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Dissertation Proposal

CITY KNOWLEDGE

An Infrastructure for Urban Maintenance, Management and Planning

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ABSTRACT

This thesis addresses the collection, organization, integration, distribution and use of urban knowledge by government agencies for the development of actions related to city maintenance, management and planning. After identifying what elements of the urban realm are the target of knowledge-based interventions by city agencies, this research will explore the feasibility and desirability of the creation of a reliable, permanent, updatable, maintainable, reusable and sharable knowledge infrastructure to support municipal maintenance, management and planning operations.

As part of this study, the technical, institutional and logistical obstacles that complicate the development of such an infrastructure are analyzed, and followed by the demonstration of one possible pathway for the gradual accrual of city knowledge. As an alternative to the prevailing top-down and bottom-up approaches to the organization of municipal information, this dissertation explores a "middle-out", parallel, distributed approach that promises to gradually produce a flexible, multi-purpose knowledge infrastructure on which day-to-day operations as well as long-range planning decisions can be based. As soon as civic authorities begin to treat city knowledge as they treat any other infrastructure element of the urban realm, we should witness a shift from the current "plan-demanded" mode of data collection, to a more "plan-ready" approach to knowledge accrual, which may lead to "plan-demanding" situations in which the mere existence of this urban knowledge may engender plans which otherwise may have never been envisioned.

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INTRODUCTION

CONTEXT

My personal experience in urban studies and planning in my hometown of Venice, Italy, as well as more recent forays in Boston and Cambridge, have lead me to realize that cities often lack a comprehensive and systematic "knowledge infrastructure" on which to base planning decisions, from the grand urban design projects to the more mundane municipal maintenance tasks. What I found to be the prevalent mode of functioning of the various branches and departments of a modern city is a form of "ad hoc-ism" whereby data are collected for specific purposes and then quickly forgotten or stored in inaccessible places, unbeknownst to any other department or even to other personnel in the same department. Although some systematic data collection takes place, mostly for regulatory or revenue-generating purposes (such as for permits, licenses, property assessments, and the like), even these data are often hard to obtain or utilize, both internally by the rest of the municipality and, even less so, externally by academic scholars, independent researchers or planners. Frequently, access to important information is made possible only through personal connections and by means of "under the counter" transfers which bypass the official channels that otherwise would render the dissemination of data virtually impossible.

ad-hoc data collection

lack of dissemination and re-use

Due to the dearth of coordination between departments, I have personally encountered several situations whereby the same data were being collected by different departments almost simultaneously. Moreover, I have also personally witnessed how a single department will pay external consultants to collect the same type of data multiple times, over the course of a few years. Redundancy and waste seem to be endemic when it comes to municipal data collection, due to the apparent lack of long-term planning and standardization.

redundancy and waste

PREMISES

The basic premise of this research is that a majority of the characteristics that make up the physical city change very slowly, if at all, and are thus amenable to a gradual and systematic collection effort, the bulk of which would only have to be conducted once. Until now, the complexity of the gargantuan task of collecting and organizing such a multidimensional body of information has discouraged a wholesale approach to the accumulation of city knowledge. Today, however, technical tools that can facilitate the recording and archiving of most, if not all, of the idiosyncratic features of the urban landscape have finally become widely available and affordable, making it possible to realistically envision how cities could begin to accumulate this wealth of information about themselves.

permanent features

slow change

systematic accumulation

This thesis takes advantage of the window of opportunity created by recent advances in Geographic Information Systems (GIS) , the World Wide Web(WWW) and other information and communication technologies to propose a specific institutional and organizational, as well as technical, approach that will enable cities to gradually and non-traumatically accrue and maintain an exhaustive, comprehensive, flexible, reliable, multipurpose and sharable knowledge-base.

recent technological advances

Goals

inventory information needs

With this research, I plan first of all to find out what information is commonly required and collected by typical municipal departments for urban maintenance, management and planning purposes. I then intend to make the case that City Knowledge is a resource to be fostered and maintained as any other infrastructure of the city is.

establish importance

Investments in City Knowledge should therefore be viewed as capital outlays and steps should be taken to ensure that taxpayer money is well spent. Just as a city would not dream of rebuilding its sewer system over and over again (or to create two parallel sewer systems), so too each municipality should ensure that information about important urban elements is not lost, inaccessible, underutilized or redundantly collected.

address obstacles

This dissertation will explore ways in which cities can overcome the most common obstacles – be they organizational, financial, technical, psychological or logistical – that are hindering the institutionalization of a knowledge infrastructure.

propose approach

Using real-life case studies, I will propose unobtrusive mechanisms that can be put in place at the ground level (or "frontline"), to gradually, but systematically, build up a body of knowledge about the city. Upon this infrastructure, plans can be devised when needed, but more importantly, with this information readily available, municipal agencies can better serve their constituent taxpayers, who are footing the bills and are living, day in and day out, with the positive or negative consequences of the ongoing urban management practices adopted by their town.

develop prototype applications

I will attempt to prove the concepts proposed above by developing a couple of real-life applications to be used as prototypes of city knowledge systems in two municipalities (Venice, Italy and a Boston-area city). These applications should enable the target city departments to, first of all, organize the information that is needed for their day-to-day operation. I plan to extend these applications to also demonstrate the potential for knowledge-sharing between departments once the basic systems are in place.

organize routine operations

demonstrate sharing

assess feasibility

With these "real life" case studies, I plan to assess to what degree the approach I propose is indeed feasible and advantageous. In particular, I will contrast my strategy with other possible methods for the systematic accumulation of city knowledge as well as with non-systematic, ad-hoc schemes that are frequently used to collect information when needed. I intend to compare these approaches on financial, organizational and technical standpoints.

compare to alternatives

evaluate advantages

I would like to evaluate the possible advantages of my proposed approach, both to individual municipal departments as well as to the city as a whole. In particular, I hope to investigate how such solid, fine-grained and rich datasets of usable information could be used by city planners, who most frequently need to gather a variety of information from disparate sources, across department boundaries. In this context, I will also analyze the disadvantages that may be discovered in the process, and propose remedies for them.

analyze disadvantages

distill and generalize

From the case studies, which will be based on direct personal experiences in Venice, Italy and in the greater Boston area, I will try to distill a generalizable approach that could be broadly applied elsewhere, and I will also identify the sectors of municipal operations and services that are more amenable to these tactics in the short- and medium-term. I will focus

specifically on the advantages and opportunities that exist in the areas of urban maintenance, management and planning.

explore planning implications

The final goal is to deduce – on the basis of specific case studies – and hypothesize, at a more theoretical level, to what degree the whole process should be guided by a "planning mindset" that will broaden the scope of the data-collection for each class of urban elements, enriching the datasets with teleologic parameters that will maximize the information content for little or no added cost. This "enrichment" of the datasets may facilitate sharing and may also determine the cost-effectiveness of field campaigns both for the collection of baseline data as well as for subsequent periodic updates.

