Rule modeling for automatic verification of RDC-50 requirements in EAS

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ABSTRACT

The modeling of rules for the automatic verification of requirements of architectural programs of Health Care Establishments (EAS) represents one of the many challenges related to the adoption of the BIM methodology in the processes of the Coordination of Projects and Works of Cogic-Fiocruz. These programs need to comply with the requirements of RDC-50. With a new process of approval of most of the activities of the EASs in the city of Rio de Janeiro, by the municipal secretariat and no longer by the State Health Surveillance and, when the visa service in plan is terminated by the municipal agency, the possibility and severity of the risk of non-compliance of the EAS already built or in project increases. The objective of this research is to study how to model rules for automatic verification of RDC-50 requirements, in the Solibri Model Checker (SMC) tool, using information from the BIM model of the Germano Sinval Faria School Health Center (CSEGSF), located at the Manguinhos Campus of Fiocruz, in Rio de Janeiro. The research methods used were bibliographic and documentary reviews, as well as exploratory research. In this study, the conditions for achieving the objective are presented, the importance of the organization and the information classification system and the modeling of the rule itself in the SMC, for the automatic verification of the minimum areas of the environments of the CSEGSF BIM model, according to the requirements presented in RDC-50. It also presents a reflection on the parameterization of the requirements of RDC-50 and the construction of domain-specific ontologies for various aspects of the SUS system, with its challenges and difficulties.

Keywords: Building projects, Health Care Establishments, Rule modeling, Automatic verification of requirements, RDC-50.

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INTRODUCTION

The National Health Surveillance Agency (Anvisa) is responsible for regulating the planning, programming, preparation, evaluation and approval of physical projects of Health Care Establishments (EAS), through the Technical Regulation of Collegiate Board Resolution No. 50, of February 21, 2002 (RDC-50).

ANVISA guides state and municipal health departments in complying with and interpreting the Resolution, and they are responsible for its application and execution, and may, in addition to RDC-50, establish other supplementary or complementary rules, to adapt to local specificities.

In 2017, the State Health Surveillance of Rio de Janeiro ended the off-plan visa service for basic projects of various health care activities in the city of Rio de Janeiro. Through Joint Resolution SES/SMS/RJ No. 538 of March 1, 2018, the responsibility for the application and execution of RDC-50 and other state and municipal rules was transferred to the municipal secretariats of Rio de Janeiro. Within this new context, so far, the Municipal Health Department of Rio de Janeiro does not offer the off-plan visa service for EAS, which increases the possibility and severity of the risk of non-compliance of the hospital building already built.

Fiocruz is a health science and technology institution, linked to the Ministry of Health and which aims to produce, disseminate and share knowledge and technologies aimed at strengthening and consolidating the Unified Health System (SUS), thus contributing to the improvement of the quality of life of the Brazilian population, to the reduction of social inequalities and to the national dynamics of innovation, having as its central value the defense of the right to health and broad citizenship. (Fiocruz, 2019)

In its portfolio of services offered to the population, there are health care activities, through the various EASs of the Foundation. One of these is the Germano Sinval Faria School Health Center (CSEGSF), located on the Manguinhos Campus, in Rio de Janeiro, which offers basic health care services.

In 2018, the physical space occupied by the CSEGSF was subjected to a point cloud survey, allowing the building to be modeled according to its built form, an action integrated with the adoption of the BIM methodology in the management processes of Fiocruz's building stock, in alignment with the guidelines of Federal Decree No. 10306/2020, which establishes its use in the direct or indirect execution of engineering works and services, carried out by the agencies and entities of the federal public administration, within the scope of the BIM-BR strategy (National Strategy for the Dissemination of Building Information Modeling).

Interventions through renovations in public buildings are quite frequent, especially in EASs, as well as the standards for health spaces are dynamic, and must be aligned with advances in science and medicine, the evolution of public policies, the demographic profile of users, epidemics and several other factors.

Even an EAS accredited and renovated less than 15 years ago can still present aspects of non-compliance, enhancing future costs with corrective works.

The automated evaluation of a space becomes feasible and advantageous from the application of resources and tools based on the BIM methodology. The possibility of a verification of the environments that simulates an inspection by the Sanitary Surveillance can minimize the risks of non-conformities pointed out by the agency, not only in the design phase, but also in the post-occupational evaluation phase, favoring the planning of future renovations. This research presents possibilities of contribution to the management of the building through the automatic verification of RDC-50 requirements, in this case, of an already built space. This could also be applicable to a project that has not yet been built.

OBJECTIVE

The objective of this article is to study how to create and model rules for automatic verification of RDC-50 and SomaSUS requirements, in the Solibri Model Checker tool, using the information from the BIM model of one of Fiocruz's EASs – the Germano Sinval Faria School Health Center (CSEGSF).

METHODOLOGY

The research methods used were bibliographic and documentary reviews, as well as exploratory research.

There are three conditions, initially verified, for the success of this proposal. The first necessary condition is to ensure the standardization of the nomenclature of the areas (spaces and activities) so that it is possible to create the rules. The second condition is the parametric construction of the rule so that automatic verification is feasible. The third condition refers to the use of verification software – the Solibri Model Checker.

In order to make automatic verification feasible, facilitating the design process and verification of requirements, it was necessary to select one of the various parameters of RDC-50 and the configurations to be used so that the schedule foreseen for the survey was met. Thus, the parameter of the minimum area required for each compartment of the EAS was used.

THE CASE STUDY: GERMANO SINVAL FARIA SCHOOL HEALTH CENTER

The Germano Sinval Faria School Health Center (CSEGSF), created in 1968, still as the Germano Sinval Faria Training Unit, is a national reference institution of the SUS for tuberculosis and other lung diseases, standing out as a support body for national actions in public health. It is a component unit of the Sérgio Arouca National School of Public Health (ENSP), founded in 1954, and has occupied its current headquarters, the Ernani Braga Pavilion, since March 23, 1964 (OLIVEIRA, 2003, p. 151-163). It is located on the Manguinhos campus, in Rio de Janeiro, and is one of the technical-scientific units of the Oswaldo Cruz Foundation (Fiocruz), an agency linked to the Ministry of Health.

The current headquarters was designed by Floroaldo Alano and Josélio Médici who adapted an existing reinforced concrete structure, abandoned since the 1940s, with 1,251 m², possibly built to be an annex to the Torres Homem Municipal Hospital. The structure was sold by the government of Carlos Lacerda to the Ministry of Health. The project included additions, such as the auditorium and the outpatient clinic, now the health center. The work was completed in a short period of time, from 1965 to 1966 – during this period ENSP worked in an improvised way at the National Children's Department, on Avenida Rui Barbosa, in Flamengo, where the Fernandes Figueira Institute is located today. In addition to being fast, the construction was low-cost, without the use of noble materials. With the inauguration of the new building, ENSP began to offer postgraduate courses, in addition to conducting research and studies in public health. (CASTRO et al., 2004; OLIVEIRA, 2003, p. 154-155).

The Health Center occupies an annex of the so-called Ernani Braga Pavilion, with a single floor. Figure 1 shows its location. The Manguinhos campus is accessible both from Avenida Brasil and Avenida Leopoldo Bulhões, by urban bus or train, or from Rua Sizenando Nabuco, by car or on foot, with the closest access to the Health Center through the entrance of Avenida Leopoldo Bulhões, 1480.

