Web." ICAIL-2009 Barcelona, Spain, 2009, 185–93.

Hopkins, Lewis D., Nikhil Kaza, and Varkki George Pallathucheril. "Representing Urban Development Plans and Regulations as Data: A Planning Data Model." Environment and Planning B: Planning and Design 32, no. 4 (2005): 597–615. https://doi.org/10.1068/b31178.

Hopkins, Lewis D., and Gerrit Jan Knaap. "Autonomous Planning: Using Plans as Signals." Planning Theory 17, no. 2 (2018): 274–95. https://doi.org/10.1177/1473095216669868.

Ivson, Paulo, Andre Moreira, Francisco Queiroz, Wallas Santos, and Waldemar Celes. "A Systematic Review of Visualization in Building Information Modeling." IEEE Transactions on Visualization and Computer Graphics, 2019. https://doi.org/10.1109/TVCG.2019.2907583.

Jansen, Bas, Felienne Hermans, and Edwin Tazelaar. "Detecting and Predicting Evolution in Spreadsheets-a Case Study in an Energy Network Company." Proceedings - 2018 IEEE International Conference on Software Maintenance and Evolution, ICSME 2018, 2018, 645–54. https://doi.org/10.1109/ICSME.2018.00074.

Johnson, Bonnie J., and Ward Lyles. "The Unexamined Staff Report: Results from an Evaluation of a National Sample." Journal of the American Planning Association 82, no. 1 (2016): 22–36. https://doi.org/10.1080/01944363.2015.1109471.

Kahila-Tani, Maarit, Marketta Kytta, and Stan Geertman. "Does Mapping Improve Public Participation? Exploring the Pros and Cons of Using Public Participation GIS in Urban Planning Practices." Landscape and Urban Planning 186, no. February (2019): 45–55. https://doi.org/10.1016/j.landurbplan.2019.02.019.

Kim, Joongsub. "The Four Roles in the Context of Difficult Challenges Faced by Reviewers." In What Do Design Reviewers Really Do? Understanding Roles Played by Design Reviewers in Daily Practice, 99–109. Springer Nature Switzerland, 2019.

https://doi.org/10.1007/978-3-030-05642-1.

Klosterman, R E. "Computer Applications in Planning." Environment and Planning B: Planning and Design Anniversar (1998): 32–36.

Klosterman, Richard. "Comment on Drummond and French: Another View of the Future of GIS." Journal of the American Planning Association 74, no. 2 (2008): 174–76. https://doi.org/10.1080/01944360801982203.

Koch, Patrick. "Now You're Thinking With Structures: A Concept for Structure-Based Interactions with Spreadsheets." In Proceedings of the 5th International Workshop on Software Engineering Methods in Spreadsheets, 2018. http://arxiv.org/abs/1809.03435.

Kuller, Martijn, Megan Farrelly, Ana Deletic, and Peter M. Bach. "Building Effective Planning Support Systems for Green Urban Water Infrastructure—Practitioners' Perceptions." Environmental Science and Policy 89, no. June (2018): 153–62. https://doi.org/10.1016/j.envsci.2018.06.011.

Lai, Huahui, Xueyuan Deng, and Tse Yung P. Chang. "BIM-Based Platform for Collaborative Building Design and Project Management." Journal of Computing in Civil Engineering 33, no. 3 (2019): 1–15. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000830.

Landis, John D. "Fifty Years of Local Growth Management in America." Progress in Planning, 2019, 1–23. https://doi.org/10.1016/j.progress.2019.100435.

Langenheim, Nano, Marcus White, Jack Barton, and Serryn Eagleson. "Designing with Data for Urban Resilience." In Planning Support Science for Smarter Urban Futures: Lecture Notes in Geoinformation and Cartography, edited by S. Geertman, Andrew Allan, Chris Pettit, and John Stillwell, 113–33. Springer International Publishing, 2017. https://doi.org/10.1007/978-3-319-57819-4.

Laurini, Robert. Information Systems for Urban Planning. London: Taylor & Francis, 2001.