At the same time, this research will also explore under what circumstances the availability of such rich city knowledge could promote the emergence of a need for new plans that are dictated by the mere existence of such information.

DATA, INFORMATION AND KNOWLEDGE

data, information and knowledge

Whereas in the paragraphs above I have used the terms "data" and "information" synonymously, there seems to be some consensus on a hierarchy of "types of information", from data to information to knowledge (some scholars, such as Klosterman, even add a fourth level of intelligence)[1]. In this context, *data* would refer to raw facts, both quantitative and qualitative, *information* would pertain to data manipulated and organized in a meaningful form, and *knowledge* relates to "understanding based on information, experience and study".[2] *Intelligence*, a term which agencies such as the C.I.A. frequently use to refer to "top secret" information, is sometimes considered to be the application of knowledge to guide behavior[3]. In the paragraphs that follow, the terms are occasionally used more or less interchangeably, as synonyms, especially in quoted references[4], even though a portion of my dissertation will be devoted to differentiating between the three levels and investigating the transformation between one stage and the next, with additional emphasis on how knowledge affects actions (and plans).

from knowledge to action

Figure 1 reflects the aforementioned taxonomy and also summarizes the typical processes involved in the decision-making that leads to action on the part of municipal agencies. Knowledge is supported by hard facts, based on data, which is organized into information, but it also taps into the "fuzzier" realm of "experience", whereby social, institutional, legal, tactical, methodological and theoretical factors play a role in the shaping of final decisions leading to actions.

lack of data (hard facts)

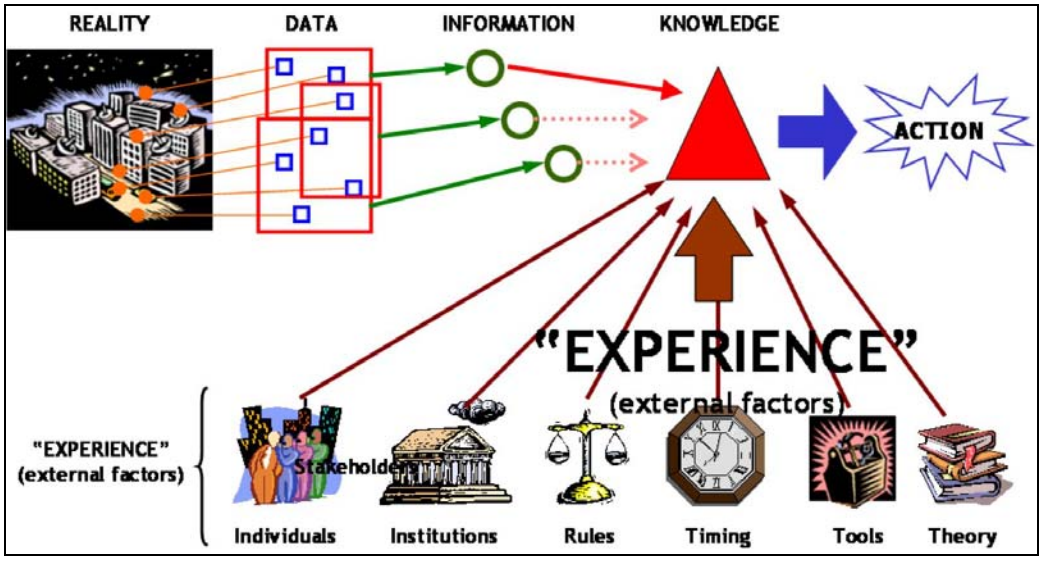

Figure 1. Data, Information, Knowledge and Action.

[1] Klosterman, Richard E.. 2000. "Planning in the Information Age", p. 42.

[2] *Idem.* See also Laurini, *Information Systems for Urban Planning*, pp. 41-42 and p. 149.

[3] *Idem.* I am not convinced by this fourth level, since it seems to me that it basically labels a goal which is implicit in the gathering of knowledge more than a "type" of information…

[4] Often, the authors I quote will use "information" to mean "data, information and knowledge".

The "hard facts" are unfortunately not as available as one would imagine them to be. In fact, many distinguished planners of the past (such as Olmsted, 1913, Geddes, 1915, and Mumford, 1961) as well as many contemporary observers of urban affairs (e.g. Yeh, 1999) clearly point out that we are not doing a really good job of knowing our cities. In summary, as Yeh succinctly put it: "[t]oday, the main constraints on the use of GIS in urban planning are not technical issues, but the availability of data, organizational change, and staffing"[5].

My personal experience confirms these views. Despite the relative "permanence" and "immutability" of the physical elements composing our urban realms, knowledge of our cities is not as developed as one would hope it to be. Although data are gathered daily for a variety of reasons, information is not necessarily obtained as a consequence and knowledge is hardly augmented in the process. The seemingly subtle differences between data, information and knowledge are quite apparent in the fields of urban maintenance, management and planning. Data are all too frequently collected to satisfy very specific needs. They are rarely organized into information that can be used for other purposes and thus they hardly ever contribute to the creation of knowledge on which decisions and actions can be fruitfully based.

"Plan-Demanded" Knowledge

In fact, the planning process is indeed predicated on the availability of a myriad of data, but information is almost never available as a consequence of a systematic data-collection strategy by government agencies. Rather, "[t]o develop new land-use plans and proposals (or to form opinions as new opportunities and proposals surface), all of these agencies typically spend considerable energy researching and analyzing land use and ownership in the neighborhoods surrounding the sites that are targeted in the plans."[6] Urban Planning is largely based on ad-hoc collections of data, gathered on an "as needed" basis in what I term a "plan-demanded" mode of operation. Every time a plan is envisioned or proposed, "we need to integrate, and reinterpret many data sources now dispersed among agencies and groups that are administratively isolated and focused on different issues and goals"[7].

