

Annex I

Table summarizing the progress reached for each of the tasks involved in the project and proposals for future steps.

		Progress						Notes	Reliability				Difficulties / hinders	How to improve		
		0	1	2	3	4	5	6	L	M	H	A		Short term / little effort	Medium term / effort	Long term / big effort
Preliminary work																
Regulations interpretation and formalization	As-is inv.												High uncertainty and ambiguity in the text (even for human understanding)	Collaboration with municipality officers	Find patterns in the regulations texts by means of natural language processing techniques	Huge collaboration (e.g. many cities / nation-wide)
														Outcome: unique interpretation of the regulations	Outcome: Analysis of regulation and development of mechanisms to extend the formalization	Outcome: New regulations machine readable/easily formalizable
	GL												Outside the project core scope.	Collaboration between developers and municipality officers	Experts in formal language for rules to be involved	Agreements by many cities / nation-wide
														Outcome: Criteria to follow when writing regulations to avoid ambiguity ¹	Outcome: Intermediate formalization method that both developers as well as legal people can relate to. ²	Outcome: Standardized and scalable criteria to formalize and write machine-readable rules
	Impl.												High uncertainty and ambiguity in the text (even for human understanding)	Collaboration between developers and municipality officers	Implementation of the formalization methods agreed as guidelines	Complete implementation of the formalization methods agreed as guidelines and systematic, tested use of them (by municipalities and by tools).
														Outcome: Manual implementation of other regulations	Outcome: Tool assisting the translation of the regulation written according to the guidelines to machine readable code.	Outcome: Automatic integration tool-machine readable regulations (e.g. new regulations are very easily implemented).

¹ <https://digitalagencynetwork.com/9-tips-to-avoid-ambiguity-when-writing-requirements-for-a-web-project/>
<https://www.aclweb.org/anthology/Y98-1027.pdf>

² [https://en.wikipedia.org/wiki/Cucumber_\(software\)#Gherkin_language](https://en.wikipedia.org/wiki/Cucumber_(software)#Gherkin_language)

IFC models quality	As-is								Analysis of the provided models w.r.t. criteria useful to checks and automation				Lack of automatic validation tools	Review and test of more models	Collaboration with designers	Integration of the application examples with new design cases / modelling techniques / standard releases	
														Outcome: Outline of common problems and errors in BIMs	Outcome: Outline of problematic modelling cases and proposal of solutions.	Outcome: Consistent models up-to date with respect to the techniques.	
	GL								Outline of common errors, Proposal of useful modelling criteria or objects storage				Partial view, short time for testing	Analysis of how the different inaccuracies affect the implementation of automatic tools.	Collaboration with designers and BIM modelers	Extensive agreement on criteria to produce suitable IFC models	
														Outcome: Modelling and validity criteria to be respected by IFC models in order to work with automatic tools.	Outcome: collection of “modelling patterns” how reoccurring situations that don’t have an immediately clear mapping to IFC/BIM could be modelled.	Outcome: Agreements designers-developers-standard about how to model and implement specific modelling and their export to standardized format.	
	Impl.								Manual inspection					Lack of clear constraints in IFC, different implementations of IFC, few designers’ official best practices reflected in the IFC file	Define and implement an initial set of tools to check certain model issues (and possibly fix some of them).	Extend the testing of the tool to several models, improve performance and increase the number of validation/fixing functionalities.	Improvement of BIM software and standard implementation, according to guidelines and agreements.
															Outcome: Set of tools to validate, fix and control w.r.t. certain issues the exported IFC by BIM software	Outcome: Comprehensive set of tools to validate, fix and control the exported IFC by BIM software	Outcome: Full consistency of the exported IFC by BIM sw with standard and guidelines. Full control.
IFC models georeferencing	As-is							Check models georeferencing						-	Provide education and documentation	-	
														Outcome: Integration of training about georeferencing within design and BIM courses.	-		
	GL							Define criteria according to literature and the needs of the project						Comprehensive review of the ongoing research and filling of remaining gaps.	-	-	
														Outcome: Comprehensive white paper on research and best practices about georeferencing IFC models.	-	-	

