

MAPPING GEO-INFORMATION EDUCATION IN EUROPE

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ABSTRACT

At the 2009 AGILE preconference workshop about the European Qualification Framework, it was concluded that no clear overview exists of what GI content is taught where. To help the GI domain getting a clearer picture, a first version of a method for mapping GI teaching content was developed. It uses the first version of the Geoinformation Science & Technology Body of Knowledge as a common frame of reference for characterizing GI courses and curricula, provided by either academic, vocational or private sector. This GI education content mapping method is presented here, together with the results of an exploratory international user survey, including a map of the responses.

1. INTRODUCTION

In Europe, the Bachelor-Master system for tertiary education and ECTS credit points as a unit for study load have been implemented in 90% or more of the educational organizations (Kas 2010). These measures were taken during the last decade to harmonise the educational infrastructure in the European Union. Another measure to ensure quality is the introduction of the European Qualification Framework (EQF) (EU 2008). EQF might influence the content of Geo Information (GI) education. This is because EQF is set up for cross border diploma recognition. National Quality Assurance organizations are expected to translate the level of educational programs in their country to an international system of eight levels. This should be done in each content domain by an international body with domain expertise, a "sectoral organisation" (EU 2008, par.12). Although this does not apply to academic degrees -they are already accepted across borders- it seems very likely that the existence of such an international body will influence the ideas within a domain about what belongs to which educational level in EQF.

For the GI-domain no European sectoral body has yet been established to execute that task. And, as organizations within the main components of the domain (e.g. surveyors, remote sensing specialists, cartographers, geographers) act pretty independently, one might doubt if it can be considered as one domain. In spite of this doubt, two developments could help to consolidate a GI domain.

First, the INSPIRE directive (EU 2007), is of great importance for the exchange of spatial data among and within European member states. It is presently about halfway in the implementation of its objectives. One of the results are national geodata portals. Although INSPIRE has no educational dimension, it sets a standard for co-operation and exchange and thus for cross border connectivity and harmonization of GI infrastructure. It is hoped that this will trickle down into GI education in the connected countries.

The second development is the publication of the Geographic Information Science & Technology Body of Knowledge (DiBiase, deMers et al. 2006), hereafter referred to as "GI-BoK", by the American Association of Geographers. It was intended to set a standard for curriculum development, but adoption outside the US is limited. In her recent survey, Masik

found an acceptance in 27 European countries of about 22% of the 99 responding GI teaching universities (Masik 2010).

In Europe, it looks like every organisation that provides GI education or GI training has its own way of describing the GI courses it offers. This could be a handicap for mutual understanding and co-operation, for being understood by the private sector and, for staff and student mobility. As these are objectives of the European Higher Education Area (NN 2010) and for 2020 of the Bologna Process (NN 2009), it is obvious that in the GI domain there is room for improvement. Could a wider acceptance of GI BoK mean an underpinning for EQF and INSPIRE and at the same time provide a foundation for a more coherent GI domain?

The GI domain would benefit from using a widely accepted common frame of reference for describing GI course content. In Europe, GI-BoK is not yet widely accepted, so it would be interesting to explore some aspects of its usefulness as a frame of reference. At the AGILE* conference in 2009, it was concluded that there is little overview about what aspects of GI are taught where (Rip 2009). Bill's "Geoinformatics-Service"(Bill 2001) provides a map of GI education locations in Europe, but the objective of this paper is different. Our intention is to map educational content instead of the geographical location of organizations, and find out if GI-BoK could be used for that purpose.

1.1 Research questions

So the EduMapping Research Initiative was proposed to the AGILE board. Upon their agreement explorative research was begun to find out if GI-BoK could be a frame of reference. With that objective in mind, the research question was threefold:

- How to characterize education content with GI-BoK? Which subjects are dealt with in GI courses and curricula? University study guides or training offer brochures, as long as they are in the same language, seem to vary in a subtle way per individual organisation. Do the same words mean the same things? What happens when course content description is based on the GI BoK hierarchy of Knowledge Areas (10), Units (72) and Topics (1330)?
- On which points does GI-BoK not suffice? Some comments have been made about GI-BoK

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(Reinhardt and Toppen 2008), (Rip 2008), (Toppen and Reinhardt 2009). Further elaboration seemed possible, specifically in the direction as indicated by Van Orshoven (Orshoven 2009), supplemented with a closer look at subjects not yet included in GI-BoK.