Automation plays a certain role in this process, in that some planning data are collected fairly rigorously by some government agencies, but the tendency toward automation in this field has been limited, for the most part, to areas that are under strict regulatory control (like land use) or that generate municipal revenue (like parcel ownership). Record keeping in such instances has always been necessary to the proper functioning of civil society, so the introduction of Information Technologies (IT) has been merely a convenient way to make the process faster and smoother. Generally speaking, though, the representation of space in many municipal computerization efforts has been shortchanged. At best, locations are represented by address, with all of the standardization and referencing problems that such an approach entails. A systematic approach to the acquisition of fine-grained city knowledge is still considered too cumbersome, even after the introduction of the first G.I.S. tools in the late 80's. Unfortunately, without a reliable, shared knowledgebase of urban information, the "speed-up" effect brought about by traditional

[5] Yeh, A. G.-O, 1999. "Urban Planning and GIS" in Longley *et al.,* eds., *Geographical Information Systems*, p. 887.

[6] Joseph Ferreira Jr., in *High Technology and Low-Income Communities*, second page of chapter 7.

[7] *Idem.*

automation "may not make much of a dent in the considerable amount of time that our prototypical neighborhood planner must spend studying land use and ownership"[8].

Examples of "plan demanded" data gathering abound. In fact, most data gathering outside of the realms of regulatory or revenue-generating operations probably fits in this category. In my own personal experience, I have encountered and actually participated in several plan-demanded campaigns of data collection, both in Italy and in the U.S. For instance, I have led teams of students from the Worcester Polytechnic Institute (WPI) in campaigns to collect information about numerous aspects related to the canals of Venice. The data are currently used by Insula S.p.A. (a private-public company in charge of the maintenance of the Venetian canals) to actually conduct dredging and restoration projects on the Venetian waterways. The data we collected included: measurements of the physical dimensions of the canals, including the water depth and sediment levels at the bottom; a catalog of all sewer outlets and wall damage along canal banks; measures of the water currents in the canals; counts of the boat traffic in the canals and quantification of the wakes produced by passing motorboats; an inventory of all bridges spanning the canals and an assessment of their state of (dis-)repair; a similar census of all boat docks and their condition; a series of campaigns to quantify the amount of cargo delivered to each island in the city; and several other more specific studies.

examples of plan-demanded data collections

Similarly, I coordinated programs for the systematic inventory of: trees in the city of Venice and in the City of Cambridge, Massachusetts; parking facilities in downtown Boston, Cambridge and Newton; underground storage tanks for the Boston Fire Department; brownfields for the Boston Redevelopment Authority; historic monuments and landmarks for the Boston Landmarks Commission and for a variety of Venetian organizations; archeological sites both in Boston and Venice; etc. Overall, I have participated in over 100 such projects on both sides of the Atlantic.

All of these projects were completed to fill informational lacunae and were used by the sponsoring agencies to carry out specific actions related to urban maintenance, management and planning that required immediate attention. All of them are examples of "plan-demanded" data gathering.

"Plan-Ready" Knowledge

While involved in the aforementioned "plan-demanded" projects, I immediately realized that such herculean efforts would be much more effective if they not only contributed to the pressing needs of the agencies that commissioned the studies, but also contributed to the long-term creation of a knowledge infrastructure that could be re-used in other contexts. While Insula S.p.A. could use the canal data for its immediate necessities, certainly such permanent and immutable features as the canal lengths and widths could come in handy for some other purpose at a later date. More importantly, the canal coding scheme that we developed, which assigned unique identifiers to each segment of the water network, could certainly be useful for posterity. If all future data-gathering utilized the same scheme, it would be possible to compare and correlate datasets referring to the same canal segment at any time. The benefits of such a standard referencing system and of any permanent records connected to it were indisputable. So, when we

standard referencing system

[8] *Ibid.,* p. 4 of chapter 7.

collected our data on all of the various elements of the urban realm, we always did so with an eye to this fundamental infrastructure of knowledge that could be reusable by other researchers or government agencies for years to come. We were able to do so, partly because of intuitive insights due to our background in the rigors of engineering, but also because we based our referential system on spatial features, which were part of the unchanging (or slowly changing) urban world. We were fortunate to have been pioneers in the use of Geographical Information Systems (GIS) as early as 1987, which opened up the possibility of actually being able to georeference our data to their real-world locations.

spatial georeferencing

What is still often lacking in today's municipal agencies, in fact, is a decentralized "informating"[9] strategy that properly accounts for the spatial dimension of urban features and makes these and other data available to those who need them. To remedy these shortcomings, I am proposing to introduce a space-based representation of the urban realm based on the fundamental, quasi-permanent physical elements that are already the object of regular municipal attention for maintenance or management. While this may not be a novel idea in itself, the innovation I am proposing would lie primarily in the manner in which these data could be systematically collected, and especially updated, by capturing transaction data starting from a few key areas that are especially relevant to planning. An important aspect of my approach is to focus first and foremost on the permanent and immutable features of the urban world, which, once recorded and organized should require very little upkeep, thus eliminating any redundant effort to collect the same data for a variety of different purposes. The representation I propose can be gradually and systematically "grown" into a reliable, flexible, multi-purpose and shareable knowledge base of the urban landscape, beginning from the "low-hanging" branches of the hierarchy of municipal agencies, which are most directly interacting with the "real world" of the city and would benefit the most from a structured approach to the representation and computerization of the urban features that are already under their jurisdiction. It is at the level of these "low hanging fruits" that the systematic approach I propose can be most effectively overlaid on ordinary municipal operations where the tradeoffs between maintenance necessities and the added requirements of the encoding of city knowledge are most advantageous.

Whereas traditional recordkeeping methods for these "atomic" elements of the urban realm are generally ill-suited to planning, because their level and method of representation is usually inadequate for higher-order manipulations, the cumulative process discussed herein would quickly begin to produce usable information for both the front-line operators of the municipal departments directly in charge of each set of urban elements, but would also generate solid, fine-grained and rich datasets of usable information that planners and decision-makers could tap into for the formulation of government actions that address more complex urban conditions. In short, the approach that is going to be explored in this dissertation promises to produce "plan-ready" information and may even lead to the inductive

[9] Zuboff, S. *In the Age of the Smart Machine.* According to Zuboff, to "informate" means essentially to be able to archive and organize data as they are produced through automated processes, so that this information can be utilized for higher-order management and control activities that go beyond the original intent of the mere automation of routine operations.

development of plans and actions that may be demanded by the preponderance of evidence produced in the process.