	Impl.					Manual change of parameters in the IFC STEP text				Outside the project core scope.	Review and improvement of existing tools; implementation of a GeoBIM procedure, using ground control points (GCPs) provided as geoinformation	Test of a tool with suitable data, in several LoGeoRefs.	Full control of IFC georeferencing within BIM sw.
											Outcome: Improvement of the available tools to store georeferencing in a specific LoGeoRef Own tool allowing the calculation of georeferencing information from GCPs.	Outcome: Improvements of the tool. Automatic georeferencing of large models in projected CRS using the necessary reference points and parameters, with full metadata.	
Check of the dimension regulation													
Extraction of building envelope	As-is					Measurement of ground truth in the IFC models and outline of pitfalls for automation				Partial subjectivity	Collaboration with municipality officers and designers for a few cases	Collaboration with municipality officers and designers for several cases	Possible update and maintenance
											Outcome: Outline of some criteria and parameters to be applied for certain cases (e.g. tolerance percentage, elements to be included/excluded, level of approximation, etc.)	Outcome: Outline of possible different criteria and parameters to be applied for more cases (e.g. tolerance percentage, elements to be included/excluded, level of approximation, etc.)	
	GL					Outline of common errors, Proposal of useful modelling criteria or objects storage				Huge variability of each building features	Possible revision of modelling guidelines to support envelope extraction processing.	Possible revision of modelling guidelines to support flexible envelope extraction processing.	Possible update and maintenance
											Outcome: (Possible) specific section of IFC modelling guidelines	Outcome: Specific section of IFC modelling guidelines	
	Impl.					Use of the Oriented bounding boxes or extraction of concave hull of storeys, tested with both the case study BIMs				Blunders and uncertainty in the IFC models. Different representation paradigm between BIM (each element as a solid) and the needed one (one waterproof surface...)	Tests and evaluation of a few envelope extraction methods	Test of different methods within up-to-date checking tools	Improvement of previous tools
											Outcome: Tool implementing the envelope extraction algorithms	Outcome: Flexible tool allowing different extraction criteria and levels of generalization	

Measure Max height	As-is							Manual measurement in Revit				Slight uncertainty about the needed reference points	Make specific implicit criteria explicit.	-	-	
													Outcome: More specific (less ambiguous) regulation			
	GL								Definition of useful criteria and parameters				-	Extend to all the similar regulations in Rotterdam	Extend to all the similar regulations in many cities	Possible update and maintenance
													Outcome: Possible outline of specific criteria to be used in similar regulations	Outcome: Possible outline of specific criteria to be used in different regulations, requiring different parameters.	-	
	Impl.								Measurement based on the BIM				Integration with suitable geoinformation needed	Improve the reference to the 3D city model or other geospatial data	Test the tool for different regulations and possible different criteria, improve flexibility.	Possible update and maintenance
													Outcome: Working GeoBIM tool	Outcome: Flexible tool		
Building segmentation	As-is							Manual detection from facades orthogonal projections exported by Revit					-	Extend to a significant sample of models	-	
													Outcome: Outline of useful examples and observation and applied criteria for segmentation			
	GL								Identification of possible criteria to formally define the discontinuities				Generalization of discontinuity detection criteria	Collaboration with municipality officers	Extend to all the similar regulations in many cities	Possible update and maintenance
													Outcome: Agreed criteria to be used in segmentation	Outcome: Possible outline of specific criteria to be used in different regulations, requiring different parameters.	-	
	Impl.								Use the storeys overlap percentage to segment BIM into several parts.				Solid envelop extraction method needed	Implement a tool to segment arbitrary buildings with one criterion	Test the tool for different regulations and possible different criteria, improve flexibility.	Possible update and maintenance
													Outcome: Simple tool	Outcome: Flexible tool		
Measure of base height	As-is							Manual measurement in Revit				Slight uncertainty about the needed reference points	Make specific criteria explicit.	-	-	
													Outcome: More specific (less ambiguous) regulation			