Liu, Yifan, Fadi Castronovo, John Messner, and Robert Leicht. "Evaluating the Impact of Virtual Reality on Design Review Meetings." Journal of Computing in Civil Engineering 34, no. 1 (2020). https://doi.org/10.1061/(ASCE)CP.1943-5487.0000856.

Marantz, Nicholas J., and Nicola Ulibarri. "The Tensions of Transparency in Urban and Environmental Planning." Journal of Planning Education and Research, 2019, 1–12. https://doi.org/10.1177/0739456X19827638.

Marvin, Simon, and Andrés Luque-Ayala. "Urban Operating Systems: Diagramming the City." International Journal of Urban and Regional Research 41 (2017): 84–103. https://doi.org/10.1111/1468-2427.12479.

McKenna, H. Patricia. "Innovating Metrics for Smarter, Responsive Cities." Data 4 (2019): 1–25. https://doi.org/10.3390/data4010025.

Meijer, Albert Jacob, Miriam Lips, Kaiping Chen, and Albert Jacob Meijer. "Open Governance :

A New Paradigm for Understanding Urban Governance in an Information Age.” Frontiers in Sustainable Cities 1, no. 3 (2019): 1–9. https://doi.org/10.3389/frsc.2019.00003.

Miller, Harvey J. “Geographic Information Science III: Why Faster Geographic Information Is Not Always Smarter.” Progress in Human Geography, 2018, 1–10. https://doi.org/10.1177/0309132518799596.

Moroni, Stefano, Edwin Buitelaar, Niels Sorel, and Stefano Cozzolino. “Simple Planning Rules for Complex Urban Problems: Toward Legal Certainty for Spatial Flexibility.” Journal of Planning Education and Research, 2018, 1–12. https://doi.org/10.1177/0739456X18774122.

Nawari, Nawari O. “Generalized Adaptive Framework for Computerizing the Building Design Review Process.” Journal of Architectural Engineering 26, no. 1 (March 1, 2020): 1–17. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000382.

Noardo, Francesca, C. Ellul, L. Harrie, I. Overland, M. Shariat, Ken Arroyo, and Jantien Stoter. “Opportunities and Challenges for GeoBIM in Europe : Developing a Building Permits Use-Case to Raise Awareness and Examine Technical Interoperability Challenges Opportunities and Challenges for GeoBIM in Europe :” Journal of Spatial Science, 2019, 1–25. https://doi.org/10.1080/14498596.2019.1627253.

Palka, Gaëtan, Simona R. Grădinaru, Gertrud Jørgensen, and Anna M. Hersperger. “Visualizing Planning Intentions: From Heterogeneous Information to Maps.” Journal of Geovisualization and Spatial Analysis 2, no. 26 (2018): 1–14. https://doi.org/10.1007/s41651-018-0023-9.

Park, Soya, Amy X Zhang, and Luke S Murray. “Opportunities for Automating Email Processing : A Need-Finding Study.” In Conference on Human Factors in Computing Systems Proceedings, 1–12. Glasgow, Scotland, UK, 2019.

Pelzer, Peter, Gustavo Arciniegas, Stan Geertman, and Sander Lenferink. “Planning Support Systems and Task-Technology Fit: A Comparative Case Study.” Applied Spatial Analysis and Policy 8, no. 2 (2015): 155–75. https://doi.org/10.1007/s12061-015-9135-5.

Pettit, Christopher, Ashley Bakelmun, Scott N. Lieske, Stephen Glackin, Karlson ‘Charlie’ Hargroves, Giles Thomson, Heather Shearer, Hussein Dia, and Peter Newman. “Planning Support Systems for Smart Cities.” City, Culture and Society 12, no. August 2017 (2018): 13–24. https://doi.org/10.1016/j.ccs.2017.10.002.

Pinto, José María González, Janus Wawrzinek, Suma Kori, and Wolf-Tilo Balke. “Can Language Inference Support Metadata Generation?” In Digital Libraries for Open Knowledge: 23rd International Conference on Theory and Practice of Digital Libraries, 253–64. Oslo, Norway: Springer Nature, 2019. https://doi.org/10.1007/978-3-030-30760-8.