In 2012, the CSEGSF obtained its first international accreditation certificate. The process was carried out by the Brazilian Accreditation Consortium (CBA), which applied the international method of the North American organization Joint Commission International (JCI) and granted the unit international recognition of the quality of services provided to the population. In this process, the procedures and physical infrastructure were evaluated.

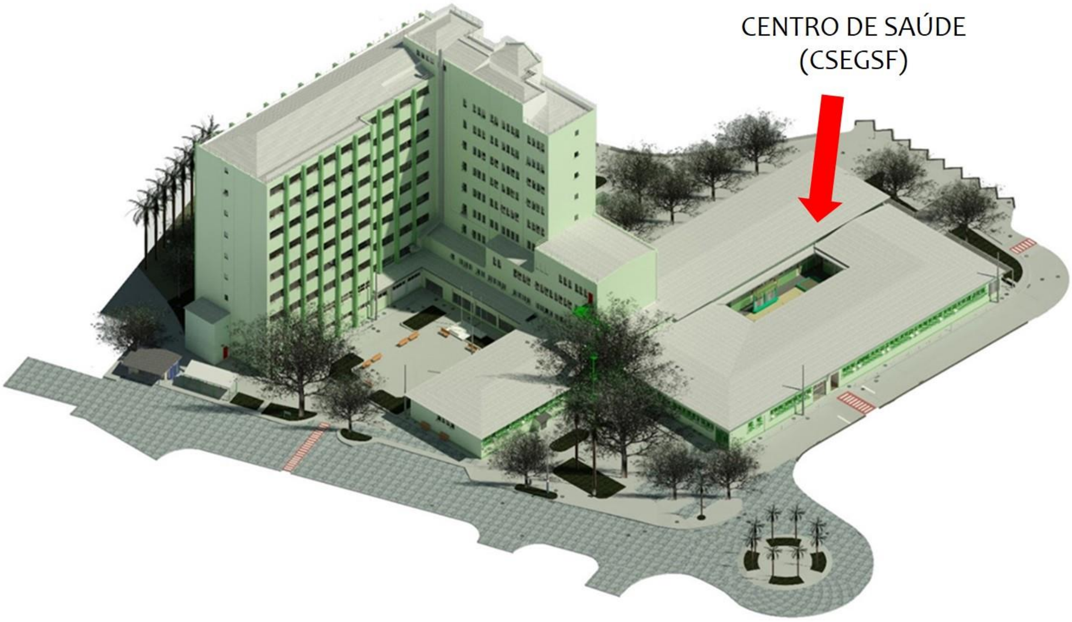
Figure 1 - Location of the Ernani Braga Pavilion, at the Manguinhos Campus of Fiocruz - ENSP and Health Center.

Source: Fiocruz (2024). Adapted by the authors.

CADASTRAL SURVEY IN BIM

From the hiring of the "As is" survey by point cloud of the ENSP building (Ernani Braga Pavilion), with eleven floors and 12,151.07m² of total built area, the Coordination of Projects and Works (CPO) team began the process of information management, through the cadastral update of the built park. Figure 2 presents an image of the BIM model resulting from the point cloud modeling, captured from the survey service using the laser scanner, with the indication of the location of the Health Center.

Figure 2 – BIM model of the Ernani Braga Pavilion, with the indication in red of the location of the Health Center.



Source: CPO (2018). Adapted by the authors.

It was found that BIM modeling, based on the point cloud, meets the requirements for automatic evaluation of the model, based on one of the criteria indicated in the 2017 study by Santos, Ribeiro. These authors consider that the BIM model should present a minimum level of development equivalent to a preliminary project, which in the BIM methodology corresponds to ND 300. In this way, it was possible for this building to be the object of this study.

PROGRAM OF SPACES

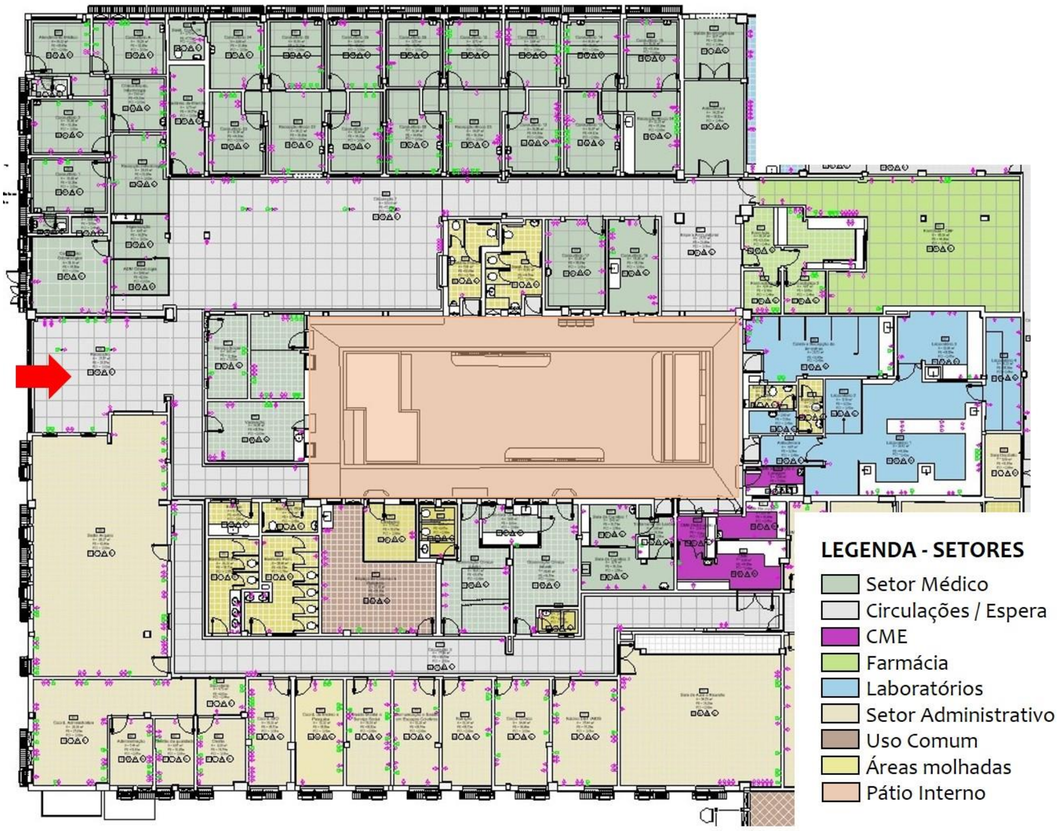
The Health Center has 1,673 m², with environments grouped as: Medical Sector, Circulations, Waiting, CME, Pharmacy, Laboratories, Administrative Sector, Common Use and Wet Area, as shown in Figure 3. The entrance (reception) is indicated by a red arrow.

The Diagnosis and Therapy Support Sector houses the Pharmacy, the Material and Sterilization Center (CME) and the Laboratories and, together with the Medical Sector, is located around the internal courtyard, which provides natural lighting and ventilation to these environments. The CME receives and sterilizes all the material used in the Health Center and the Analysis Laboratory performs Bacilloscopy and Mycobacterial Culture exams for patients in this and other units.

