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File formats for very large maps and digital preservation

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Abstract

Digitizing very large maps is a real challenge. Since many years, wavelet compression and multi-resolution formats are the best technical solution, but only recently cultural heritage communities look to the JPEG 2000 format as a valid choice in the digital preservation.

Two concepts are crucial in this important change: first, this format can be "visually lossless", although digital representation of the object changes after compression; second, compression is not a danger itself in preservation, but can be instead an improvement of the file robustness.

The paper deals with several issues involved in the use of JPEG 2000 in map digitization: research and tools concerning file robustness, metadata extraction, special scanners and applications to make available very large maps on the web, GIS implementation on historical maps.

1. Large maps and file formats

I will try first to provide briefly an overview of the efforts made in more than 10 years, to digitize old maps, with some specific information about experiences that have been made in Italian State Archives. We can assume that the problem can be split in two parts: digital capture and digital information management.

1.1. Increasing digital capture

Digitizing documents has often been a trivial work, until we were faced with maps. Although at the beginning we were satisfied by making a scanning of a photo of the original, and including it in the catalogue, the development of digital libraries pushed our efforts – and technology at the same time – to more advanced solutions, trying to provide not only a visual description, but a digital surrogate of the original that could be accessed in a virtual context.

Now, digitizing very large maps is a real challenge from a technical point of view: there are limits both in the optic, and in the electronic components and at the same time in the general architecture of a scanning device. In the middle of the nineties the Library of Congress Map Division adopted a prototype of flatbed scanner (Tangent) that was able to provide a 300 ppi resolution for sheet maps of A1 format[1]. A few years after some roll scanners were available from Colortrac, Vidar, and other firms then employed three camera + CCD sensor units, reaching 300 ppi on maps that were larger than A0 and that could be very long.

It is often discussed what "high resolution" means in this field, as this is a typical "technology driven" concept: the "high resolution" in current opinion is often the highest resolution that commercial scanners can provide at that moment. In my experience the only meaning of the expression is relating to the user need(s): for digital materials to enter "into the daily work of the research community"[2] they must be used and managed as we do with originals. Several uses, several quality levels: illustrative, readable, palaeographic, enhanceable. So we do not have to wait for a more enhanced technology if all user needs(s) are satisfied: some years ago Tony Campbell, the curator of MapHist website, wrote me that he reserved the term *high resolution* for those cartographic images where every name is legible - or, better, we would assume that in *high resolution* every *sign* is legible, as cartography deals with written *and* drawn information. In my experience – but since 1996 there is a well known literature about these topics[3] – a 300 ppi resolution is enough for drawn maps, and a 400 ppi resolution is needed for printed maps.

I will not discuss in this paper about colour resolution, because in my opinion a 24 bit file is enough to represent cartographic documents. As you know digital cameras, scanners and file formats implement a more advanced bit depth, up to 48 bit: but this option seems to be more oriented to the digital representation of reality, or of traditional photographic materials, where an extreme accuracy in capturing the continuous tone image is needed. This is not the case of our historical maps, where colours give crucial information, but the difference, and not the continuous range of reds or green is relevant.

In the State Archive of Rome we began digitizing some of our map series and collections in 1997, using a Colortrac scanner[4], and the same happened in other Italian State Archives in the context of the "Imago project"[5]. Maps were a crucial issue of the project because we had serious problem of conservation – original maps were too often accessed – and traditional photograph techniques never reached a final solution for virtual access.

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[1] David Yehling Allen, *Creating and Distributing High Resolution Cartographic Images*, «RLG Diginews», 2/4 (15 agosto 1998): http://worldcat.org/arcviewer/1/OCC/2007/09/28/0000073852/viewer/file1145.html#feature . See also http://pubs.usgs.gov/of/2002/of02-370/cahill.html

[2] Manfred Thaller, *From the Digitized to the Digital Library*, D-Lib Magazine, February 2001, Volume 7 Number 2: http://www.dlib.org/dlib/february01/thaller/02thaller.html .

[3] James M. Reilly e Franziska S. Frey, *Recommendations for the Evaluation of Digital Image. Produced from Photographic, Microphotographic, and Various Paper Formats*: http://memory.loc.gov/ammem/Ipireprt.pdf .

[4] The roll scanner we used in the late '90 the State Archive of Rome was a Rigoli/Colortrac http://www.colortrac.com . This kind of scanners used 3*5.000 and then 3*7.500 CCD sensor can also be adapted to a glass table to scan registers, as for the SMA scanner: http://www.sma-edoc.com.