	GL							-	Extend to all the similar regulations in Rotterdam in collaboration with municipality officers	Extend to all the similar regulations in many cities	Possible update and maintenance
									Outcome: Possible outline of specific criteria to be used in similar regulations	Outcome: Possible outline of specific criteria to be used in different regulations, requiring different parameters.	-
	Impl.							Solid envelop extraction and building segmentation method needed	Make the measurement based on the building envelope	Test the tool for different regulations and possible different criteria, improve flexibility.	Possible update and maintenance
									Outcome: More reliable tool.	Outcome: Flexible tool	-
Measure overlap of the two building parts	As-is							Variations in each storey.	Extend to a significant sample of models	-	-
									Outcome: Outline of useful examples and observation and applied criteria for possible uncertain cases.		
	GL							-	Collaboration with municipality officers	Possible update and maintenance	Possible update and maintenance
									Outcome: (Possible) Agreed criteria to be used in overlapping calculation		
	Impl.							³ Solid envelop extraction and building segmentation method needed	Improvement of the tool using the agreed criteria and different possible references (envelope/bounding box) and different approximations or statistical parameters.	Possible update and maintenance	Possible update and maintenance
									Outcome: Very reliable (A) tool.		
Measure overhangs.	As-is							Understanding of facades directions and reference points	Make specific criteria explicit (e.g. balconies, etc.).	-	-
									Outcome: Outline of useful examples and observation and applied criteria for possible uncertain cases.		

³ Easily potentially reached: based on statistical parameters instead that on human subjective judgment and approximation.

	GL								-	Definition of geoinformation requirements	Collaboration with municipality officers	Possible update and maintenance
										Outcome: Criteria needed for reference objects in geoinformation and unique reference with what written in regulations.	Outcome: (Possible) Agreed criteria to be used in overhangs calculation	
	Impl.								Automatic calculation of façade directions, with suitable connection with geoinformation	Automatic reading of geospatial information	Test the tool for different regulations and possible different criteria, improve flexibility (e.g. non-rectangular buildings).	Possible update and maintenance
Check of the parking regulation												
Find and measure apartments	As-is								Division of the building elements into several models; manual search for the right lfcSpace to be considered	Review and test of more models	Collaborate with designers	Integrate the application examples with new design cases / modelling techniques / standard releases
	GL								Further investigation and testing needed.	Agree on a specific representation for related lfcSpaces Propose a structured enumeration extension for lfcSpaces	Outline of requirements supporting automatic computation of building units and related gross floor area.	Agreement designers-municipality-standardization and implementation in software.
										Outcome: Criteria to be followed in modelling the lfcSpaces in the BIM	Outcome: Criteria to be followed in modelling the IFC	Outcome: Affirmed best practice
	Impl.								Modelling is not based on official well-known criteria and high-level quality	Inclusion of the proposed enumeration values into the tool.	Automatic computation of building units (as lfcSpaces) and related gross floor area.	Test tool in different settings/for different requirements
										Outcome: Improved tool	Outcome: Improved tool	Outcome: Flexible and scalable tool

Progress

	As-is investigation and description	Guidelines and requirements definition	Implementation of supporting tools
0	Not performed	Not performed	Not performed
1	Partial	Approximation, from the data of this case study.	Partial
2	Approximation, valid for this case study.	Approximation, from the data of this case study plus literature review	Approximation, valid for this case study and Boompjes BIM only
3	Valid for this case study, with related literature review.	Valid for this case study, consistent with related literature review.	Valid for this case study, with both BIMs
4	General findings scalable to any BIM	General guidelines and requirements scalable to many case studies.	Working procedure scalable to any BIM
5	General findings / methodology scalable to any BIM and any regulation of the same type	General guidelines and requirements scalable to many case studies [+ tested in tools /reviewed and agreed by stakeholders].	Working procedure scalable to any BIM and any regulation of the same type
6	A comprehensive investigation, reference for any similar task in any case study.	Guidelines and requirements reviewed and agreed by a high number of stakeholders and professionals, and tested in many tools.	The best procedure scalable to any BIM and any regulation of the same type

DEGREE of reliability

A - Better result than human-based

H - High

M – Medium

L - Low