The areas in which patients receive care were classified as Medical Sector: reception, clinical observation, special care area, breastfeeding room, collection room, vaccination and offices. Clinical Observation is subdivided into three areas: the nursing room, separated by glass from the two rest areas (one for children and one for adults); and each of the rest areas has two beds. The Special Care area is subdivided into two areas for non-invasive lesion treatments. One of the areas is used to treat infected lesions and is equipped with an exhaust fan with an absolute filter (HEPA).

This sector has 20 offices, divided into two subareas: those for Infectious Diseases, and the other offices, divided into 4 blocks of 5 offices. Each of the blocks has an access room where an initial service is performed by nursing professionals, such as weighing and measuring blood pressure.

Figure 3 – Sectorization of the Health Center.



Source: CPO (2018). Adapted by the authors.

The Administrative Sector consists of rooms and bathrooms for the internal team. They are occupied by the head, coordination, administration, medical archive and multipurpose activities, such as classes, meetings and training.

The area classified as for common use corresponds to the Social Room and Cafeteria for employees. In the wet areas, toilets were included for the use of patients and companions.

The Health Center was built in masonry, and most of the walls were plastered and painted, with the exception of the corridors of the patient sector, which are covered at half height with tiles, however, some internal walls were made later, in *drywall*, regularized with putty and paint. As for the ceilings of the rooms, they were plastered and painted or have a modulated ceiling in plates. The floor has three types of coating: the original is in high-strength mortar; in the "clean areas" it is cemented painted with epoxy; and the most recent floors are covered with porcelain tiles.

AUTOMATIC RULE CHECKING

AUTOMATIC VERIFICATION TOOLS

According to Eastman et al. (2009), there are three ways in which the verification of rules can be carried out, with specific uses and objectives:

1) an application developed to work in another tool, such as a plug-in, allowing verification at any time;
2) as a computer software, parallel to the design software;
3) as a web-based application, which accepts the derivative design from various platforms.

The tool chosen by the authors of this research for automatic verification of the rules is developed by NEMETSCHEK COMPANY, a German software company, aimed at the entire life cycle of buildings and infrastructure projects.

Solibri Model Checker is a quality assurance solution for BIM validation, compliance control, design review, analysis and code verification, which allows you to adapt the Ruleset Manager for the generation of custom rules for model verification. It automatically analyzes and groups interferences according to their severity, also looking for components and materials that are missing from the model. The tool extracts the data in the form of a report, with the possibility of using Excel functions in them. Importing the model is possible in IFC, compressed IFC (IFCZip), and DWG formats. To carry out this research, three Solibri test licenses were used that were made available for 45 days.

CLASSIFICATION OF INFORMATION FOR RDC-50

For the application of RDC-50 requirements, there would be the possibility of using international classification systems, such as OmniClass. However, when observing the spaces defined in this system and their corresponding functions, it is verified that they are dissonant with the spaces provided for by Anvisa's rules, which is more detailed and comprehensive for certain disciplines, in addition to containing programmatic differences. Standards established by public agencies are linked to regional parameters and inherent to the specialization and selectivity of themes, while international systems have the objective of generalization and standardization.

In addition, RDC-50 aims at the assessment of biosafety, while OmniClass is aimed at the objectives of the construction industry. Probably the application of other classification systems would not meet the objective of normative evaluation within ANVISA's parameters. To illustrate this incompatibility, in Figure 4 extracted from OmniClass, the pediatric office (OmniClass number 13-51 11 19) is defined as a space intended for the care of patients aged 1 to 20 years; For the Brazilian health system, together with the Statute of the Child and Adolescent, a patient is considered pediatric when he or she is between 0 and 18 years old. Another noteworthy point is that the tables for classification of environments of ABNT Standard 15.965 referring to the classification of environments (4A) and Units (4U) had not yet been published at the time of the experiment, hence the OmniClass system was used.

Figure 4 - Classification and description of health care areas of the OmniClass.

1	Table 13	Spaces by Function				
2	OmniClass Number	Level 1 Title	Level 2 Title	Level 3 Title	Level 4 Title	Definition
312	13-49 23 13			Computer Server Room		Climate controlled space for servers associated with office environments
313	13-51 00 00	Healthcare Spaces				Space which is used for services directly related to the heath care and medical practice. Most uses are applicable to providing medical care to humans as well as veterinarian services for animals. Size of the space may vary according to the size of the patient however the functions would be consistent as in admissions, diagnostics, surgery etc.
314	13-51 11 00		General Examination Spaces			Spaces used by multiple medical services for routine patient examinations.
315	13-51 11 11			Exam Room		Space used for routine, urgent, and emergent examination (physical inspection of a patient or parts of his body) in order to verify health or diagnose disease or injury. May also be Space used for minor procedures such as injections, wound care, and suturing.
316	13-51 11 13			Exam Room, Airborne Infection Isolation		Space used for examination of patients who are suspected to have or have a condition which could pose an airborne infection threat to other patients.
317	13-51 11 15			Exam Room, Isolation		Space used for examination of patients with suspected contagious diseases.
318	13-51 11 17			Exam Room, OB/Gyn		Space used for gynecological examination of women.
319	13-51 11 19			Exam Room, Pediatric		Space used for examination of patients who conform to institutional criteria as being children, generally 1 year old to 20 years old.
320	13-51 11 21			Exam Room, Protective Environment Isolation		Space used for examination of patients who are suspected to have or have a condition which makes them highly susceptible to infection.
321	13-51 11 23			Exam Room, Podiatry		Space used for the diagnosis and treatment of disorders of the foot, ankle and leg.
322	13-51 11 25			Exam Room, Security		Space used for examination and holding of patients who are under custodial observation due to mental infirmity or judicial restraint.

Introduction | Table 13 | Table 13 FLAT | Transition Matrix | 2011-05-16 Transition Matrix

Source: Omniclass.

RDC-50 is organized into themes focused on the planning of the spaces of the EAS, in chapters ordered within a hierarchy of complexity and specialization of the disciplines involved. Its form, partly structured in patterns and tables, contributes to the automation of the structuring of rules.

Within the diversity of themes to be inspected by RDC-50, the dimensioning of spaces is considered the most relevant and recurrent. From small offices of self-employed professionals to large hospitals, the dimensions associated with the correct nomenclature of the compartments are parameters that are very likely to be inspected. In addition to having a high impact on construction and urban space, the minimum areas seek to ensure quality in health care processes. The minimum areas and dimensions of the spaces are easily found in this standard, which presents this information in a column in spreadsheets grouped in a single chapter, as shown in Figure 5.

Figure 5 - Example of one of the several tables of environments related to care activities provided for in the RDC-50 standard.