My own approach to the development of "plan-ready" city knowledge is, in a sense, an attempt to bring more "automation" into the planning process, so that the "informating" will be based on reliable, systematically collected, up-to-date and easy-to-update data. This approach espouses Zuboff's argument, though it is applied to fields (city maintenance, management and planning) where informating requirements are already evident and implicit (or "tacit"[10]) knowledge is already used empirically. The difference between the more traditional manufacturing, and data processing applications studied by Zuboff and the urban disciplines that I am interested in, is that while information about many aspects of urban life is somehow available to city managers and planners – on demand and with substantial effort – there is little or no automation to feed the demand for such information. Whereas the traditional industries in Zuboff's case studies followed the straightforward path of technological development from a manual management and control of operations to a computer-assisted, automated version of the same tasks, many areas of urban management and planning do not have any automation in place at all. Yet, the power of information, which was only gradually realized as an afterthought of automation in Zuboff's companies, is an ever present reality in the urban management and planning arena, where the need for informating actually predates the need for automating.

ambulance dispatching system

Over the years, I have accumulated a number of personal cases in which data that were collected for one purpose were later used for a completely different reason, without the need to go back in the field. For example, in 1997, we were asked to develop a prototype of an ambulance dispatching system for the Venice general hospital. Ambulances in Venice are, of course, boats that need to contend with the same obstacles as their land cousins, such as traffic congestions, and the like, but also have to deal with the vagaries of tidal fluctuations which may make some routes impassable, either because of high tides, which make some bridges too low to pass under or because of low tides, which make it impossible to navigate where the sediment build up has made the canals too shallow. To tackle this problem, we actually borrowed a software package from the Planning Support Systems group of the Department of Urban Studies and Planning (DUSP) at MIT, called TransCAD[11]. This application figures out the shortest route (by time or by distance) and is capable of taking into account "delays" due to a variety of causes. Thanks to our extensive knowledge of the canal system, we were able to re-utilize our information about the depth of canals and the height of bridges to insert appropriate delays along the routes, depending on the tide levels. More importantly, we were able to create the canal network graph needed to run the whole system, basing it on the canal centerlines that we had already determined in the course of another project[12]. Moreover, we had to tweak the system to allow for two separate routes, a sea route to a specific dock location, and a land route, from the dock to the emergency address. We already had all of the dock locations from another

[10] Choo, *Information Management for the Intelligent Organization*, p. 11.

[11] Which incidentally is produced by a company that is the off-shoot of the same MIT department.

[12] We had created the centerlines to "measure" the canal lengths.

project and all of the address locations as well. The only thing we had to do from scratch was develop a land network graph and we were already in business…

This project exemplifies the power of "plan-ready" information, when data are collected with an eye to the potential re-utilization of the information in a context that is different from the one for which the original data collection was conducted. In this case, we actually tapped into at least four previous projects, which were completed long before this study was even envisioned. The utilization of all these datasets in this particular application was never even remotely imagined at the time when the data were collected. What made all of this possible was the fact that each dataset was connected to spatial features of the canal network, through standardized reference identifiers of the canal segment codes in all of the records.

"Plan-Demanding" Knowledge

Although the mere availability of "plan-ready" information would already be a major step forward in the management of urban affairs, there is an even more intriguing byproduct of the approach that I am propounding. It seems plausible that, once enough plan-ready information is available to a variety of municipal agencies, the data may begin to "suggest" the need for plans that would otherwise go unnoticed. Patterns may emerge from the data repositories that require attention and this in turn may lead to the spontaneous emergence of the need for solutions in the form of actions or plans.

This is not a far-fetched concept, since it is really how many city plans are born anyhow. Except when real-estate development pressures force a certain "reaction" on the part of city planners, many plans are "proactive" and reflect the overall "direction" in which the city would like to go. If negative trends are somehow noticed, or if citizen groups voice concerns or demands for a certain correction in the way the city is moving, plans are usually generated to counteract these negative tendencies. If the pattern of development is perceived as positive in one part of a city (or in a nearby community), plans are created to try to emulate the success stories elsewhere.

Having a serious critical mass of city knowledge at one's disposal, would probably invite exploratory analyses that would most likely generate ideas for corrective plans (in the case of negative patterns) possibly based on positive trends noticed elsewhere thanks to the same body of knowledge. Sometimes, planners may suddenly realize that they had actually misdiagnosed a certain urban condition or they may find the real cause of a problem whereas they had been attacking only the symptoms for years.

I have at least one example from my personal experience of a real case of "plan-demanding" knowledge, again from a real experience in Venice, Italy. It all started in 1995, when, under the auspices of UNESCO, we first began to study the quantities of deliveries made to each of the 125 islands that compose the city of Venice. This plan-demanded study was meant to quantify the amount of cargo that was unloaded onto each island from each of its perimeter docks. The purpose was to determine how much disruption would be caused to the cargo delivery system if and when a particular canal around the island was closed for maintenance, thus eliminating a number of docks for the cargo operations. The study purported to pinpoint critical areas that needed to be taken into account when the canal closures were planned, to

plan-demanded: cargo deliveries data

avoid isolating an island completely, thus forcing delivery personnel to surmount a number of bridges with loaded carts in order to make a delivery. The best sequencing of canal closures was thus arrived at, taking into consideration not only the effects on deliveries to local businesses, but also the amount of traffic that would be diverted to nearby canals when a specific canal was shut down for maintenance, which would in turn impede the flow of traffic and hence make deliveries on other perimeter canals more difficult. This was a successful project that led to some follow up studies in other areas of the city, commissioned by Insula S.p.A., which is the company in charge of making the canal closing decisions. Thus, plan-demanded information was turned into plan-ready information.

plan-ready: canal closure analysis

The plan-ready information that was generated by these projects led to the realization that there were in fact many cargo boats that were affected by these inevitable maintenance works. For instance, a specific island near the Rialto bridge was visited by about 100 cargo boats every day. What was even more interesting though was the realization that these 100 boats carried cargo that, by volume, would have fit easily in about 5 or 6 fully-loaded boats… The sequencing of canal closures was therefore made much more difficult than it had to be by some absurd inefficiency in the actual cargo delivery system. The problem, we quickly discovered, is that cargo in Venice is not delivered "by destination" but "by product". The "water boat" drops off cases of water in each of the islands, as do the "wine boat" and the "beer boat", and the "toilet paper boat" and so on. Each boat only drops off a few boxes or cases, and each boat visits many many islands every day. No wonder there was such a glut of boats around these islands!

plan-demanding: cargo system re-engineering

The discovery of the exact extent of the wastefulness at play in what was already known to be a sub-optimal system, transformed the plan-ready information into plan-demanding knowledge since a study was commissioned by the local boat "teamster" union (*Consorzio Trasportatori Veneziani Riuniti – CTVR*) to explore ways to improve the system and eliminate these gross inefficiencies. The study, conducted in the summer of 2001, resulted in a proposal for a central warehouse where cargo would be sorted by destination and delivered by only a few fully-loaded boats to only a handful of contiguous islands, in one of the 16 zones in which the city was divided. The project was awarded the WPI President's Prize as the best project of the year 2001 and the CTVR is currently negotiating the funding needed to implement the proposal and thus reduce overall cargo boat traffic and the consequent wake damage in Venice by over 90%.