- How to present the results of the characterization? The ambition was to find a way to create a visual representation of the GI education area.

2. METHODOLOGY

The first step was to devise a way to describe courses. This resulted in a spreadsheet form in which local education content can be related to GI-BoK categories with its number of credit points (ECTS) as a measure of size. After a few local try-outs, an improved version was sent out to other education organizations in the Netherlands and a number of organizations elsewhere in Europe.

A basic requirement for the form was, that it could be used for individual courses and for complete curricula of either academic or vocational nature, as well as vendor software training.

2.1 Data acquisition

Data were acquired by soliciting responses from a group of about 25 persons, selected from the personal network of the authors. The criterion for selection was their involvement in GI-education. They were provided with a spreadsheet file, a description of the procedure to follow and an example of a completed response.

Every respondent was asked to do the following, based on a description of a GI curriculum or course of their choice and their personal expertise:

- assess the coverage of GI-BoK categories and their timeshare in the course or curriculum they were involved in,
- list the subjects and assess their timeshares in the course that are of a GI-nature but not mentioned in GI-BoK,
- list the names and timeshares of generic education elements like internships or thesis writing. For these elements, it cannot be predicted which GI-BoK categories will be addressed, so they are better kept apart.
- list the subjects and their timeshare that are of a non-GI nature, yet part of the course.

For this task, the respondents must enter names and ECTS sizes of curriculum components in the top row of the columns in the spreadsheet. In the leftmost column of the spreadsheet, four categories of possible course elements are provided: those mentioned in BoK, GI elements not in BoK, Generic elements and Non-GI-elements.

For the elements mentioned in BoK, the respondent is allowed to enter a score on the Knowledge Area level as well as on the Unit level. In this way, the respondent could indicate a timeshare on the GI-BoK level that provides the best match between BoK concepts and respondent's concept of the course. Scores for units will be aggregated to their Knowledge Areas.

For the GI-elements that cannot be found in BoK, the respondent must fill in the names of those elements and assess its size in the appropriate column. The same should be done for all the course elements that belong to the last two categories.

The sum of the filled-in timeshares in the column of a curriculum component represents its total size.

All row values, converted from timeshare to ECTS, are added up in the rightmost column of the spreadsheet. In each row, the

sum of the filled-in timeshares in the rightmost column represents the total size of that element. In that column, the total

Table 1 Example of a summary result

Summary for a curriculum	ECTS size	share
Cat.1: GI subject groups, mentioned in BoK 2006	42.5	52%
..Knowledge Area AM. Analytical Methods	11.5	10%
Knowledge Area CF. Conceptual Foundations	3.5	3%
Knowledge Area CV. Cartography and Visualization	6.0	5%
Knowledge Area DA. Design Aspects	15.0	13%
Knowledge Area DM. Data Modeling	6.0	5%
Knowledge Area DN. Data Manipulation	1.5	1%
Knowledge Area GC. Geocomputation	1.0	1%
Knowledge Area GD. Geospatial Data	14.0	12%
Knowledge Area GS. GI S&T and Society	1.5	1%
Knowledge Area OI. Org. & Institutional Aspects	2.5	2%
Cat.2: GI subjects, Not in BoK 2006	6.5	5%
Cat.3: Generic	43.0	36%
Cat.4:Non-GI subjects	8.0	7%
total	120.0	100%

curriculum is represented by means of timeshares for GI-BoK Knowledge Areas.

From the contents of the rightmost column, a summary result is made (Table 1). With that, the conversion from a local curriculum description to one in terms of GI-BoK has been realized.

2.2 Presentation

Showing every single description as an individual table is not satisfactory when the objective is to make a map that gives an overview of the positions of the descriptions. How to do that? After a number of attempts, the following treatment appeared fruitful.

First, the focus was limited to only the GI-in-BoK-category. This is a list of 10 Knowledge Areas each with a number of credit points as an attribute, which could be visualized in a spider chart (Fig.1).

This is not yet satisfactory because the number of spokes is high and their alphabetical order is not related to the content of the matter.