[5] A description of Imago Project in Italian State Archives is in P. Buonora, *Digitization and online access strategies/ Numérisation et stratégies de l'accès en ligne*, International Congress of Archives, Vienna 21-29 August 2004, available at: http://www.wien2004.ica.org/fo/speakers.php?ctNv1=48&ctNv2=&IdSpk=388&AlphSpk=B&p=3&SpkV=2.
For some more attention on cartography, see ID., *Digitalizzazione e accesso on-line per la cartografia storica*, in *Un accesso migliore è possibile … verso l'integrazione delle risorse informative per l'architettura e l'urbanistica*, Atti delle ottave giornate di studio del CNBA, Venezia, 28 – 31 maggio 2003 (I quaderni del CNBA, n° 7), edited by Laura Casagrande, Serena Sangiorgi, Pierre Piccotti, Venezia CNBA - Casalini Libri, 2005; available at: http://www.iuav.it/CNBA/Giornate-d/2003-Le-Ot/Abstract--/Buonora.doc_cvt.htm

But the problem of map dimension in the archives is, generally speaking, more critical than in libraries. Printed maps have the physical limit of a copper plate, while drawn maps may be very large, when several paper sheets are joined together: this happens very often in the archives, when we are dealing with cadastral series in large rolls, or with long maps created for water management and building roads.

This need of a very special device to capture large roll maps of the Italian Archives pushed a small company in Rome (Metis) to create a prototype called DMC (Digital Macro Camera), that can reach a 250 ppi resolution on a surface of 126 x 104 inches. The original is placed behind and pushed softly to a very large vertical glass plate, and a mobile sinchro-light blade follows the scanning. The camera has a unique optic, but the 10.000 CCD sensor makes three scannings, matching them in a unique file up to 3.3 Gb, up to 38.000 x 31.000 pixels[6].

Thanks to this device, in 2005 the State Archive of Rome added a new relevant digitized asset to its online access service: the original big roll maps of the Roman region, from the Gregoriano Cadastre, were scanned in one single file. Most of the about 500 cadastral maps were scanned in a single file, and only a few of them were so large to require a double scanning; a mosaic technique can be applied in these cases, but requires a considerable effort in time and accuracy for matching the two images.

The Gregoriano Cadastre is the first modern cadastre of the entire Pontifical State: it was promoted by Pio VII in 1816 and activated Gregorio XVI in 1835. It was made by the *Presidenza generale del Censo*, with the same technique that was adopted during the Regno d'Italia (1805-1814) in making the napoleonian cadastre in the Legazioni province (Bologna and Romagna) and in the Marche region. Two copies of it were made, one was kept in the *Presidenza generale del Censo* (now at the State Archive of Rome), one in the local offices of the Cancellerie del Censo (now in several State Archives of the ancient Pontifical State).

It is composed by three related series: maps (1:2000, in one large roll in Rome, in single sheets in the local version), reduced maps (1:4000 o 1:8000), owners registers (*brogliardi* or *sommarioni*). The roman version of the collection is generally the most complete, original and well preserved comparing to the one in the local archives, where originals were often remade during more than 100 years. In other words, this cadastre offers the more complete vision of the land and urban shape relating to ancient Pontifical territories.

1.2. File size problems

The increasing file size due to the enhancements of capture devices produced other problems. In 1997-1999, when we scanned long maps (up to 2 meters) with our Colortrac, the technical limit was not the scanner resolution of the map size, but the file size that could be managed by the scanning software (1 Gb) and Photoshop (500 Mb).

Also today, file size limit for operative systems is 4 Gbytes and if you want to perform some digital imaging task on a large image file (brightness, tone level, sharpening) the best choice is to make it with the scanning software, without using a digital imaging program. However, after creating a large file the problem is how to manage it, both in a LAN and in a web context. Not all visualization free tools are able to manage a file size greater than 1 Gb, and the problem is still more complicated in a web context: how to send to the user an image so large with the speed limitation of the Internet?

This problem in the beginning kept cartographic heritage apart from the Digital Library world, where only normal book pages and small archival documents were available. Visualization tools involved a simple download of the file, or the download of the image file together with

[6] http://www.metis-group.com/ENGLISH/PAGES/MAIN.htm . Metis DMC was first successfully employed on very large format maps of the State Archive of Turin.

some java applet to visualize it on the client computer, allowing some interactions by the user (rotation, magnification)[7].