CURRENT TRENDS IN URBAN INFORMATION SYSTEMS

top-down approaches

The municipal IT development paths, prevalent in the late 80's and early 90's, can be categorized in two distinct camps. On the one hand, there were big-league, top-down efforts that nevertheless suffered from a variety of technological limitations that only recently have begun to be resolved, such as limited processing power, narrow bandwidth, awkward (or non-existent) interoperability and an overall dearth of standardization. Parallel to those efforts, there was a growing number of scattered, haphazard, bottom-up Geographical Information System (GIS) approaches that popped up ubiquitously in public agencies all around the world. These efforts, due to their insularity, were able to sidestep many of the technological hurdles that hampered the success of their contemporary top-down approaches that had began to systematically record and manipulate spatial location, but suffered from a host of other problems, such as the almost complete lack of interoperability, a substantial redundancy of efforts and the limited scope and power of the applications that were produced.

bottom-up approaches

enterprise GIS

The more recent top-down enterprise GIS examples in San Diego, Singapore and Hong Kong are direct descendants of the earlier top-down efforts, but they are benefiting from much improved hardware and software platforms, which have ostensibly resolved many of the technical issues and have begun to integrate georeferencing and geoprocessing methods into "enterprise" Information System (IS) operations. These enterprise approaches seem to be the most appealing to today's public agencies and private businesses. Planning agencies are now attempting to develop fully-functional Spatial Decision Support Systems (SDSS) and Planning Support Systems (PSS)[13], mostly adopting a loosely-coupled architecture whereby data are exchanged through shared files, though tighter coupling is becoming more and more possible (though not necessarily desirable, in my view), especially between GIS and modeling packages.

technical advances and standards

Advances in Database Management Systems (DBMS), such the Structured Query Language (SQL) standard and Open Data Base Connectivity (ODBC), are making the interoperability of dabasases more and more seamless. Graphics and multimedia can now be intermingled with vector maps and alphanumeric data, through Object Linking and Embedding (OLE) standards as well as COM, DCOM and CORBA protocols, and thanks also to the customization capabilities provided by GIS-specific OCX and ActiveX tools (e.g. Mapinfo's MapX and ESRI's MapObjects) for the development of front-ends that can bring together a variety of data elements under a unified Visual Basic or C++ interface[14]. Collaborative Planning Systems (CPS) have been envisioned, and pioneered in our own PSS group here at MIT[15], which will make multimedia a more integral part of the planning process. Even the quality and accuracy of electronic basemaps has improved dramatically thanks to advances in Global Positioning System

[13] Yeh, pp. 882-884.

[14] I have personally been involved in several projects that produced these types of hybrid, multimedia interfaces.

[15] Schiffer, "Managing Public Discourse".

(GPS) technologies and also thanks to the improved ability to reconcile maps based on a variety of cartographic projections.

the web

The World Wide Web represents the next frontier in GIS development, with new possibilities emerging thanks to the advent of web-mapping packages such as ESRI's ArcIMS and Mapinfo's MapXtreme, though bandwidth limitations still limit direct interaction with server-based maps through the web. The current mode of operation still relies on the transfer of map images (in raster format) from the back-end server to the front-end client, though JAVA applets are making the actual client interfaces look and feel more and more like "real" GIS. Interoperability can greatly benefit from web-based map servers and appropriate use of metadata dictionaries in conjunction with "smart" web-enabled client applications, regardless of the hardware platforms and the operating system adopted.

a middle-out approach

In short, the needs and wants of municipalities, which have been computerizing many of their operations and may have been dabbling with bottom-up GIS applications for the last few years can now be met with the most recent advances in spatial management technologies which are not only affordable but also more suited to the new decentralized, "middle-out" approach to the spatial representation of urban features that will be the focus of my dissertation. I call my approach "middle-out" because it does not subscribe to the one-size-fits-all, centralized, top-down strategy that has recently gained some currency in major metropolitan areas, nor is it a mere fend-for-yourself, fragmented bottom-up tactic that, while useful to some agencies, remains largely unusable and unused by anyone outside the small circle of people who are directly involved with it. A middle-out approach would combine the best of both worlds by creating a loosely-coupled, distributed city knowledge system that is built gradually over time by a number of parallel efforts in a variety of city departments, all abiding to a overall coordinating strategy that assures compatibility and opens the door to interagency and interdepartmental sharing. My own research and experience seems to confirm that an informating approach that is neither truly top-down, nor merely bottom-up has a chance to be successful in the real world of municipal governance of urban assets. The current technological trends described above would make my approach much more feasible today that it would have been in the past. In particular, the loosely-coupled nature of web-based applications, and the overall architecture of the WWW provide a natural infrastructure for my middle-out approach which is now "ripe" for real world implementations.

pseudo- and proto- middle-out approaches

Some development paths being recommended today resemble this middle-out approach[16]. For example, the City of Cambridge, Massachusetts has begun an effort of this sort, by distributing GIS specialists in the main city departments under the orchestration of the MIS department, although that endeavor is still in its infancy. My middle-out approach would be more similar to the Digital Earth effort[17], but limited, at first, to individual municipal boundaries and to the agencies operating therein. Ferreira, in particular, has championed a variation of this middle-out approach when he proposed the use of lookup tables to correct on-the-fly the "stubborn"

[16] See for instance Campbell, *op.cit.* and Yeh, *op. cit.*

[17] http://www.digitalearth.gov/

standardization errors that regularly appear in municipal datasets[18], as well as (with Evans) when he discussed a more general approach to the "messy" technical and organizational issues confronting GIS today[19]. What these new methodologies have in common is a recognition that "GIS technologies are *not* divorced from the interplay of organizational life: rather they are subject to its vagaries and power relationships"[20]. A middle-out approach will not only simplify the more technical pitfalls of pure top-down and bottom-up approaches, but also promises a more gradual, hence smoother, and less traumatic path for the organizational transformations needed to ensure a widespread acceptance and a successful adoption of GIS technologies in municipal agencies.