Therefore, in a second step, the Knowledge Areas were

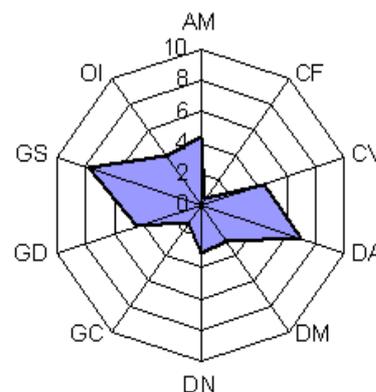


Figure 1 Initial presentation of the in-BoK category

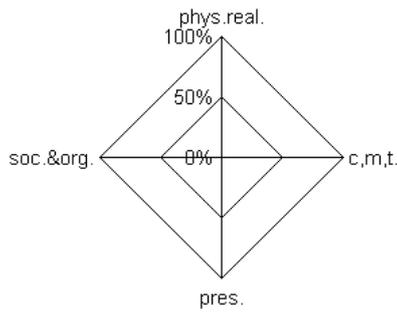


Figure 2 A BoK-based reference system

rearranged into two pairs of two groups. The first pair represents the relationship between data about aspects of our world and the presentation of those data. This is a continuum from measuring the world (including facts about its past, its future and its virtual constructions, like a cadastre) to picturing the results. The second pair represents the relationship between society and its knowledge about handling geodata. This is a continuum from organisation to tools, linking society to knowledge. The rearrangement is illustrated in Fig. 3.

Those two groups can be represented by two axes at right angles with each other, one vertical, one horizontal, crossing each other halfway. With the crossing point taken as the origin for each of the four directions, this gives an area in which positions can be determined by values on the axes.

By assigning a negative sign to the values for Presentation and for Society, a reference system is established, on which an area of interest can be visualized as a polygon by connecting the scores for the aggregated Knowledge Areas in clockwise fashion: **soc.&org.**, **phys.real.**, **c,m,t.**, **pres.**

The unit on the axes is the %, being the timeshare devoted to one of the rearranged categories. The result is shown in Fig. 4. Please note, that the % in Fig.4 is not the proportion of the curriculum as a whole, but the timeshare of the first category: subjects mentioned in GI-BoK. So, if the in-BoK share was 50%, of the curriculum size, those 50% will be considered as a 100%. This was done to avoid the influence of the overall curriculum size, and thus make small courses and large curricula comparable on the basis of their content.

With this reference system, the Content Areas (CA) of GI-curricula were depicted.

Visualization as shown in Fig.4 would not be satisfactory when an overview of a number of curricula CA's is needed. Combined

from:	to:
AM	Society & Organisation
CF	GS. GI S&T and Society
CV	OI. Org. & Institutional Aspects
DA	Concepts, Methods, Tools
DM	AM. Analytical Methods
DN	CF. Conceptual Foundations
GC	DA. Design Aspects
GD	DN. Data Manipulation
GS	GC. Geocomputation
OI	
	Physical Reality
	DM. Data Modeling
	GD. Geospatial Data
	Presentation
	CV. Cartography and Visualization

Figure 3 Rearrangement of Knowledge Areas

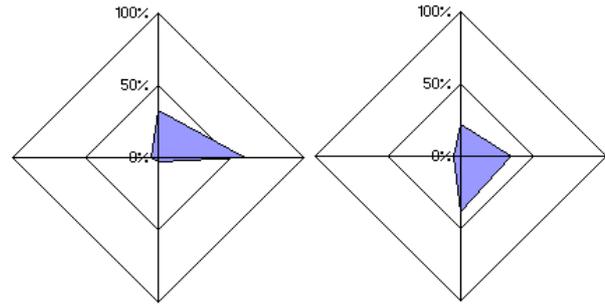


Figure 4 Content Area visualization of 2 GI-curricula

in one visualization, the CA's would overlap, at least partly, and cause visual clutter.

A way to overcome this is to condense the CA from a polygon into a single point, its geometric centre of gravity or centroid. Calculation of centroid coordinates was based on formulas mentioned by Bourke (Bourke 1988). The value range in any of the four dimensions is 0-32.

By providing every centroid with the ECTS size of the GI-in-BoK category as an attribute, the variety in sizes of the in-BoK-part of curricula can be shown at the same time, expressed by means of a circle with a radius around the centroid location, as shown in Fig.5.