For cartographic archives a first solution was splitting the full image into a mosaic, and let the user download only one portion each time[8]. A successive step was implementing software to make an image server work in interaction with the clients on the web: the file was not downloaded by the client – it would take too long for large digital images – but it is uploaded in the server memory and the required portion/magnification of it is interactively delivered on request. To make it work, some programs have been implemented to build a "pyramid" of different resolutions starting from the full resolution file and producing several further reduced resolutions up to a thumbnail image.

These applications can generate a pyramid of resolutions, in batch or by-the-fly. Among the first solutions of this kind implemented I can mention the State Archive in Turin[9], or the Ancient Cadastre of the Dèpartement de la Mayenne in France[10], but this approach became typical and very popular in Zoomify[11], which is based on pyramid of tiles of JPEG files. More recently also Tiled Pyramidal TIFF format was implemented by an open source software - IIP Image[12]. Making a Pyramidal TIFF does not reduce storage problems through compression: on the contrary produces bigger files than the original TIFF image. Nevertheless, several State Archives in Italy opened this year their web access services on cartographic collections integrating an IIP Image software with a finding aids management system: Trieste[13], Venice[14] and Genova[15].

1.3. Multi-resolution formats

All the cases above are dealing with a multi-resolution approach based on what software does with traditional formats (JPEG or TIFF), not with wavelet formats, which involves a different kind of digital image/object. The Tiled Pyramidal TIFF format for instance seem to be a compromise for those who want to provide access to their maps online, but do not trust any kind of compression for high quality images.

The reasons for this mistrust in image compression was examined last year in a paper on JPEG2000[16]: basically, people think that any compression is a loss of information. The reason is that they see the digital image as a sequence of numbers, while it is at the same time – as any image is – a perception of reality that depends on our senses (as Galileo explained in the *Saggiatore*). As our sight is more sensible to luminance signal and less to chrominance, this component of the image can be easily compressed – i.e. represented with less accuracy in its mathematical expression – still being "visually lossless". No difference could be *perceived*. By the way, IIP Image announced that also JPEG2000 format will be supported in the near future.

[7] An example of this kind of software is ViewTIFF by Acordex (http://www.acordex.com/vtj/index.html), that was used in 2000 by the Florence State Archive to provide virtual access to the documents of the fond "Mediceo Avanti il Principato": http://www.archiviodistato.firenze.it/Map .

[8] See British Columbia cartographic records: http://www.bcarchives.gov.bc.ca/cartogr/general/maps.htm .

[9] The web access service was available at http://ww2.multix.it/asto/ricerca.htm , but at the moment the Archive is editing a new website: http://www.archiviodistatotorino.it/User/index.php .

[10] http://www.lamayenne.fr/?SectionId=400 .

[11] See in the FAQ section http://www.zoomify.com/support.htm "what is Zoomify?".

[12] http://iipimage.sourceforge.net/images.shtml

[13] Catasto Franceschino: http://www.hdue.it/AWASTrieste/login.jsp

[14] Progetto Divenire: http://www.archiviodistatovenezia.it/divenire/home.htm .

[15] Progetto Topographia: http://www.archivi.beniculturali.it/ASGE/cartografia1.pdf .

[16] P. Buonora, F. Liberati, *A Format for Digital Preservation of Images. A Study on JPEG 2000 File Robustness*, on D-Lib Magazine, July/August 2008.: http://www.dlib.org/dlib/july08/buonora/07buonora.html

Of course correct compression implies sophisticated techniques: the continuous tone image (color or grayscale) is eventually tiled in parts; each part is decomposed in a YCbCr color space (Y is the luma, or the brightness in an image, Cb and Cr are blue and red chroma components); pixels in each canal are de-correlated by a mathematical transform separating high frequencies and low frequencies of the signal in several bitplanes. This means that the relevance of the information or *energy* (low frequencies) concentrates at certain bitplanes and that other bitplanes (high frequencies) can be easily compressed.

Mathematics is very relevant in this issue. The function to transform data (i.e. decorrelate adjacent pixels) was in the old JPEG an orthogonal transform, the discrete cosine transform (DCT); further developments in the JPEG committee[17] agreed to a new compression approach, based on a frequency transform and upon new mathematic algorithms called *wavelets*. The results of these efforts are amazing: it's impossible to perceive any difference in between an original high quality image in TIFF format and its version compressed 20:1 (color) or 10:1 (grayscale) with wavelet techniques.