automating place transactions

In fact, Geographical Information Systems (GIS) and DataBase Management Systems (DBMS) – while rather commonplace in today's city government – are scarcely used to systematically keep track of essential urban elements, such as roads, trees, sewers, etc. in an "automatic" fashion. Ad hoc or "implicit" knowledge is used instead to produce maps and datasets that feed the decision-making process on a need-to basis, case by case. Widespread informational lacunae exist despite the fact that many municipal activities leave a paper trail that would easily lend itself to automation. Roads are regularly re-paved, cleaned and cleared of snow, so someone is issuing work-orders or stipulating contracts for these services. Similarly, trees are bought, planted, removed and trimmed and paperwork is produced to make each of these actions happen and to keep track of the corresponding expenditures. Sewers, like many other components of the urban infrastructure, are subject to similar record-keeping procedures, plus they are also regulated and licensed. Seldom are these opportunities tapped into to promote the sort of "automation" that would lead to a more rigorous approach to informating urban maintenance, management and planning.

informating urban decisions

Recently, some city planning agencies have begun requiring that developers submit 3D CAD data in a standard format and, while similar attempts at a gradual accrual of computerized records from the ground up are being put in place in a variety of other municipal transactional contexts, we are still far from a genuine, systematic and coherent approach that will ensure that we are not simply replacing the old fashioned paper files with lots of disjointed computer files. My middle-out approach, on the contrary, is an attempt to promote a gradual, modular and methodical process of data collection and organization, predicated on the construction of a space-based "scaffolding" onto which every piece of data that is acquired is archived, thus creating a "useful" and "usable" infrastructure of city knowledge that will eventually perpetuate itself through automation, and will naturally feed into the informating requirements of urban planning.

Despite the fact that Zuboff's *In the Age of the Smart Machine* was written before the web, I think its main message remains as valid today as it was in 1988. If anything, the advent of the Internet and the World Wide Web may accelerate the centrifugal forces that are flattening out Zuboff's "concentric organization" and thus potentially exacerbate the conflicts

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[18] Ferreira, *op. cit.*

[19] Evans and Ferreira, "Sharing Spatial Information in an Imperfect World: Interactions between Technical and Organizational Issues".

[20] Campbell, A. J.. 1999. "Institutional Consequences of the use of GIS" in Longley *et al., op. cit.*, pp. 621-631.

between managers and subordinates. The technology itself, once again, is not the solution, nor the problem. But it may contribute to a more rapid transformation of the internal organizational dynamics of government agencies toward a "connected distributed"[21] *modus operandi*, that will enfranchise the citizenship as well as the front-line civil servants. This, in turn, may set the stage for a truly devolved informating "wholeness"[22], where managers and managed contribute together, "holistically"[23], to a middle-out approach for the management of urban affairs. The Internet and the WWW would certainly facilitate such an approach.

Finally, all of these innovative approaches may incrementally lead to "*a truly interactive, timely planning dialogue between neighborhood planners and city agencies – as well as* [to] *a mode of interagency* [and – I would add – 'intra-agency'] *coordination that might allow agencies to keep pace with one another*"[24] and with their public constituency. Once again, the interconnectivity provided by the WWW today makes this interactive approach all the more feasible and affordable, both for our cash-strapped public agencies and even for the less fortunate groups in our society.

[21] Thomas W. Malone, *Is Empowerment Just a Fad?* (1997)

[22] Zuboff's term.

[23] This term borrowed from Evans and Ferreira, "Sharing Spatial Information in an Imperfect World: Interactions between Technical and Organizational Issues", p. 458.

[24] Ferreira, *Information Technologies*, *op. cit.,* last paragraph.

RESEARCH QUESTIONS AND HYPOTHESES

The domain of inquiry of this dissertation is the collection, organization, integration, distribution and use of knowledge by government agencies for the development of actions related to urban maintenance, management and planning.

Research Questions

My primary research questions can be formulated as follows:

what is it and where does it come from?

? *What constitutes "City Knowledge"? What are the permanent and more dynamic elements that make up "City Knowledge"? Who creates, modifies, destroys or affects the elements that make up a city? Who decides which elements are worth keeping track of and which aren't?*

who uses it?

? *Who "consumes" City Knowledge? What are the common uses of it? Who has access to it? Who should or should not have access to it?*

is it truly useful or needed?

? *Is the accumulation and long term maintenance of city knowledge a worthwhile endeavor in principle? If so, why? Are there measurable advantages to be derived from the development of new municipal "Knowledge Infrastructures"?*

why hasn't this been done already?

? *What are the current technical, institutional and logistical obstacles to the accumulation of city knowledge? Can these hurdles be surmounted today? If so, how?*

how do we get it?

? *What realistic approach(es) can be used to accumulate city knowledge? What areas of urban maintenance, management and planning are more amenable to these approaches and why?*

how do we keep it?

? *How do we ensure that this knowledge is retained and maintained? Will the upkeep be feasible and cost effective? How do we avoid collecting the same data over and over again in the future?*

how do we share it?

? *What are the potential interdepartmental advantages or disadvantages to be derived by a sharing of city knowledge across agencies? What may be the implications of knowledge-sharing for urban planning? Will knowledge-sharing lead to the need for different approaches toward knowledge-gathering? If so, how?*

Research Hypotheses

Preliminary research suggests an initial set of hypotheses to begin to address the above questions, as described in the paragraphs that follow. It is important to note that this research will be based primarily, if not exclusively, on cities from North America and Europe.

city knowledge

- Cities constantly produce and consume information. Unfortunately, the paper-trails created by numerous work-order transactions are not sufficiently captured and shared.
- As a consequence, information is not readily available when needed even though it may exist somewhere within the municipal bureaucracy.

- Day-to-day actions about maintenance, as well as long-range strategic decisions about the direction of development of a city are all based on city knowledge.
- This knowledge is not usually as complete, encompassing or up-to-date as the decision-makers or knowledge-users would like it to be.

obstacles

- Technical and institutional hurdles have prevented cities from embarking in systematic collection and organization of city knowledge.
- The real or perceived technical reasons that existed in the past are no longer a "real" obstacle.

standards

- Standardized reference systems that allow parallel development of departmental information systems are not in widespread use in U.S. or European cities.
- Standards for the coding and sharing of information are also rare in these cities.

jurisdictions

- City departments have no clear awareness of what department is keeping track of what at any particular time.
- Jurisdictions ("ownership") over slices of the public urban realm can be determined unequivocally for most day-to-day government activities.

automation

- Computer automation, if adopted at all, is generally used to organize data for administrative, regulatory or fiscal purposes.
- If any multi-user system exists in the city, it is probably connected to these fiscal, regulatory or administrative aspects (like taxes, permitting, payroll, etc.).
- Municipal maintenance and management personnel would benefit from automation of the processes they currently already engage in.

spatial detail

- Spatial characteristics of data are shortchanged in the majority of current systems. At best, addresses are used to keep track of location.
- Space, on the other hand, can be the "unifier" among all the various datasets held by a number of municipal departments.