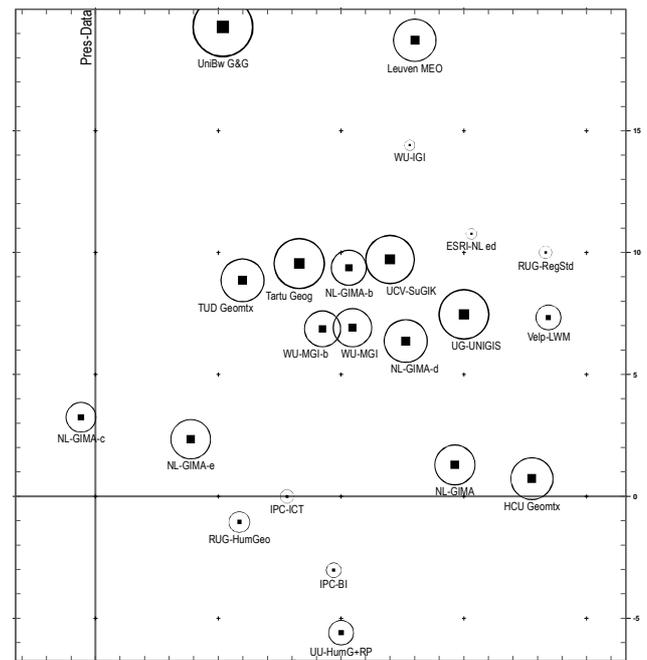


Figure 5 Mapping of Content Area centroids with ECTS size for the in-BoK category as radius. Units are %

3. RESULTS

At the time of writing this paper, the number of filled-in forms was 23, by 20 respondents from seven European countries. About three quarters of these responses came from the Netherlands. This includes five responses describing the GIMA curriculum and two responses describing Wageningen University's Master of Geo Information curriculum. Respondents from Germany and Poland reported problems with filling in the form, which resulted in a non-response from Poland. Most of the respondents described a course or

curriculum at a university, but there are some examples from other organizations. One of them is from ESRI-Netherlands and is about a 'Learning Path', a sequence of courses. A Dutch institute for vocational education, IPC-Groen, submitted descriptions for three chains of GI application courses.

The total size of the described educational items varied between 4.2 ECTS and 270 ECTS with an average size of 89.4 ECTS.

The size of the in-BoK category in those items varied between 2.9 ECTS and 90 ECTS, with an average of 33.1 ECTS.

The proportions of the categories are shown in Table 1.

Table 2 The proportions of content categories

	GI in-BoK	GI not-in-BoK	Generic	Not GI
Average proportion in course/curriculum descriptions (N=23)	45.2%	11.9%	28.9%	14.3%
proportion range (min.-max.%)	7-80%	0-44%	0-58%	0-83%

The '**GI in-BoK**' category has the highest average proportion, which was to be expected as the majority of the responses describes GI-directed education.

The '**Generic**' category has the second highest average proportion, because it includes sizable learning activities like Thesis Writing, Internships, Case Studies and Final Assignments.

The '**Not GI**' category has a higher proportion in case the GI courses are part of a non-GI-curriculum, in which the use of GI is trained and applied in the context of an application field. Examples from more than 60 subjects reported in this category were: Project Management, Statistics, Land Evaluation, Excel software, Methodology of Science, Software Engineering, Learning to use the Blackboard Learning Environment and Writing Research Proposals.

The '**GI not-in-BoK**' category contains:

- Specific GIS and RS software training
- Examples of GIS importance
- Geocoding Address matching
- OGC Simple features in DBMS
- SDI,
- INSPIRE
- OGC Service standards
- Application Domain courses
- Geo ICT
- Higher Geodesy
- Image Processing
- Data Processing Models

3.1 User errors

It occurred a number of times that respondents did not fill in the form correctly, e.g. in the wrong column. In other cases new columns were added in the worksheet without adaptation of the summation formula in the rightmost column. Those errors were corrected after reception of the worksheet.

Possible errors in categorizing learning subjects, like assigning 'Using R-software' to the GI not-in-BoK category, were not corrected, because the respondent may have had good reasons for doing so.

3.2 Remarks from respondents

Respondents were invited, in about half of the cases, to report in 9-99 words their "dislikes and likes" of this approach. Six respondents reacted to this request.