Unfortunately, it took many years to make an agreement for a new open standard. Firms were competitors for proprietary wavelet formats, and would not lose their market. At the end of the nineties at least three wavelet formats had a significant spread: ERDAS ECW[18], Lizardtech MrSID[19], Centrica XL Image[20]. ERDAS-ESRI was a leader company for GIS (Geographic Information Systems), as well as Lizardtech, that had nevertheless applications in the Cultural Heritage (Library of Congress); Centrica is a small Italian firm in Florence, and worked managing digital imaging in some important museums. Following the Library of Congress Map Collections experience in the American Memory project, also in the State Archive of Rome a virtual access service was opened on the web in 2002, converting our digital asset into MrSID format and using Lizardtech software[21]. It must be said that JPEG2000 became a *de jure* ISO standard in 2002[22], but it took several years after to make it a *de facto* standard[23].

As well as for visualizing locally a JPEG2000 high resolution image, captured from a very large map, delivering it on Internet is not a trivial task: I mean items as the roll maps of the Roman region we scanned in 2005 with Metis DMC, that produced a file size up to 3.3 Gb. At the moment, the only way I know is to use some professional image server software as Lurawave JP2 image content server, by Luratech[24], or the Lizardtech Express Server that was used by us in 2007 to provide access online to these roll maps[25]. Basically, we need a server with at least 4 Gb RAM available and an image server software that fill and clean a cache memory configured on fast hard disks.

2. Preservation

The argument that no difference could be perceived between an original TIFF file and a wavelet compressed file encouraged the idea that also a compressed format could be a format for

[17] http://www.jpeg.org/
[18] http://www.ermapper.com/
[19] http://www.lizardtech.com/
[20] http://www.xlimage.it/
[21] http://www.cflr.beniculturali.it/Imago/English/index.html
[22] Editor's Interview: Jpeg 2000. Dr. Daniel Lee, ISO SC29/WG1 (Jpeg), in RLG DigiNews, vol. 6/6, December 2002. http://digitalarchive.oclc.org/da/ViewObjectMain.jsp?fileid=0000070519:000006287816&reqid=24150#interview.
[23] A detailed analysis of related discussions, documents and bibliography can be found in my D-Lib article mentioned above.
[24] https://www.luratech.com/products/imaging-solutions/lurawave-jp2-image-content-server.html
[25] http://www.cflr.beniculturali.it/Patrimonio/Archivi/ASRoma/ASR_CatGreg_Agro.php

preservation[26]. This proposal has to face another objection, which sounds like this: "a compressed file is a more complicated digital object, *ergo* it is less robust to bit error occurrence and more difficult to maintain". I will now try to discuss these issues.

2.1. Storage issues

When we digitize thousands of large maps in high quality, the impact of our activity on the storage side is very relevant. In the late nineties we had only CDs and juke-boxes, and storing a TIFF version at 300 ppi of thousands of large maps was not so simple. The ones that made it are faced today with hundred of CDs, with a 2-4% on unreadable disks: I have to confess honestly that my choice in 1999 in the State Archive of Rome was to compress – with some accuracy – in JPEG and give up keeping the original TIFF, that in our case would have taken 7-8 Tb of storage.

A solution seemed to be the lossless option of wavelet compression[27], where information is also not lost from a mathematical point of view: but who cares if we simply compress in 2:1 ratio, when we are dealing with so many Tb? On the other hand, wavelet "lossy" mode allow an optimal ratio compression 20:1 for color images, because, as we know, chrominance signal can be better compressed than luminance; this also means that a color capture is encouraged versus a grayscale one, that can be only compressed in a 10:1 ratio.

As for storage devices itself, an up-to-date technical solution today involves both a generous disk-array device and an LTO unit to backup. Optical media that were the only chance of massive storage some years ago are today more a problem than a solution[28], and can be employed only to transfer or deliver third copies of the files to the users. I would stress that maintaining digital assets online – or easily up-loadable online - on our systems is the only way to assure a correct strategy for digital preservation, as we will see further discussing about checking file integrity.

2.2. File robustness

Moreover, wavelet approach in JPEG 2000 implemented some features that were just options in the JPEG standard, or some new features that make the file format more "robust", i.e. suitable for preservation.

