DIN SPEC 91607:2024-11 (E)

Digital twins for cities and municipalities

Contents

Page

Foreword 6

Introduction 10

1 Scope 12

2 Normative references 12

3 Terms and definitions 12

4 Abbreviated terms 17

5 The digital twin concept 20
5.1 Origins of the digital twin 20
5.2 Geographical information system (GIS) 21
5.3 Building information modelling (BIM) 21
5.4 City information modelling (CIM) 22
5.5 Transferring the concepts to cities and municipalities 23

6 Urban digital twins (UDTs) 23
6.1 Explanation of urban digital twins 23
6.2 Stakeholders and added value 25
6.2.1 Stakeholders 25
6.2.2 Added value 26
6.3 Characterization and abilities of a UDT 27
6.3.1 General 27
6.3.2 Characterization of the requirements of a UDT for digital infrastructures 28
6.3.3 Abilities of a UDT 28
6.4 Twin groups 29
6.5 Maturity model for urban digital twins 30

7 Data and analyses 32
7.1 General 32
7.2 Knowledge pyramid 32
7.3 Implementation of the knowledge pyramid (5 levels) 32
7.3.1 Raw data 32
7.3.2 Structured data 33
7.3.3 Data modelling in the municipal field 33
7.3.4 Context-sensitive data 35
7.3.5 Knowledge 36
7.3.6 Analogous procedure as for the BIM methodology 36
7.3.7 Action 36
7.4 Requirements on data and data quality 37
7.4.1 General 37
7.4.2 Technical requirements 37
7.4.3 Legally relevant requirements 37
7.4.4 Content requirements 37
7.5 Metadata and metadata catalogues 38
7.6 Analyses and simulations 38
7.7 Visualization and representation of data 41
7.8 Knowledge graphs (analytical knowledge generation) 43
7.9 Federation of data 44

8 System architecture ... 46
8.1 General ... 46
8.2 Architecture infrastructure for urban digital twins ... 47
8.2.1 Generic architecture ... 47
8.2.2 Sample architecture of a twin application ... 49
8.3 Capabilities ... 52
8.3.1 Capability map ... 52
8.3.2 Description of capabilities ... 52
8.4 Standards and interfaces ... 62
8.5 IT security in the UDT context ... 64
8.5.1 General ... 64
8.5.2 Security of the digital infrastructure and physical operating environments ... 65
8.5.3 Security aspects of administration and user management ... 65
8.5.4 Security aspects in the implementation of use cases in UDTs ... 66

9 Examples of use cases ... 66
9.1 General ... 66
9.2 Methodology and procedure ... 66
9.3 Use case template ... 68
9.4 Use cases ... 69
9.4.1 Build the foundation: Geo base twin ... 69
9.4.2 Integrated neighbourhood development ... 71
9.4.3 Digital building approval procedures ... 73
9.4.4 Digital participation ... 76
9.4.5 Management of infrastructures for municipal services of general interest ... 79
9.4.6 Climate-resilient transformation of municipalities ... 81
9.4.7 Energy management ... 83
9.4.8 Disaster management ... 86
9.4.9 Traffic planning and traffic management ... 88
9.4.10 Other usage scenarios ... 90

10 Organization and roles ... 91
10.1 General ... 91
10.2 Adaptation of the organizational structure to horizontal topics ... 92
10.3 Adjusting the organizational structure to the UDT ... 93
10.4 Data governance ... 97

11 Process model and design principles ... 101
11.1 General and motivation ... 101
11.2 Procedure for introducing a UDT ... 102
11.3 Example of the use of UDTs in the context of BIM ... 105
11.4 Design principles ... 106
11.4.1 General ... 106
11.4.2 Social design principles -- Ethical guiding principle ... 107
11.4.3 Ecological design principles ... 107
11.4.4 Economic design principles ... 108
11.4.5 Technological design principles ... 109

12 Operation and added value of UDTs ... 109
12.1 General ... 109
12.2 Typical operating models ... 110
12.3 Value added analysis ... 111

Bibliography ... 113

Figures Figure 1 -- Three main components of digital twins ... 20

Figure 2 -- Knowledge-based UDT action model ... 24

Figure 3 -- Selection of social stakeholders of an urban digital twin with subordinate user groups and selected fields of application (from inside to outside) ... 25

Figure 4 --Abilities of UDTs and digital infrastructure 28

Figure 5 -- Schematic representation of the modular structure and linking of an urban digital twin ecosystem 30

Figure 6 -- Maturity model for urban digital twins 31

Figure 7 -- Knowledge pyramid in the context of digital twins for municipalities 32

Figure 8 -- Selective and structured representation of the reality of a use case (UC) using data 34

Figure 9 -- Overview of data modelling and relevant exchange formats in the context of UDTs 34

Figure 10 -- Stage model of the analysis methods used in UDTs 39

Figure 11 -- Iterative analysis cycle in the context of UDTs 41

Figure 12 --Application examples for combined methods of representation 43

Figure 13 -- Example of a knowledge graph 44

Figure 14 -- Levels of merging raw data to support traffic control depending on air quality 45

Figure 15 -- Detailed sketch of a federated architecture of an urban digital twin 48

Figure 16 -- Example structure of the analysis and simulation components of a twin application 50

Figure 17 -- Interaction of OUPs, CDEs and data spaces in the implementation of urban digital twins 51

Figure 18 -- Capability map 52

Figure 19 -- Establishing use cases in four phases 67

Figure 20 -- Number and assignment of the submitted usage scenarios to the spheres of activity
Figure 21 -- Expansion of municipal processes to include digital transformation including UDTs 92

Figure 22 -- Integration of coordinating bodies, e.g. for sustainability, UDTs and data governance in municipal organizational structures 92

Figure 23 -- Presentation of a generic municipal administration with integrated, overarching UDT coordination 93

Figure 24 -- Organizational structure for implementing a UDT 94

Figure 25 -- Model for the introduction of UDTs 102

Figure 26 -- Example schema of interaction possibilities between BIM information and urban digital twins 106

Tables Table 1 -- Overview of analysis methods used in UDTs 40

Table 2 -- Overview of types of representation in UDTs ranging from haptics to AR/VR 42

Table 3 -- Capabilities of the digital infrastructure for the category Integration 53

Table 4 -- Capabilities in the category Generate Knowledge 56

Table 5 -- Capabilities for the category Decide 59

Table 6 -- Capabilities for the category Intervene 61

Table 7 -- Use case template 68

Table 8 -- Build the foundation: Geo base twin 69

Table 9 -- Integrated neighbourhood development 71

Table 10 -- Digital building approval procedures 73

Table 11 -- Digital participation 76

Table 12 -- Management of infrastructures for municipal services of general interest 79

Table 13 -- Climate-resilient transformation of municipalities 81

Table 14 -- Energy management 83

Table 15 -- Disaster management 86

Table 16 -- Traffic planning and traffic management 88

Table 17 -- Other usage scenarios 91

Table 18 -- Key roles and their responsibilities in connection with UDTs 94

Table 19 -- Core topics of data governance (as in [10], greatly abbreviated) 98

Table 20 -- Prioritization of strategic and operational data governance measures 99

Table 21 -- Comparison of typical operating models and possible effects on a municipality 111

Table 22 -- UDT value creation canvas 112