Case study of Conformity Assessment based on ISO 31101 and Safety management systems of Robotic Services

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ABSTRACT

In response to demographic shifts such as declining birthrates and an aging population, Japan has pioneered the integration of service robots to mitigate labour shortages across various sectors. Unlike industrial robots, which are confined to manufacturing environments, service robots operate in public environments like restaurants, train stations, and airports, performing tasks ranging from food delivery to security and guidance. Their deployment in public spaces necessitates stringent safety protocols to ensure they can safely interact with and assist humans.
Conventionally, the safety of these robots has been managed by embedding protective functions directly into their designs. However, the diverse applications and environments these robots operate in present challenges for manufacturers alone to ensure comprehensive safety. Initially, robot developers focused heavily on safety, which extended development timelines and inflated costs, hindering widespread adoption.
Recognizing that safety is not solely dependent on hardware but also on usage, operation, and environmental factors, there has been a shift towards engaging users in risk communication. This approach aims to achieve a balanced safety assurance at a manageable cost, which is critical for the broader acceptance and implementation of service robots. To formalize these practices, Japan introduced the JIS Y1001 standard in 2019, focusing on operational safety management for service robots. Further efforts led by the National Institute of Advanced Industrial Science and Technology (AIST) culminated in the establishment of the international standard ISO 31101[1] in November 2023, which outlines safety management requirements for robotic service providers[2].
The Japan Quality Assurance Organization (JQA) proposed hypotheses regarding the benefits of ISO 31101, including enhancements to user experiences, service provider operations, and the value of third-party conformity assessments. To evaluate these hypotheses, Kawasaki Heavy Industries (KHI) conducted a case study in collaboration with AIST and JQA at a robotic restaurant. This study assessed interested parties identification, role distribution, documentation processes, and compliance with ISO 31101 standards. The findings indicated a need for clearer guidelines and support mechanisms to encourage adoption among application service providers (ASPs).
Overall, while ISO 31101 is likely to facilitate the expansion of service robots by standardizing safety and operational procedures, there remains a significant need to promote and support its benefits to ensure its widespread utilization. This standardization is anticipated to not only enhance safety but also accelerate the integration of robots into societal roles, thereby addressing labour shortages more effectively.

1 INTRODUCTION

In recent years, Japan has taken the lead in addressing the issue of labour shortages in response to the declining birthrate and aging society faced globally, and service robots have begun to be introduced in various industries to solve this problem. For example, service robots are being used to serve food in restaurants, clean floors and provide security and destination guidance at train stations and airports. Unlike industrial robots used in factories, service robots are used in public places, i.e., in environments where ordinary people are present. Therefore, it is important to ensure safety and security with the intention of coexistence, and even collaboration and cooperation, with people without harming them.
Regarding the safety of service robots, ISO 13482 was developed in 2014 based on a Japanese proposal, which provides requirements for the design and manufacture of safe service robots based on risk assessment. On the other hand, the applications and environments in which robots are used are diverse, and it is difficult for service robot manufacturers to design and manufacture robots to ensure safety in any application or usage. In other words, it is important for users to use and operate robots appropriately. From this perspective, Japan developed JIS Y 1001 in 2019, which focuses on operational safety management of service robots, and AIST in Japan led the way to the

publication of ISO 31101 in November 2023. There, the requirements for safety management for ASPs of robotic services were presented.

2 HYPOTHESIZED BENEFITS OF APPLYING ISO 31101

The authors hypothesize in this study that an Application Service Safety Management System (ASSMS) based on ISO 31101 will benefit ASP and improve their services as a benefit of applying ISO 31101. By establishing an ASSMS based on ISO 31101, an organization's system can be established, and work processes can be made more efficient by establishing an organization's system and clarifying work procedures and rules. As a result of its operations, ASP can implement reasonable safety measures. It is also considered to ensure and improve the safety and security of employees, as well as the joy of working, through visible management and common goal setting, etc. It is expected that the establishment and operation of operational systems will both improve services and assure profits. To verify this hypothesis, a case study of ISO 31101 conformity assessment was conducted on the robot restaurant service of Future Lab HANEDA at Haneda Innovation City, operated by KHI.