Frequencies transform made by the wavelet algorithm in JPEG 2000 is always *progressive*: you can see the image appearing blurred and becoming sharper, as the successive high frequency levels are de-compressed and added to the image representation. This also means that in case of data failure you will never see, as happens in corrupted JPEG images, a first part of the image and then a black/grey space, because the sequential decoding found corrupted bits.

In the JPEG 2000 – or in others using wavelet compression – crucial information is concentrated in a main header and eventually in tile headers, containing metadata about image portions. A random error is always possible when we store Tb of data, but statistically it will involve the *body* of the file, and not the header. It happened to me, migrating my MrSID maps to JPEG 2000, to have some failures: two original MrSID images were corrupted, but only a

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[26] Robert Buckley, *Jpeg 2000 - a Practical Digital Preservation Standard?* Technology Watch Report, Digital Preservation Coalition February 2008. Available at http://www.dpconline.org/docs/reports/dpctw08-01.pdf .

[27] See (in Italian only) F. Lotti, *La qualità delle immagini nei progetti di digitalizzazione*, in « Digitalia », dicembre 2006, pp. 22-37. http://digitalia.sbn.it/upload/documenti/digitalia20062_LOTTI.pdf

[28] See OptiMA (Optical Media Analysis) project reports http://www.cflr.beniculturali.it/Progetti/OptiMA/Optima.php .

very small portion of these very large maps had lost information, and was easy to fix the problem, as all the rest of the image was perfect.

This experience – and some suggestions from Manfred Thaller – gave us at the Digital Laboratory of the ex-CFLR (Centre for Reproduction of Italian State Archives) the idea of enhancing JPEG 2000 robustness by making a tool to backup the main header (which takes only a few percentage of the file size), to check its integrity in time and eventually restore the correct header in the file. We called it FixIt! and it is possible to download it from the Laboratory website[29]. This strategy allows us to face also the eventuality of an error occurring in the header.

The problem now becomes file robustness itself, regardless of the crucial part of the header, comparing different formats. At the Digital Laboratory we developed an experimental testbed using a Kodak set of standard images and introducing random errors in TIFF, JPEG and JPEG 2000 versions of the files – excluding JPEG 2000 main header[30]. The results were that, augmenting bit error rate, JPEG crashes first, then TIFF get corrupted (its structure causes the loss of a whole line when the beginning bit is corrupted), and finally JPEG 2000 has some failures, regardless to its lossless or lossy mode.

2.3. Preservation tools

Our FixIt! is only one of the tools we have to adopt a digital preservation strategy for significant assets of digitized maps. If we consider that we store Tb of data, it is evident that checking in time integrity of the files cannot be done by opening each image with a viewer, and looking if it is corrupted or not. Neither a browsing, massive tool will help if it opens only thumbnails: the thumbnail is only a portion of the file, not the real full resolution image contained in it, and we may have a perfect thumbnail with a corrupted image. All the work of checking integrity must be done automatically, in batch, and made in every crucial step of the image production until the transfer to the final storage; after that it must be repeated in time, because storing Tb of data some failures are the rule, not the exception.

Two approaches are used to manage this scenario. First, after the image has been produced and quality controls have been done, we must be sure that the file is coherent with its standard in all its parts, i.e. that a TIFF file structure is integer and has all its syntactic elements in their places. This work can be done with the JHOVE (JSTOR/Harvard Object Validation Environment)[31] free tools. The Digital Laboratory adopted the JHOVE JPEG 2000 module and suggested some enhancement for massive validation offline: JHOVE modules work checking file syntax on a schema which is usually provided online by Harvard University Library.

When we know for sure that images are good, and file syntax and structure are coherent with file specifications, we can limit our work to check if any bit changement/corruption occurred in time. Any operative system or device use a checksum technique to assure data integrity, but there are specific approaches for mass storage, that goes from simple free MD5 (Message-Digest algorithm 5)[32] utilities to the integration of MD5 routines in the storage management, as in the Sun Modular Datacenter recently created for Internet Archive[33]. However, MD5 will not tell us anything else than some bits are changed: after that we will have to apply again more sophisticated ways to fix the problem, as JHOVE or our FixIt! tools.

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[29] http://www.cflr.beniculturali.it/Progetti/JPEG2000.php
[30] See all experimental results on the D-Lib article mentioned.
[31] http://hul.harvard.edu/jhove/
[32] http://en.wikipedia.org/wiki/MD5
[33] http://www.sun.com:80/featured-articles/2009-0325/feature/index.jsp

2.4. Geo metadata

Metadata are another crucial issue for preservation, but discussing it in this paper would take too long. But let me focus on a two topics.