bottom-up GIS

- GIS adoption consists of mostly bottom-up efforts in a minority of city departments
- There exist a great deal of duplication and a variety of versions of the same layers, without clear ownership of the originals in many cases.
- Updates to the layers are sporadic and uncoordinated, with only rare exceptions.

top-down GIS

- When top-down enterprise GIS approaches have been attempted, progress has been slow and resistance has been great.
- These approaches are expensive and funds tend to dry up before major achievements can be attained.

plan-demanded data collection

- Cities spend a measurable and often considerable amount of money to commission studies from consultants for the purpose of collecting (and analyzing) data that are needed in order to make some imminent decision about an issue of immediate importance.
- Once the data are collected and the reports delivered, the decisions are taken and the data are (mostly) forgotten.
- The same types of data are collected over and over, even for items that do not change dramatically over time.

middle-out approach

- After having assigned clear jurisdictions, multiple, parallel, yet coordinated, efforts by several departments can gradually produce

reliable, flexible and sharable city knowledge that can become a permanent feature of the city infrastructure.

- Many elements of the urban realm are permanent and change very slowly, thus requiring a one-time-only investment in the initial data-gathering, mapping and database archival

updates

- After an initial effort to capture the status-quo of the current inventory of permanent, physical elements of the city, city knowledge can be kept up-to-date by capturing transactions and recording the slow changes as they happen.
- Data can be kept up-to-date through contractual mechanisms and by maximizing the informational return of any maintenance or management activity that brings personnel in direct contact with elements of the urban realm.
- Transaction-based detail about place can be built into IT (E-government) automation.

inter-departmental collaborations

- Administrative databases are usually not accessible outside the department in charge.
- Different departments already have to share information with each other for a variety of institutional reasons.
- Streamlining of the sharing and collaboration process would probably be welcomed by those involved.
- The cost of client-server and multi-user systems is becoming more and more affordable even for smaller municipalities.
- The ubiquitous presence of the internet, as well as current trends in metadata, warehousing and federated systems make sharing of alphanumeric and spatial data across departments more feasible than it has ever been.

RESEARCH METHODOLOGY

My overall research design is intended to address the main research questions listed above through a series of logical steps, to be carried out more or less in parallel, aimed at achieving the following primary research objectives:

Research Objectives

- To characterize the constituent elements of city knowledge and identify the municipal agencies that are the main producers and consumers of such knowledge.
- To determine the relevance, feasibility, usefulness and value in the creation and maintenance of a "knowledge infrastructure" alongside the more traditional infrastructure components of a city (transportation, utilities, etc.).
- To identify the practical methods, the information technologies and the organizational strategies that may be widely adoptable by public agencies to collect, organize and apply "City Knowledge" to urban planning and management.
- To assess not only whether this knowledge can be advantageous in satisfying the ongoing requirements of day-to-day city operations, but also whether it can be profitably used as a tool for the development of decisions, plans, policies and actions that in turn will affect urban maintenance and management, as well as city design and development.
- To investigate how a coordinated effort across different departments could be cost effective by minimizing data-collection expenditures and reducing duplication and how the sharing of city knowledge could improve the overall efficiency and efficacy of the entire municipality.
- To explore the implications of this new infrastructure, not only for the careers of planning practitioners, but also in the potential (re-) structuring of government organizations, and in the creation of private enterprise approaches for the actual implementation of such infrastructures.

Literature Review and Background

Municipal Information Requirements

First of all, I plan to identify the primary informational requirements of a sufficiently rich subset of the areas of city operations which are most ripe for a wholesale "informating" effort, to demonstrate the desirability of reliable, specific, up-to-date (and updatable) urban data for municipal maintenance, management and planning activities. I will prepare for this step through a thorough initial review of the existing literature on City Management. I will also tap into my own personal experience and insight and on my numerous contacts within municipal governments both in the U.S. and in Italy. Possible field methods may involve the compilation of "free lists"[25] by selected city officials as a starting point, followed by focus groups and/or structured interviews with heads of various departments and divisions to whittle down the initial lists.

[City Management literature]

[free lists]

[focus groups]

[structured interviews]

[25] Bernard, H.R., *Research Methods in Anthropology*, p. 282.

Municipal Practices

[literature]

[interviews]

[telephone survey]

Secondly, I plan to confirm the proposition that municipal governments do not, as a rule, approach city knowledge in a systematic way, except when they are somehow forced to by administrative, regulatory or revenue-generating circumstances. In conducting this piece of research I will again start from the literature. This will be augmented with specific examples from the aforementioned interviews with city officials. If needed, I may consider a randomized telephone survey of municipal department heads to get an adequate factual foundation for my claim.

Obstacles and Hurdles

[literature]

[telephone survey]
[interviews]

Thirdly, I will try to identify the underlying institutional, psychological, organizational, technical, personnel and/or financial reasons for this lack of a systematic approach to city knowledge accumulation. In addition to reviewing the literature on these subjects, I will include questions prodding these issues in the aforementioned telephone surveys and face-to-face structured interviews. This is the only explanatory component of my research, which is otherwise mostly descriptive and exploratory.

Financial Aspects

[literature]

[municipal records]

[case studies]

Fourthly, I will try to quantify the financial resources that are devoted to ad-hoc, *plan-demanded* data collection on a yearly basis, to support my claim that a systematic approach would, in the long run, be not only operationally useful, but also economical and affordable. I will explore the possible existence of studies on government expenditures for technical consulting services to try to get a quantitative measure of the level of funding devoted to *una tantum* data collection. I will try to obtain more specific figures in the course of the multiple embedded case studies[26] described below. These quantitative data will help make the case for a distinct advantage to my proposed approach to the cumulative, distributed accrual of city knowledge.

Overall Strategies

[interviews]
[archival records]
[questionnaires]

standards
sharing
automation

Most of the exploratory and descriptive phases will be based on structured interviews, historical and archival materials, and possibly on questionnaires. I will also try to tease out information about rival approaches to urban data collection and management, i.e. the "top-down" and "bottom-up" strategies that have prevailed in municipal contexts for the past two decades. As part of this study, I will investigate the inner workings of the different departments and try to evince what, if any, overall knowledge management strategy is in place to tie them together. I will also explore the use of automation to informate the municipal government, especially in the realm of permitting and regulation and in revenue-generating contexts.

Case Studies

Finally, I will conduct a multiple case-study on two different cities in two different countries (Boston, MA and Venice, Italy)[27] to confirm that the plan-demanded *modus operandi* predominates even in widely different government milieus and across international cultures. I may also include a case at a different "level" of government, above the municipal realm (i.e. State or Federal) to demonstrate that the same issues exist vertically as well as horizontally. The case studies I intend to conduct are of the so-called

[26] Yin, R.K., *Case Study Research*, p. 54.