UNIDADE FUNCIONAL: 1- ATENDIMENTO AMBULATORIAL				
N.º ATIV.	UNIDADE / AMBIENTE	DIMENSIONAMENTO		INSTALAÇÕES
		QUANTIFICAÇÃO (min.)	DIMENSÃO (min.)	
1.1 a 1.5	***Ações Básicas de Saúde***			
1.1	Sala de atendimento individualizado	1	9,0 m²	HF
1.1, 1.3, 1.4 e 1.5	Sala de demonstração e educação em saúde	1	1,0 m² por ouvinte	HF
1.1	Sala de imunização	1	6,0 m²	HF
1.5	Sala de armazenagem e distribuição de alimentos de programas especiais		1,0 m² por tonelada para empilhamentos com h.= 2,0 m e com aproveitamento de 70% da m³ do ambiente	
1.2, 1.4, 1.5	Sala de relatório		1,0 m² por funcionário	
1.11	***Enfermagem***			
1.11	Sala de preparo de paciente (consulta de enferm., triagem, biometria)		6,0 m²	HF
1.11	Sala de serviços		8,0 m²	HF
1.8; 1.11	Sala de curativos / suturas e coleta de material (exceto ginecológico)		9,0 m²	HF
1.11	Sala de reidratação (oral e intravenosa)		6,0 m² por paciente	HF;EE
1.11	Sala de inalação individual	1, obrigatório em unidades p/ tratamento de AIDS	3,2 m²	HF;FAM;FO;E
1.11	Sala de inalação coletiva		1,6 m² por paciente	HF;FAM;FO
1.11	Sala de aplicação de medicamentos		5,5 m²	HF
1.7	***Consultórios*** [1]			
1.7; 1.8	Consultório indiferenciado	NC=(A.B):(C.D.E.F.) *	7,5 m² com dim. mínima=2,2 m	HF
1.7	Consultório de serviço social – consulta de grupo		6,0 m² + 0,8 m² p/ paciente	
1.7; 1.8	Consultório de ortopedia		7,5 m² ou 6,0 m² (+ área de exames comum a outros consultórios com área mínima de 7,0 m²). Dim. mínima de ambos=2,2 m	HF
1.7; 1.8	Consultório diferenciado (oftalmo, otorrino, etc.)		A depender do equipamento utilizado. Distância mínima entre cadeiras odontológicas individuais numa mesma sala = 1 m	HF
1.7; 1.8	Consultório odontológico coletivo			HF;FAM;FVC
1.7; 1.8	Consultório odontológico		9,0 m²	
	Internação de Curta Duração [2]			
1.11	Posto de enfermagem e serviços	1 a cada 12 leitos de curta duração	6,0 m²	HF;EE
1.11	Área de prescrição médica		2,0 m²	
1.8; 1.9; 1.10; 1.11; 1.12	Quarto individual de curta duração	1	10,0m² = quarto de 1 leito 7,0m² por leito = quarto de 2 leitos 6,0m² por leito = quarto de 3 a 6 leitos N.º máximo de leitos por quarto = 6 Distância entre leitos paralelos = 1m Distância entre leito e paredes: cabeceira = inexistente; pé do leito = 1,2m; lateral = 0,5m Na pediatria e na geriatria devem ser previstos espaços para cadeira de acompanhante ao lado do leito	HF; HQ; FO; FAM; EE; ED
1.8; 1.9; 1.10; 1.11; 1.12	Quarto coletivo de curta duração			

Vide Portaria Conjunta MS/GAB nº 1 de 02/08/00 sobre funcionamento de estabelecimentos privados de vacinação e Portaria MS/GAB nº 44 de 10/01/01 sobre hospital-dia no âmbito do SUS.

[1] *Admite-se consultórios agrupados sem ambientes de apoio, desde que funcionem de forma individual. Nesse caso os ambientes de apoio se resumem a sala(s) de espera e recepção e sanitário(s) para público e, caso haja consultórios de ginecologia, proctologia e urologia, sanitário para pacientes anexo à esses.*

[2] *Quando o EAS possuir unidade de internação, esta pode ser utilizada para manutenção de pacientes em observação pós-cirurgia ambulatorial.*

Source: Anvisa (2002).

RDC-50, in addition to being organized, is comprehensive when it lists the possible spaces within an EAS. There are more than 200 different environments, each one housing specific activities - these are coded within the standard itself - with their own physical requirements, most of the time being requirements of minimum areas and/or dimensions.

To differentiate such spaces, RDC-50 establishes names that, in order not to be duplicated, sometimes become long and composed of many words, such as "storage and distribution room for food of special programs" different from "storage and distribution room for sterilized materials and clothing".

Long names in the graphic representation of the project tend to be abbreviated subjectively, subtracted, poorly written, broken down into separate words into distinct objects when developed in CAD. When one seeks to automate the verification of a long expression, this becomes a weakness, which could be circumvented if there were a standardized coding in the description of these compartments.

In 2004, the Ministry of Health presented SomaSUS, prepared by the team of the Study Group in Hospital Engineering and Architecture of the Federal University of Bahia (GEA-Hosp/UFBA), in partnership with the Institute of Biomedical Engineering of the Federal University of Santa Catarina (IEB/UFSC). Since its creation, it has been developing, updating and adding more information to the planning of EASs. Until 2023 it was publicly and interactively available on the internet. In May 2024, the system was re-edited and presented in a new version (SomaSUS).

The elaboration of SomaSUS was based on RDC-50, transposing the spaces to illustrated cards with schematic layout, proximity flowchart, installation points, lists of furniture and equipment necessary or usually applied and other information, in addition to RDC-50. One of its most significant contributions to this study is in the version prior to 2024, being the presentation of a code system for each compartment, associating, for example, code AMB04 for "storage and distribution room for food of special programs" and CME08 for "storage and distribution room for sterilized materials and clothing".

Table 2 presents an example of a list of compartments for RDC-50. In this case, the parameters for verification are the names of the compartments and their minimum areas.

Table 2 - Example of a list of RDC-50 compartments and minimum areas.

PARAMETER NAME	MINIMUM AREA PARAMETER
ADMINISTRATIVE ROOM	5,5
AREA FOR THE EXECUTION OF ADMINISTRATIVE, CLINICAL, NURSING AND TECHNICAL SERVICES	5,5
MEETING ROOM	2
INDIVIDUALIZED SERVICE ROOM	9
DEMONSTRATION ROOM AND HEALTH EDUCATION	1
IMMUNIZATION ROOM	6
STORAGE AND DISTRIBUTION ROOM FOR FOOD FROM SPECIAL PROGRAMS	
REPORT ROOM	1
PATIENT PREPARATION ROOM	6
SERVICE ROOM	8
DRESSING ROOM / SUTURES AND MATERIAL COLLECTION	9
REHYDRATION ROOM	6
INDIVIDUAL INHALATION ROOM	3,2
COLLECTIVE INHALATION ROOM	1,6
MEDICATION APPLICATION ROOM	5,5
UNDIFFERENTIATED OFFICE	7,5
SOCIAL WORK OFFICE	6
ORTHOPEDICS OFFICE	7,5
OPHTHALMOLOGY OFFICE	
OTORHINOLARYNGOLOGY OFFICE	
GYNECOLOGY OFFICE	7,5
PROCTOLOGY OFFICE	7,5
UROLOGY OFFICE	7,5
COLLECTIVE DENTAL OFFICE	
DENTAL OFFICE	9
NURSING STATION AND SERVICES	6
MEDICAL PRESCRIPTION AREA	2
SHORT TERM SINGLE ROOM	10
SHORT-TERM COLLECTIVE ROOM 2 BEDS	14

Source: Anvisa (2002). Adapted by the authors.

The codification also goes beyond the compartments established by RDC-50, differentiating, for example, a "nursing and service station" from an infirmary to that of an ICU. Chart 3 presents examples of SomaSUS coding.

Chart 3 – Example of SomaSUS codes for environments and their respective names and minimum areas.