Filling in the form for an educational item presupposes some degree of familiarity with GI-BoK, and the availability of at least a description of the course or curriculum contents.

One respondent admitted to be not very familiar with GI-BoK, and also not to be aware of all the details of the entire curriculum he is involved in. Too many other educators play a role in it. Other respondents complained that it was a lot of work to describe a curriculum this way and some respondents simply gave up. One respondent stated, that the curricula at his university "are based on a completely other logic than BoK". Nevertheless, he filled in the form.

With regard to actually filling in the form, which means making choices about if or where a course element matches with a GI-BoK Unit or Knowledge Area, the following comments were received. One respondent stated that the procedure is quite difficult, selective and generalizing. It is subjective with a non-perfect repeatability. Another respondent wrote "this is a mapping between two fuzzy sets".

The same respondents liked the approach for the following reasons, that fall into two groups:

Local curriculum management

- it shows how time is spent within a curriculum and so provides a basis for judging if subjects get their fair share of teaching time, or too much or too little. Intense reviewing of the own curriculum is useful.
- the mapping approach can help to find the main focus of a course or program. It would be good to compare mapping results with descriptions from the course/program owner, to see how it works out in practice.
- it contributes to conceptual harmonization.
- like a shopping list, it helps not to forget important things.
- the category "GI-not-in BoK" is interesting, as well as knowing which Knowledge Areas are not addressed.

Comparison

- it will be interesting to see what the scores are across many universities.
- the mapping approach could help to show the huge variety in GI education.

3.3 Repeatability

Several respondents commented on the part of the procedure where a link must be made between an educational subject and an element in the GI-BoK hierarchy. They point at the subjective nature of this part of the procedure, which will limit repeatability of the assessment. Their remarks are confirmed by the five responses for the GIMA-curriculum, of which the results do not lead to similar scores.

In their assessments of the categories (GI in-BoK, GI not-in-BoK, Generic, Not GI), the two student-responders rate the GI in-BoK category much lower than coordinators and staff members. Within that category, the students did not always arrive at the same values.

The results for GIMA for the four content categories are shown in Table 3. More detailed results for GIMA, for the first category GI in-BoK, show the scores for the GI BoK Knowledge Areas. They are listed in Table 4.

Table 3 Results of five assessments of the four content categories of the GIMA curriculum

	Response 2	R.14	R.15	R.19	R.20
	local GIMA coordinators	stud1	stud2	uninvolved staff	involved staff
in-BoK	34%	25%	19%	33%	39%
Not-in-BoK	2%	3%	6%	1%	1%
Generic	52%	57%	52%	58%	53%
Not GI	12%	15%	23%	8%	7%

Table 4 Results for the assessments of the GI in-BoK category of the GIMA curriculum (120 ECTS) by five respondents

	Response 2	R.14	R.15	R.19	R.20
	local GIMA coordinators	stud. 1	stud. 2	uninvolved staff	involved staff
AM	8%	2%	2%	6%	4%
CF	5%	2%	2%	4%	0%
CV	3%	1%	1%	2%	4%
DA	3%	3%	1%	4%	6%
DM	3%	5%	2%	6%	2%
DN	3%	2%	2%	3%	3%
GC	2%	2%	1%	3%	1%
GD	1%	4%	1%	3%	4%
GS	2%	3%	4%	3%	6%
OI	4%	1%	4%	4%	3%
GI in-BoK	34%	26%	19%	39%	33%

At the other hand, two assessments for the Wageningen University curriculum 'Master of Geoinformation' (MGI) were done by the studies coordinator and by one of the authors of this article (not involved with MGI). Their scores, although not identical, are similar. The Content Area Map (Fig.5) shows that centroids WU-MGI and WU-MGI-b are neighbours.

3.4 Visualization

The calculated centroid coordinates were used for a cartographical presentation. On this map, the assessments for the Geodesy & Geoinformation curriculum (Bundeswehr Univ., Munich, Germany) and the Master of Earth Observation curriculum (Leuven University, Belgium) came out highest in the Physical Reality dimension with scores around 19 on a scale of 0 - 32.

In the Concepts, Methods, Tools dimension, the highest scores, just over 18, were for the course Spatial Analysis with GIS at Groningen University and for the GI-elements in the Land and Water Management curriculum at Larenstein professional university (both in the Netherlands).