3 CONFORMITY ASSESSMENT BY A THIRD PARTY

JQA provides various services as a third-party conformity assessment body. Conformity assessment is defined in ISO/IEC 17000:2020[3] Conformity assessment - Vocabulary and general principles as “demonstration that specified requirements are fulfilled.” The results of an assessment by an independent third party are generally considered more reliable than an assessment by a supplier or a consumer since there is no risk of conflict of interest between the supplier and the consumer in the conformity assessment. For this reason, third-party assessment is considered meaningful in situations where high objectivity and reliability of assessment results are required. To confirm this, JQA conducted this case study together with AIST and KHI as a third-party conformity assessment body, as a fair and neutral party with no interest in the organization being assessed under ISO 31101.

4 SOCIAL DEMONSTRATION INITIATIVES AS A ROBOT MANUFACTURER

4.1 Basic Approach at KHI

For the future development of an aging society with a declining birthrate, the importance of activities or the social deployment and establishment of robotics has been recognized. We believe it is necessary to enhance and systematize operational management in using robots more wisely and efficiently. As a robot manufacturer, KHI is trying to show society how robots can be used in industrial and service fields, including their operational aspects, through examples of applications that take advantage of their various features. By proposing the application and operation of robots and utilizing them in product development, we aim to provide an open technology platform and mechanism based on social contribution. Based on these ideas, KHI is promoting a social experiment using robots at Haneda Innovation City in Tokyo. As an example, an application of robots in a restaurant is shown in Figure 1. As shown in Figure 2, the goal is to realize safety, security, and well-being in a world where humans and robots coexist with consideration for each other.

Figure 1. *Example of Robotics Social Demonstration*

Figure 2. *Example of Robot Restaurant Service*

4.2 Overview of Robot Services at Haneda Innovation City

A social demonstration of a robotics restaurant that cooperates with humans is being conducted at Haneda Innovation City in Tokyo to demonstrate the service robot and establish a system. As shown in Figure 3, the

restaurant is divided into three areas: cooking, serving drinks, and eating and drinking, with a variety of robots working in each area. The industrial robot shown in Figure 4 is used for cooking, the cooperative robot shown in Figure 5 for drinks, and the service robot shown in Figure 6 for serving. Robots in the cooking area are physically isolated from humans. The entrances and exits of the cooking and serving areas are isolated by electrical devices as mobile robots pass through them. Although cooperative robots are used for drinks, they are physically separated from each other in terms of risks such as spilled drinks. Catering robots operate in coexistence with humans. Therefore, trained operator staff monitors them.

These various robots are created in cooperation with many engineers and support members, and are operated with daily improvements and innovations. In the course of these activities, the world's first application of ISO 31101 was conducted in this study, which will be introduced in the next chapter and thereafter.

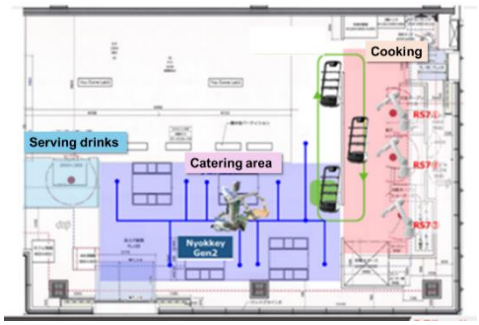

Figure 3. *Robot restaurant layout*

Figure 4. *Cooking (industrial robot)*

Figure 5. *Serving drinks (cooperative robot)*

Figure 6. *Catering (service robot)*

5 THE CASE STUDIES

ISO 31101 case studies were conducted at AIST, KHI and JQA based on the above situation. Assumptions were made that the case studies were based on the existence of a management system and processes for its operation. In addition, the assessment was not conducted on all the sections of the standard requirements. The case studies were conducted in two phases, 5.1 and 5.2. First, interested parties were identified and their roles and communication flows in the application service were organized (5.1). Next, the relation between the existing documents utilized in the robotic service at Haneda Innovation City and the documents that the standard requires to be documented was summarized and the content of the documents was discussed (5.2).