CODE PARAMETER	PARAMETER NAME	MINIMUM AREA PARAMETER
ADM03	ADMINISTRATIVE ROOM	5,5
ADM04	AREA FOR THE EXECUTION OF ADMINISTRATIVE, CLINICAL, NURSING AND TECHNICAL SERVICES	5,5
ADM12	MEETING ROOM	2
AMB01	INDIVIDUALIZED SERVICE ROOM	9
AMB02	DEMONSTRATION ROOM AND HEALTH EDUCATION	1
AMB03	IMMUNIZATION ROOM	6
AMB04	STORAGE AND DISTRIBUTION ROOM FOR FOOD FROM SPECIAL PROGRAMS	
AMB05	REPORT ROOM	1
AMB06	PATIENT PREPARATION ROOM	6
AMB07	SERVICE ROOM	8
AMB08	DRESSING ROOM / SUTURES AND MATERIAL COLLECTION	9
AMB09	REHYDRATION ROOM	6
AMB10	INDIVIDUAL INHALATION ROOM	3,2
AMB11	COLLECTIVE INHALATION ROOM	1,6
AMB12	MEDICATION APPLICATION ROOM	5,5
AMB13	UNDIFFERENTIATED OFFICE	7,5
AMB14	SOCIAL WORK OFFICE	6
AMB15	ORTHOPEDICS OFFICE	7,5
AMB16	OPHTHALMOLOGY OFFICE	
AMB17	OTORHINOLARYNGOLOGY OFFICE	
AMB18	GYNECOLOGY OFFICE	7,5
AMB18	PROCTOLOGY OFFICE	7,5
AMB18	UROLOGY OFFICE	7,5
AMB19	COLLECTIVE DENTAL OFFICE	
AMB20	DENTAL OFFICE	9
AMB21	NURSING STATION AND SERVICES	6
AMB22	MEDICAL PRESCRIPTION AREA	2
AMB23	SHORT TERM SINGLE ROOM	10
AMB24	SHORT-TERM COLLECTIVE ROOM 2 BEDS	14

Source: SomaSUS. Adapted by the authors.

Associating these codes with spatial objects at the time of modeling, as one of its parameters, provides automation and more accurate reading of the project. Regardless of the name of the compartment presented in the project, by associating each environment with its SomaSUS code, it will bring greater reliability to the automated evaluation process, with the security of the results. The column with the name of the compartments would be unnecessary for verification. It is important to note that the code is not necessary for the construction process or for Anvisa's evaluation process.

Thus, despite its usefulness in the automatic verification of requirements, it is not recommended to replace the names of these compartments in the project documentation with codes, which would make it difficult to read, and it is unlikely that anyone, whether layman or specialist, has in memory all the codes and their associated environments.

According to Mendonça (2020), the software to be used in the verification must "recognize" the classification system used in the model. Solibri has some systems loaded in its database, including OmniClass, and also allows the adoption of the user's own systems. In this research, the SomaSUS codes for the environments will be used and not the OmniClass classification. In the automatic verification process, the environment code parameter will be directly associated with the minimum area.

PREPARATION OF THE BIM MODEL

In Revit, there is a specific category of object called *Room*, being a unit of the subdivision of space, that is, a compartment. Room instances have fields to allocate location data, some of which are automatically generated through a specific command:

- Level
- Area
- Perimeter
- Height
- Volume
- Phase

And other data that must be filled in (optionally) by the designer:

- Workset
- Number
- Name
- Image
- Comments
- Occupation
- Department
- Base finish
- Ceiling Finish
- Wall Finishing

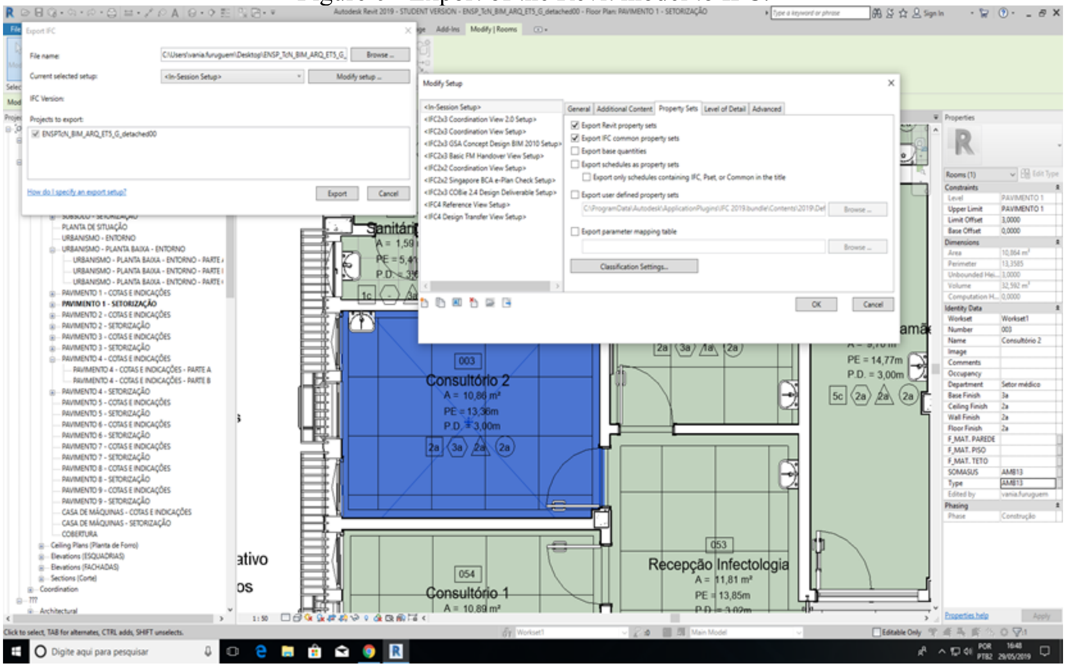
- Floor Finishing

However, there is no specific field for the insertion of codes such as those of SomaSUS. In this case, you must use one of these fields offered for manual completion or customize the Room data grid, creating one more field. In this research, it was decided to create a new field, arbitrarily called Type.

For each Room in the Health Center model, its corresponding SomaSUS code was then filled in. As an example, Clinic 2 was coded as AMB13.

The model was then exported to IFC through the predefined settings (Figure 6).

Figure 6 - Export of the Revit model to IFC.



Source: The authors.