[27] I may add other cities, especially if I should discover any municipality whose approach to knowledge-building approximates my own.

building blocks

"embedded" type (Yin) since they will focus on the municipalities as a whole, as well as on the target departments and their sub-units such as divisions, all the way down to individuals. Multiple, convergent methods of data collection will be used at the different levels of the embedded design to address all of the research questions. From these tasks, I plan to distill a minimum set of building blocks of city knowledge that could be applicable in any municipality, identifying both the required GIS layers and the corresponding datasets.

proof of concept

prototypes

effectiveness
organizational implications

assessment

Subsequently, I will select two departments with similar roles in both Venice and Boston. I will then test my middle-out approach to city knowledge acquisition and interdepartmental sharing in both cities, by conducting a real-world experiment of my concepts through the implementation of small-scale prototypes of my proposed knowledge infrastructure in each department. I will also simultaneously identify and resolve the intrinsic institutional and technical issues in collaboration with the parties involved, in order to arrive at a realistic implementation strategy across the two departments in each of the two cities. Through this experiment, I will be able to evaluate the operational effectiveness as well as the organizational implications of a middle-out implementation by monitoring the progress of my prototype applications and by developing assessment tools to track the transformation of data into information and then into urban knowledge that ultimately will affect management or maintenance activities in the real world (Figure 2).

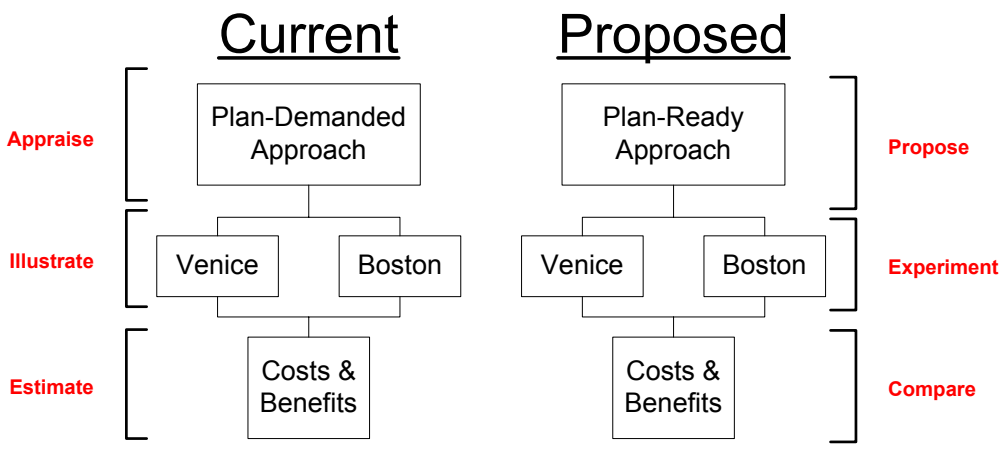

Figure 2. Assessment of the value of the "middle-out", "plan-ready" approach[28].

benefits vs. costs

impacts

In particular, I will quantify the costs and benefits associated with the middle-out approach by:

- Assessing the Impact of the prototype infrastructure on day-to-day maintenance and management activities
- Assessing its Impact on organizational structure and on individual staffers

[28] The red words in Figure 2 represent the research activities that I plan to carry out in this phase of my research.

- Assessing its Impact on planning and decision-making activities

implementation paths

In the course of my case-based experiment, I will pay particular attention to the pathways that promise to most easily informate the planning process and will try to detect any signs that may indicate that "plan-ready" knowledge may become "plan-demanding".

Analysis and Evaluation

All of these research activities should allow me to test the practicality of key examples of data encoding, feature layering, interdepartmental cross-referencing, transaction-recording and data maintenance – the key elements that will determine what value added can be expected from the utilization of recent technology in a "middle-out" strategy, and how effective such an approach is in tracking data that suits urban planning and management as well as operations. This analysis should in turn enable a rich discussion and testing of my urban knowledge ideas which should lead me to produce a final set of guidelines for the creation of full-scale, modular, middle-out knowledge infrastructures that will not only serve the immediate needs of urban management and maintenance that municipal departments are directly responsible for, but will also foster longer-range planning activities across department boundaries.

guidelines

organizational implications

I will also investigate the repercussions that this informating strategy may have in the composition and structure of these departments, which may be reshaped as a consequence of the proposed construction of a distributed knowledge infrastructure. I hope to demonstrate how a middle-out approach will entail only minor adjustments to the normal hierarchy of a public agency and should thus be less threatening to the "status quo" and therefore more acceptable to staffers and managers than other, more disruptive approaches that could instead upset the entrenched organizational equilibrium.

exportability of approach

The final result will consist of an integrated – technical as well as organizational – approach that can potentially be widely applied to certain types of departments in a variety of municipalities, and which could guarantee both the day-to-day efficiency of maintenance, management and planning operations, as well as the long-term efficacy of overall municipal functions. In other words, these case studies should allow me, in the end, to suggest "middle-out" mechanisms, both technical and institutional, that may be put in place to create the backbone of a self-perpetuating knowledge infrastructure in municipalities worldwide.

TENTATIVE DISSERTATION OUTLINE

RESOURCES, AGENDA AND TIMETABLE

RESOURCES

The principal resources that I will utilize for my dissertation are the existing scholarly and professional literature on topics of relevance to my study and the experience and insight of city officials both in the U.S. and in Europe.

AGENDA

The research agenda from this point on is as follows:

May 2002	PhD Colloquium, Set up U.S. Interviews and Case Study
June-August 2002	Venice Interviews and Case Study, First Draft of Dissertation
August-September 2002	Literature Review and Background, U.S. Interviews, Case Study
September 2002	Telephone Survey
October 2002	Trip to Venice, Case Study review, Follow-up interviews
October-December 2002	Analysis and Evaluation of Case Studies, Final Draft
January 2003	Trip to Venice, wrap-up of Venice case-study
February 2003	Final revisions
March 2003	Completion

TIMETABLE

The development of the dissertation document will occur according to the following timetable:

Chapters 1,6, 8	August 2002
Chapters 2-5, 7	Draft: August 2002, Final: October 2002
Chapter 10, 11	December 2002
Chapter 9	January 2003
First Draft	August 2002
Second Draft	October 2002
Third Draft	December 2002
Final Draft	January 2003
Completion of Thesis	March 2003

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