Plesner, Ursula, Lise Justesen, and Cecilie Glerup. "The Transformation of Work in Digitized Public Sector Organizations." Journal of Organizational Change Management 31, no. 5 (2018): 1176–90. https://doi.org/10.1108/JOCM-06-2017-0257.

Powell, Stephen G., Kenneth R. Baker, and Barry Lawson. "Impact of Errors in Operational Spreadsheets." Decision Support Systems 47, no. 2 (2009): 126–32. https://doi.org/10.1016/j.dss.2009.02.002.

Raetzsch, Christoph, Gabriel Pereira, Lasse S Vestergaard, and Martin Brynskov. "Weaving Seams with Data: Conceptualizing City APIs as Elements of Infrastructures." Big Data & Society, 2019, 1–14. https://doi.org/10.1177/2053951719827619.

Redden, Joanna. "Democratic Governance in an Age of Datafication: Lessons from Mapping Government Discourses and Practices." Big Data & Society 5, no. 2 (2018): 1–13. https://doi.org/10.1177/2053951718809145.

Riggs, William, and Kayla Gordon. "How Is Mobile Technology Changing City Planning? Developing a Taxonomy for the Future." Environment and Planning B: Urban Analytics and City Science 44, no. 1 (2017): 100–119. https://doi.org/10.1177/0265813515610337.

Rogge, Nicky, Tommaso Agasisti, and Kristof De Witte. "Big Data and the Measurement of Public Organizations' Performance and Efficiency: The State-of-the-Art." Public Policy and Administration 32, no. 4 (2017): 263–81. https://doi.org/10.1177/0952076716687355.

Roy, Sohon, Arie Van Deursen, and Felienne Hermans. "Perceived Relevance of Automatic Code Inspection in End-User Development : A Study on VBA." In Evaluation and Assessment in Software Engineering (EASE '19), April 15–17, 2019, Copenhagen, Denmark., 1–10. New York, NY, USA: ACM, 2019.

Russo, Patrizia, Rosa Lanzilotti, Maria Francesca Costabile, and Christopher James Pettit. "Adoption and Use of Software in Land Use Planning Practice: A Multiple-Country Study." International Journal of Human-Computer Interaction 34, no. 1 (January 2, 2018): 57–72. https://doi.org/10.1080/10447318.2017.1327213.

Safransky, Sara. "Geographies of Algorithmic Violence: Redlining the Smart City." International Journal of Urban and Regional Research, November 24, 2019, 1–19. https://doi.org/10.1111/1468-2427.12833.

Santos, Deborah M, and José Nuno Beirão. "Integration of BIM and Generative Design for Earthbag Projects." In Progress in Digital and Physical Manufacturing, edited by Henrique A Almeida and Joel C Vasco, 102–9. Cham: Springer International Publishing, 2020. https://doi.org/https://doi.org/10.1007/978-3-030-29041-2_13

Schedler, Kuno, Ali Asker Guenduez, and Ruth Frischknecht. "How Smart Can Government Be ? Exploring Barriers to the Adoption of Smart Government." Information Polity 24 (2019):

3–20. https://doi.org/10.3233/IP-180095.

Scott, Tyler A., and David P. Carter. "Collaborative Governance or Private Policy Making? When Consultants Matter More than Participation in Collaborative Environmental Planning." Journal of Environmental Policy & Planning 7200 (2019): 1–21. https://doi.org/10.1080/1523908X.2019.1566061.

Seamon, David. "Christopher Alexander's Theory of Wholeness as a Tetrad of Creative Activity: The Examples of A New Theory of Urban Design and The Nature of Order." Urban Science 3, no. 2 (2019): 1–13. https://doi.org/10.3390/urbansci3020046.

Shahi, Kamellia, Brenda Y. McCabe, and Arash Shahi. "Framework for Automated Model-Based e-Permitting System for Municipal Jurisdictions." Journal of Management in Engineering 35, no. 6 (2019): 1–10. https://doi.org/10.1061/(asce)me.1943-5479.0000712.