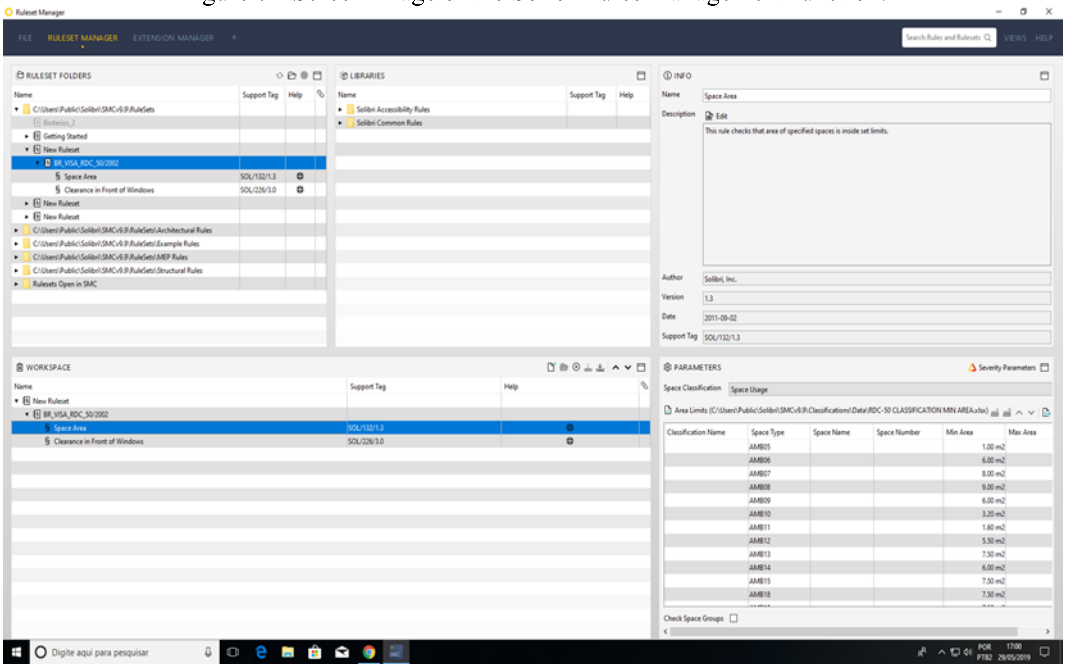
MODELING OF THE RULES

Among the rules offered by Solibri, there is the verification of areas - Space Area (Figure 7), which has the following parameters:

- Classification Name
- Space Type
- Space Name
- Space Number
- Min Area
- Max Area

For this research, the following parameters were customized for the verification of minimum areas of the RDC-50 standard: Space Type as the SomaSUS code and Min Area as the corresponding minimum area, through the import of an Excel table containing such information extracted from the standard.

Figure 7 - Screen image of the Solibri rules management function.



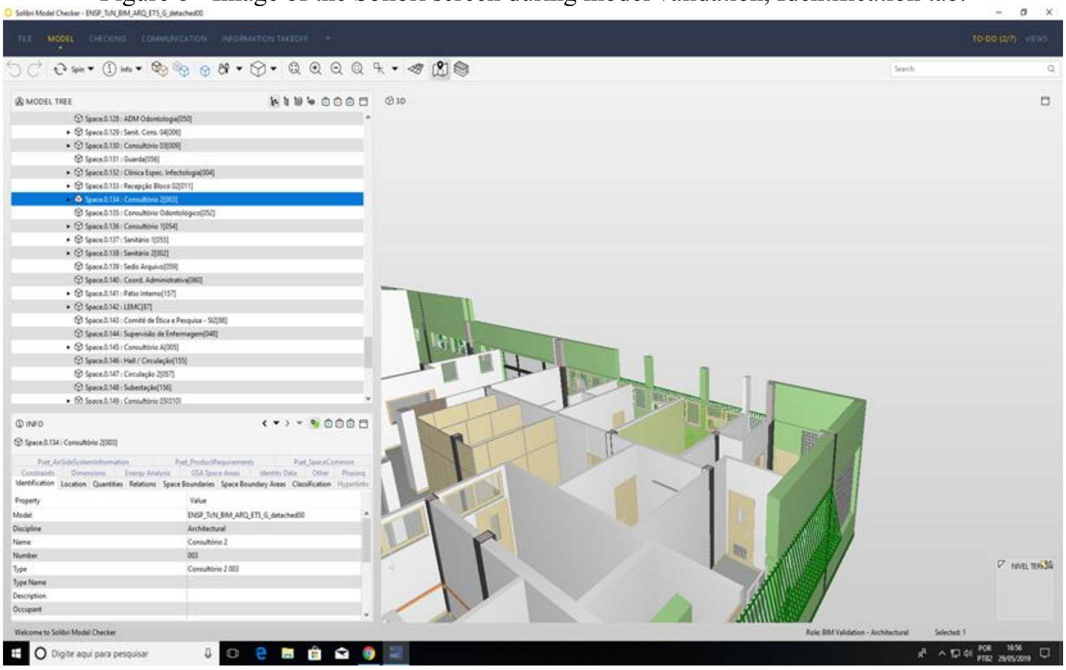
Source: The authors.

BIM MODEL VALIDATION

According to Santos (2018), there are two steps to requirements verification: model validation and requirements verification itself. When the IFC file was opened inside Solibri, it was found that not all the data contained in the Room instance in Revit was properly exported to the parameters of the rules modeled in Solibri. The Room instance has been translated as Space in Solibri. Within the Identification tab of the INFO box for the "Clinic 2" Space, there are the fields of the discipline: name and compartment number (Figure 8).

In the standardized tabs, the parameters that will be checked are also indicated. In this case, the parameters of the Identification tab are indicated.

Figure 8 - Image of the Solibri screen during model validation, Identification tab.



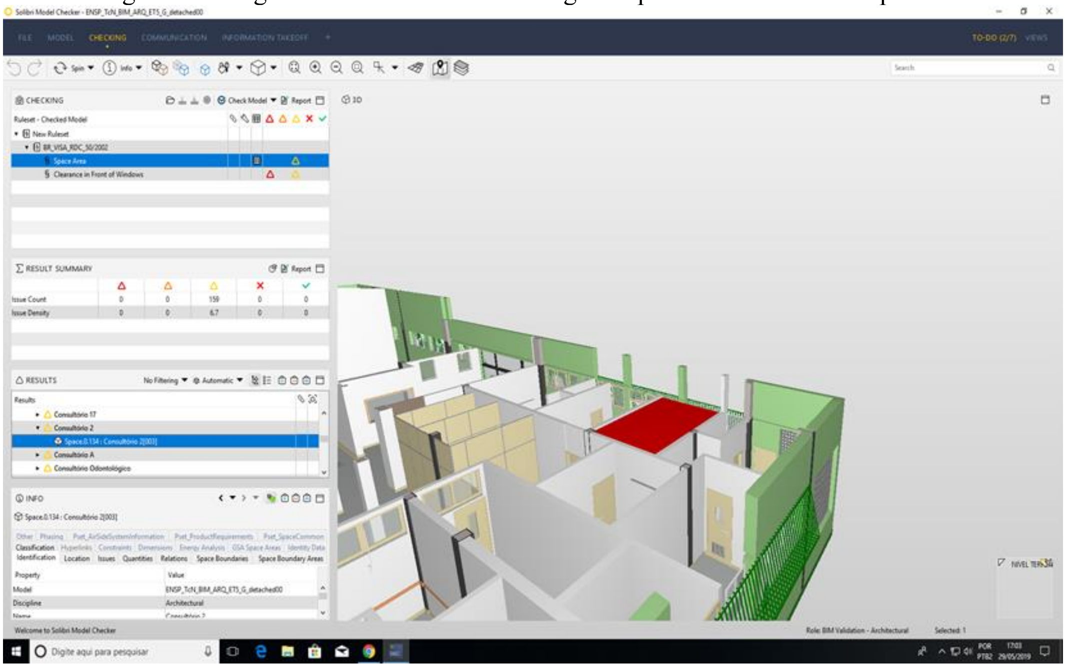
Source: The authors.

Other information from the Revit model, such as Department, Finishes and the Type field created for SomaSUS, can be found in another tab, bluish, which receives the same name used in Revit: Identity Data. Up to this point it is understood that Room information has been imported into Solibri, despite being in different tabs. And that the bluish brims are alien to Solibri's standards.