In the Presentation dimension, the highest scores were for the 3-course set "Infra-Distributietechniek" at vocational school IPC Groen (minus 7) and for three courses in the Human Geography and Planning curriculum at Utrecht University (minus 6), both in the Netherlands.

In the Society and Organisation dimension, the highest scores were for 2 different assessments of the Dutch GIMA curriculum: minus 1 and plus 4, respectively.

4. CONCLUSIONS AND DISCUSSION

4.1 Summary conclusions

Based on the outcome of this explorative and limited survey, we conclude that mapping GI education content is possible.

For that, however, an expert in both the educational item and the GI-BoK is necessary. This person has to know the details at both sides: origin and destination.

From the responses and the comments by respondents we conclude that there is an interest in this mapping approach for two reasons:

- it provides a local management tool for GI educational items with regard to content and coherence. At least, it triggers an intense review.
- it provides comparability of GI curricula and GI courses between organizations on different educational levels. Also, it enables cross border comparison of GI education, as well as comparison of private sector courses with GI education accredited by a quality assurance organization.

The common element in those two reasons is the advantage, obtainable by using GI-BoK as a common frame of reference for educational content.

Early in 2010, news was (Ahearn 2010) that in the US a National Science Foundation grant was applied for, to do work on the successor of GI BoK 2006.

This article provides input for the next version of GI-BoK by means of a list of subjects that need to be included in GI-BoK.

Additionally, our experience with content mapping leads to the suggestion to improve the user interface of GI-BoK for easier navigation in the GI domain hierarchy, as well as for easier finding matches between local terminology and the terminology in the frame of reference. An ontology-based e-tool as proposed by Painho (Painho and Curvelo 2008) might be useful for that.

4.2 Research questions

The research question how to characterize education content with GI-BoK can now be answered as follows. GI-BoK can play an important role in detailing the content description within its reach. The degree to which GI-BoK covers the GI-domain, more precise: where it differs from what is taught, is shown in two categories next to the GI in-BoK category. The category GI Not-in-BoK is self evident, and the content category labelled "Generic", which represents the application of what was learnt in a GI-context.

A fourth category "Not GI" was necessary to recognize the teaching of supporting, adjoining and contextual subjects.

The comment from one of the respondents that this procedure is like mapping between fuzzy sets seems an appropriate and concise description of the challenge it is. The risk, variety in results, is illustrated by Tables 3 and 4.

The found differences for the GIMA assessments are a result of this experimental approach in which different views on a curriculum are not distinguished. A more systematic investigation of the perception of educational content from the different points of view is necessary to support better understanding.

We think of four views: at one hand the plans and practices of producers of education, at the other hand the expectations and experiences of its consumers.

The answer to the question on which points GI-BoK does not suffice can only be provisional. This article mentions 12 subjects, considered by respondents to be GI, but not in GI-BoK. Our impression from this limited explorative survey is, that sub domains like land surveying and Remote Sensing are less well served by GI-BoK than 'classical' GIS subject groups like data handling and cartography.

This answer must be considered in combination with the received comments about not knowing GI-BoK very well, and not knowing all the details of a course or curriculum.

How to present results? This article shows a way to present curriculum assessments on three levels of condensation of the Knowledge Area scores: in a radar chart, in a Content Area polygon and in the centroid of that polygon. The objective to produce a map is best served by a diagram showing centroid positions. For that, the Knowledge Areas have been regrouped into two axes with relevance to the GI-domain.

4.3 Further research

In this exploration, we were faced with the 'diversity paradox' (Fortuijn 2002): we had to cope with the consequences of differences in language and culture, and at the same time we must try to profit from the diversity. As in the EQF-approach, our aim is not to equalize, but to offer a common reference to help mutual understanding.

The implications of our findings are, that the EduMapping method could support the implementation of EQF in the GI sector, and that it would help the cooperation between the pillars of the GI profession (Remote Sensing, geodesy, cartography, etc.) and the application fields.

Therefore our recommendation is to start systematic mapping of GI education content in Europe after working out improvements of the procedure to link educational content to GI-BoK.

This would also be an opportunity to collect input to contribute to the improvement of the next version of GI-BoK.

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