First, if we choose to compress the original file, any single step in the capture and elaboration of the image must be documented in metadata: if a RAW or TIFF file is modified and then converted in JPEG 2000, we may keep only the final JPEG 2000 file, but we have to store the TIFF metadata concerning the digital imaging operations performed. This can be done using section 10 "change history" of NISO-MIX metadata standard.

Secondly, let's consider geo-metadata in respect to file formats. A cartographic item is retrieved not necessarily using an author/title approach, but also searching for something that refers to the place described[34]. Indexing methods may use a controlled list of place names and any kind of spatial/thematic classification of those places, but if we deal with geodetic cartography we may use geographic coordinates, also in a traditional catalogue. This opportunity convinced the Italian BDI (Biblioteca Digitale Italiana) group for "Guidelines for the digitization of cartographic materials" to include geographic coordinates in the basic description elements, whenever possible[35].

With respect to our file format issues, it is very important that the geographic coordinates could be stored in the file and managed as metadata, and this is the case of JPEG 2000, as this file format was born mainly in the geographic information context. TIFF for instance has a Geo-TIFF version where geo-metadata are stored externally to the image file. These geo-metadata have both a descriptive and a technical relevance, as the programs that compare two geo-referenced maps use them to overlap, tile and zoom visualization windows.

Nevertheless, it must be clear that when we geo-reference the digital image of an historical map, morphing it on the contemporary cartography, we create a digital object quite new in respect to the original copy: so our politics in the State Archive of Rome is to distinguish clearly between virtual access service to our cartography and other information systems built using the same cartography, geo-referenced and adapted to other needs.

2.5. GIS: Building on cultural heritage

Finally, I would use the metaphor of the IFLA 2009 Congress to give some information about the partnership of the State Archive of Rome in ongoing and future projects concerning digitization and integration in GIS applications of the Pontifical Cadastre of XIXth Century described at the beginning.

Starting in 2006, with funding from CARIPLO bank, State Archive of Rome, DIPSU (Urban Studies Department) of Roma 3 University, and Soprintendenza Archeologica di Roma, began to build a WebGIS based on our map sheets 1:1000 (A0 format) of the Urban Cadastre (Gregoriano Cadastre - maps of the city of Rome).

The 300 ppi scanning of original map sheets were geo-referenced, and 3 morphing operations (on the single map sheet, within the neighborhood, among neighborhood) were applied in the process of matching it to a contemporary shape file. Using open source software, a database was created with more than 16.000 records, copying data from the owners' registers, and

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[34] See in the UK the COPAC form search: http://copac.ac.uk/wzgw/

[35] *Linee guida per la digitalizzazione del materiale cartografico*, edited by Gruppo di lavoro sulla digitalizzazione del materiale cartografico, Roma, ICCU 2006: http://www.iccu.sbn.it/upload/documenti/linee_guida_digit_cartografia_05_2006.pdf

indexes were made of the owners. An open source software application was also made to implement the WebGIS, and finally a first release for a free access online was delivered in spring 2008, providing a general service for all the different goals of our institutions[36].

This experience seems to be having good success, although serious work on the web interface is still to be done to ameliorate usability: a second project has been funded by CARIPLO, including the building of similar WebGIS for the cities of Milan and Bologna. At the same time, many local administrations of the ancient pontifical State have declared they are interested in digitizing all our Gregoriano Cadastre maps (more than 4.000 large roll maps), reduced maps, and owner's registers, to implement GIS systems for their institutional task of territorial planning.

I consider this a very good way to better preserve our cartographic heritage, as actually our collection will reveal their value only if they will be used for "building the future" and not simply to keep them safe. Funding will come in consequence of this, because resources for cultural heritage are always a small amount in comparison to resources needed for urban and territorial planning of our societies.

Let us consider the value of such an investment in the digitization of historical cartography and GIS systems if some disaster occurs, as just happened in the L'Aquila earthquake last April. In we had – and I hope we will – a GIS of the city of L'Aquila based on the first cadastral maps of late XIX Century, and could relate to it digitized versions of all other maps, building plans, and architectural drawings, we would be really able to provide to administrators an instrument to rebuild the ancient town, and the villages destroyed by the earthquake.

[36] http://www.dipsuwebgis.uniroma3.it/gregoriano .