CHECKING THE MODELED RULES

When performing the Space Area rule check for RDC-50, the Type field imported from Revit is not understood as the Space Type parameter from Solibri. This means that Solibri considers as a verification parameter, for the rule used, the data contained in the Identification tab. The Revit Type parameter is found in the Identity Data tab, as mentioned.

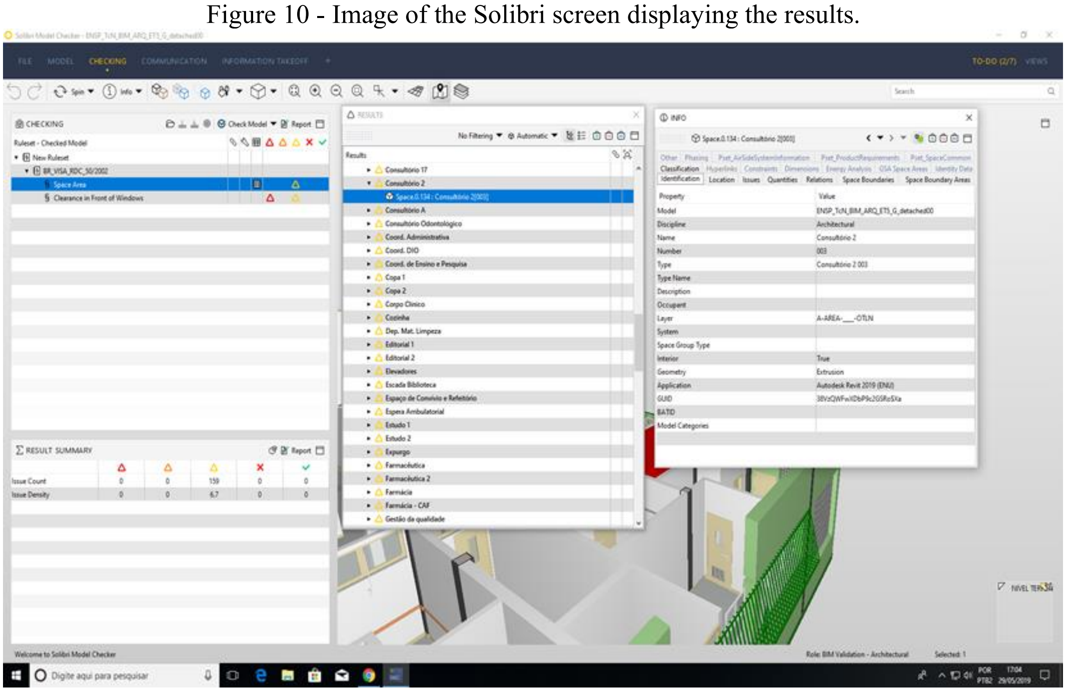
Figure 9 - Image of the Solibri screen during the Space Area verification process.



Source: The authors.

The software identifies the spaces under analysis in the color that can be previously specified. In Figure 9, the environment under analysis is highlighted in red.

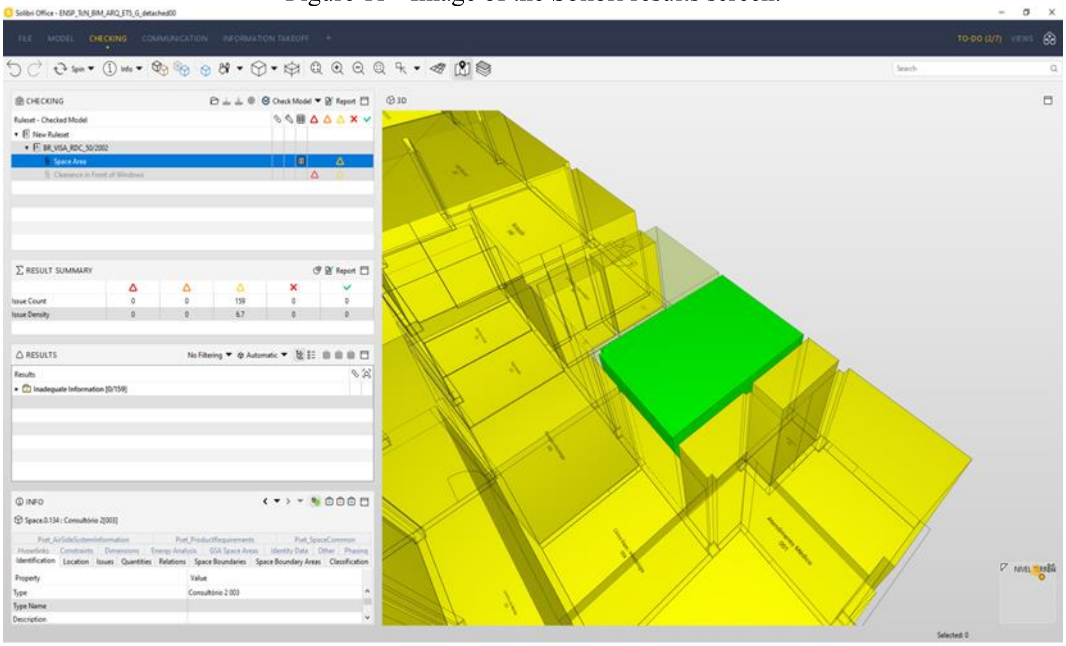
Figure 10 - Image of the Solibri screen displaying the results.



Source: The authors.

Figure 10 shows the results after the rule is checked. According to Solibri, the model studied does not present adequate information, that is, it cannot be validated for the verification of the rule, as shown in Figure 11.

Figure 11 - Image of the Solibri results screen.



Source: The authors.

In order for Solibri to recognize the SomaSUS parameter, this issue of correctly addressing parameters from Revit to Solibri must be addressed. Therefore, through the verification of the rules, it was found that the model would not yet be validated.

DISCUSSION

RDC-50 AS A DATA SOURCE FOR REQUIREMENTS

In its initial considerations, RDC-50 presents the following text:

> "Considering the need for state and municipal secretariats to have an instrument for the preparation and evaluation of physical projects of health care establishments, appropriate to new technologies in the health area." (ANVISA, 2002)

Note the date of the current rule: February 21, 2002. Considering the dynamics of the technical-scientific evolution in the biomedical area, which imposes new work processes at all times, in parallel with the technological evolution of the Brazilian AEC industry, it is quickly understood when architects and engineers specialized in EAS express the need for the standard to be revised. In 2018, an ANVISA Working Group was created for this purpose, and it is expected that this review will be completed soon. It would also include SomaSUS, which would continue to be publicly available as a guidance instrument for the management of EAS spaces. According to the article published on the Ministry of Health website, Cláudia Cury, a technician at the Ministry of Health, justifies the revision with the text:

> "The supply of physical structures, as well as the incorporation of technologies that require their qualification or adaptation are two very important guidelines for the Ministry of Health. As the manager of a system responsible for adapting RDC 50 to something more playful and

> visually interesting, the Ministry's Qualification of Investments in Health Infrastructure team has the technical competence to point out possible deficiencies in the standard and suggest improvements. And, of course, once the new version is published, we will have to completely update the technical content available on SomaSUS". (MINISTRY OF HEALTH, 2017)

In view of his speech, it can be speculated that the general structure of the rule will still be maintained, understanding that SomaSUS would continue to act as a consultation tool accessible to the general public. It should also be noted that RDC-50 does not exhaust ANVISA's standards. There are other Resolutions of the body, specific to certain EAS, amendments, ordinances, in addition to regional codes and manuals of good practices. What can be considered is that RDC-50 is the most comprehensive and central of all standards for EAS. In any case, it is necessary to think of a structured rules verification system to receive modifications to requirements in an automated way, which allows it to be connected directly to the standards in a dynamic way, in real time, in universal web language.