Shen, Ying, Li Chengpeng, Li Weiyang, Chen Naibin, and Zhao Zhigang. "Using Focus + Context Techniques to Visualize Building Information Model in Virtual Geo-Environment." International Cartographic Association, 2019. https://doi.org/10.5194/ica-abs-1-422-2019.

Soe, Ralf-martin, and Wolfgang Drechsler. "Agile Local Governments : Experimentation before Implementation." Government Information Quarterly 35, no. 2 (2018): 323–35. https://doi.org/10.1016/j.giq.2017.11.010.

Stich, Jean Francois, Monideepa Tarafdar, Patrick Stacey, and Sir Cary Cooper. "Appraisal of Email Use as a Source of Workplace Stress: A Person-Environment Fit Approach." Journal of the Association of Information Systems 20, no. 2 (2019): 132–60. https://doi.org/10.17705/1jais.00531.

Stone, Merlin, Eleni Aravopoulou, Geraint Evans, Esra Aldhaen, and Brett David Parnell. "From Information Mismanagement to Misinformation – the Dark Side of Information Management." The Bottom Line, 2018, 1–25. https://doi.org/10.1108/BL-09-2018-0043.

Sydora, Christoph, and Eleni Stroulia. "Towards Rule-Based Model Checking of Building Information Models." In Proceedings of the 36th International Symposium on Automation and Robotics in Construction (ISARC), 1327–33. IAARC Publications, 2019. https://doi.org/10.22260/isarc2019/0178.

Tasan-Kok, Tuna, Luca Bertolini, Sandra Oliveira e Costa, Hila Lothan, Higor Carvalho, Maarten Desmet, Seppe De Blust, et al. "'Float like a Butterfly, Sting like a Bee'*: Giving Voice to Planning Practitioners." Planning Theory and Practice 17, no. 4 (2016): 621–51. https://doi.org/10.1080/14649357.2016.1225711.

Vacca, Giuseppina, and Emanuela Quaquero. "BIM-3D GIS: An Integrated System for the Knowledge Process of the Buildings." Journal of Spatial Science, 2019, 1–16. https://doi.org/10.1080/14498596.2019.1601600.

Vishkaie, Rojin, Richard Levy, and Anthony Tang. “Urban Planning Process: Can Technology Enhance Participatory Communication?” Urban Planning and Design Research 2 (2014): 20–31. www.seipub.org/updr.

Vonk, Guido, Stan Geertman, and Paul Schot. “Bottlenecks Blocking Widespread Usage of Planning Support Systems.” Environment and Planning A 37, no. 5 (May 1, 2005): 909–24. https://doi.org/10.1068/a3712.

Wajcman, Judy. “The Digital Architecture of Time Management.” Science Technology and Human Values 44, no. 2 (2019): 315–37. https://doi.org/10.1177/0162243918795041.

Wang, Hao, Yisha Pan, and Xiaochun Luo. “Integration of BIM and GIS in Sustainable Built Environment: A Review and Bibliometric Analysis.” Automation in Construction 103 (2019): 41–52. https://doi.org/10.1016/j.autcon.2019.03.005.

Wang, Yun, Zhida Sun, Haidong Zhang, Weiwei Cui, Ke Xu, Xiaojuan Ma, and Dongmei Zhang. “DataShot: Automatic Generation of Fact Sheets from Tabular Data.” IEEE Transactions on Visualization and Computer Graphics - Early Access, 2019. https://doi.org/10.1109/tvcg.2019.2934398.

Wästberg, Beata Stahre, Monica Billger, Jens Forssén, and Maria Holmes. “Visualizing Environmental Data for Pedestrian Comfort Analysis in Urban Planning Processes.” In 15th International Conference on Computers in Urban Planning and Urban Management. Adelaide, Australia, 2017. https://www.researchgate.net/publication/318340921.

Xie, Qingsheng, Xiaoping Zhou, Jia Wang, Xinao Gao, Xi Chen, and Chun Liu. “Matching Real-World Facilities to Building Information Modeling Data Using Natural Language Processing.” IEEE Access 7 (2019): 119465–75. https://doi.org/10.1109/ACCESS.2019.2937219.