REFLECTIONS ON MODEL PREPARATION

The preparation of the model in Revit, in addition to the ND 300 standards being met, addresses the qualitative review of the project, which needs to be consistent with the standards adopted in RDC-50. To enable this automatic verification, the nomenclatures of compartments, equipment and other construction elements must use the same vocabulary used in the standard. For example, "sink" and "washbasin" have very different meanings and different rules. The information on the care activities that are carried out in each compartment must be consolidated in data documentation attached or entered in the model. The standard establishes and codifies each of them, assigning a specific appropriate compartment. The number of users or certain objects also interferes with the calculation of parameters, such as calculating areas. The model must also receive data from disciplines other than architecture, for the verification of installation points, and these points are also named according to the vocabulary of RDC-50. As an example, the electrical outlet should be labeled "E". And finally, in the same way that engineering elements are introduced, it is highly recommended that architectural elements not evaluated by the standard be excluded from the model so that the verification becomes faster and safer, with less risk of errors. Furniture (except stretchers and beds), roofs, landscaping and urban planning elements (except vehicle spaces), signage, are not useful for verifying the rules, despite the need to be represented in the documentation required in the approval process.

DIFFICULTIES AND RESTRICTIONS

SOFTWARE LICENSE

Initial difficulties in viewing the model were caused by the graphics card installed in the institution's computers (Intel Graphics), which is not recommended by the developer of the tool itself, as it has problems in the operation of the software.

DATA EXPORT

The solution for the correct export of the model information in Revit to the IFC must be carefully planned so that the fields with the information are correctly transferred between the applications. This task implies that the professionals involved know all the applications used and the two information structures: those of the source programs, which can be proprietary data structures, and the neutral (IFC) for the exchange. In order to start the rule verification step more quickly, the data to be verified was entered into Solibri. Ideally, the column created to insert the SomaSUS code in the data of the Room objects of the original model would be automatically identified by Solibri as an existing parameter in its rules, in this case in Space Type.

CONCLUSIONS

From the designer's point of view, we can list some difficulties inherent to the reported process. First, the use of different tools exposes processes to the risk of losing information, due to the need to constantly adapt and change data transit between models, which can be not only to manage the flow between different formats, but also to avoid the bottlenecks caused by different versions. In addition to this problem, it is noteworthy that it would be desirable for the checks to be made in sync with the project definition stage, in which the designers make the decisions. By exchanging data between applications, the personal process of decision-making reflection is usually interrupted.

Another issue is related to the existence of several coding systems that should be harmonized and evolve in parallel with the project. It is usual for more than one code system to be involved in projects, a factor that hinders the harmonization process. In this sense, it is recommended that the structuring of traditional databases, that is, databases composed of tables that contain and relate records and fields, evolve to the structuring of "interconnected knowledge bases", common in Web-semantic environments. Knowledge bases are formatted as graphs and allocated in network environments with stable URI addressing. The graphs are composed of RDF triples, which can grow and help ensure the consistency of the information contained in the project, in addition to being able to be integrated with the current LLM (*Large Language Models*) systems used by generative AI systems, resulting in a public infrastructure of digital knowledge within the open and connected data paradigm proposed by Tim Berners-Lee. It is believed that an infrastructure of this type results in greater levels of integration and assertiveness of BIM processes.

Experience shows that each compartment of the building, in addition to the code that typifies it as an environment, must have a unique code that identifies it as an instance, in other words, "every compartment must have its own identity guaranteed within a logical coding system that is independent of the chosen application". This ensures the independence of the project in relation to the application used. The list of *RDF triples* may grow and be enriched with new knowledge as the project progresses or during the life of the building (example in Table 4).

Table 04 – *Triples* for Rooms *or Spaces* S01 and S02 of the model.

SUBJECT	PREDICATE	OBJECT
S01	está_em	Floor1
S01	é_tipo_somasus	AMB20
S01	tem_nome	"Doctor's office"
S01	nome_somasus	DENTAL OFFICE
S02	está_em	Floor1
S02	é_tipo_somasus	AMB20
S02	tem_nome	"Doctor's office"
S02	nome_somasus	DENTAL OFFICE

Source: The authors.

To format the structuring of knowledge suggested in this article, one of the main elements needed is the definition of ontologies. A SomaSUS ontology needs to express how the elements of the system should "be". This allows the definition of the query pattern composed of "subjects, objects and predicates", executed thanks to filtering languages such as SPARQL. The definition of the characteristics of the properties (transitivity, reflexivity, functionality, etc.) will allow to reduce the definition of rules, as it will increase the possibility of inferences by logical calculation. Another benefit that stands out and that is related to query independence is that it allows the knowledge model to be computationally agnostic, that is, independent of the various formats usually used by the applications of the AEC industries, whether proprietary or neutral. Ontologies are usually readable by computational agents and, depending on the language used to write them (Manchester and Turtle mainly), they are also easily readable by human agents. Therefore, we highlight as a strategic need the elaboration of specific domain ontologies for all public entities that manage built assets.

The environments, compartments and equipment of the model to be analyzed must be fully with the same nomenclature used in RDC-50 and SomaSUS, since the beginning of the conception. In the case of projects prepared by outsourcing, this obligation must already be included in the Term of Reference of the contracting and the inspection of the public agency must be attentive and already verify this issue, at each delivery of the product, at each phase of the project. The automation of this process deserves to be developed.

After checking the rule in Solibri, the report indicated that the model presented inadequate information for the process, that is, that it could not yet be considered validated. In order for Solibri to recognize SomaSUS parameters, the Revit parameter addressing must be equivalent to that of the verification software parameter. In this case, it is necessary to understand which parameter of the rule corresponds to the parameter of the model to be exported, in order to form the proper links and correspondences between the information.

Another simpler verification proposal than the experiment carried out with Solibri, could be performed from Revit, using the Schedules Keys type tables with the definition proposed for each type of compartment. By activating the Location Points of the families, the range of possible checks can be expanded, such as the inclusion of equipment necessary for each type of compartment.

Following this same line, a proposal is being developed for the organization of information in BIM models, using as parameters for the environment: SomaSUS code, SomaSUS name, SomaSUS sector and the name of each environment. In addition, the definition of the appropriate location of these parameters, for later use in the automatic checking of rules, fills in the gaps to be filled, according to a necessary standardization.

Through this research it is possible to infer that, by solving the difficulties encountered throughout the process, the automatic verification of RDC-50 requirements, both in the case of a space already built and in the case of a project not yet built, can minimize the risks of non-conformities that are usually pointed out, both in inspections by Anvisa and by accreditation bodies. It was also possible to verify that the automated evaluation of the requirements declared by the rules and regulations can speed up the process in a global way, bringing benefits to the professionals who prepare the projects, to those who have the function of verifying them and to those who supervise them.

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