5.1 Identification and role organization of interested parties

The following steps were taken to carry out and the deliverables of this phase are shown in Figure 7.

1. identification of interested parties
2. determination of the scope of ISO 31101
3. organization of interest parties' roles

First, the interested parties involved in the robotic service were identified. This was because it was considered necessary to clarify the characters before organizing their roles. As a result of the identification, the interested parties for this service were as follows.

【KHI, SIer A/B, Deliverer, Restaurant operators, Guests, Researchers in the same place, Observers】

Next, the scope of application of ISO 31101 had to be clarified in order to organize the respective roles. Therefore, it was decided to define the scope of application as the lifecycle from service planning, system design to realisation of the service, and actual operation, and to use this as the axis for organizing the roles. While dividing the stages of the lifecycle in detail would enable an elaborate organization, it was considered that a simple organization would make it easier to obtain a common understanding among the parties concerned. As a result of efforts to simplify as much as possible, it was decided to divide the life cycle into four compartments.

According to the ISO 31101 definition, roles were assigned to identified interested parties. Interested parties were mapped to the life cycle axes to represent the scope of activities. In addition, the content and path of each activity were visualized by using arrows to represent the communication that occurs among interested parties. The results of the role organization showed that KHI plays three roles in Figure 7: RSP, ASP, and OPA. It can be read that the KHI is the main structure of the interested parties for the robotic service. With this, the interested parties and their interrelationships in the entire life cycle, the scope of application, can now be recognized with a glance.

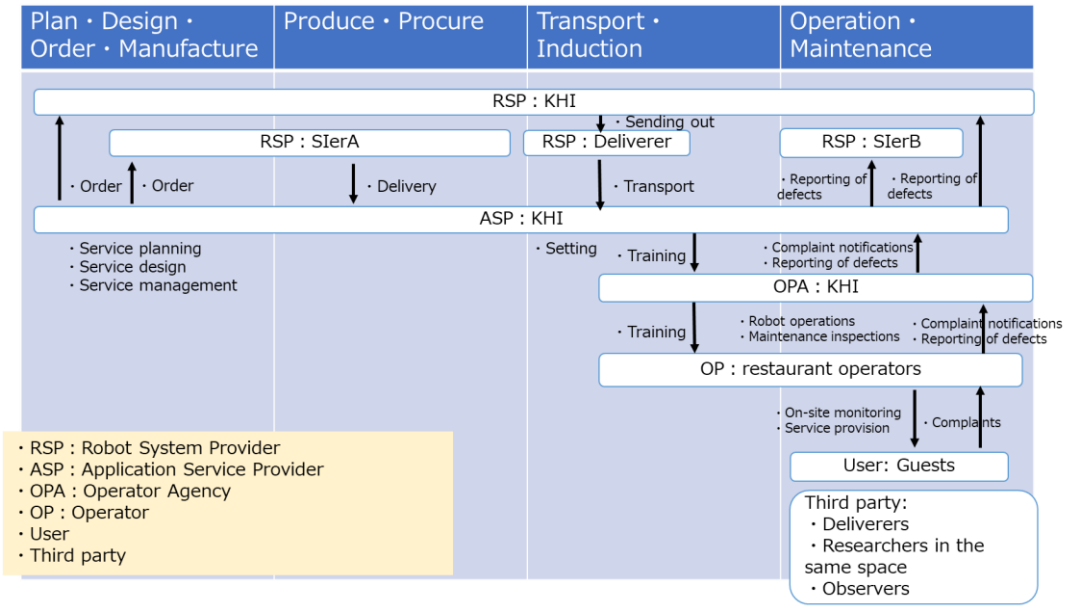

Figure 7 *Mapping of Interested parties and activity areas*

5.2 Review and comparison of the documentation utilised by the robotic service with the documentation required by the standard

The following steps were taken to carry out and the deliverables of this phase are shown in Table 1.

1. listing of documents required by ISO 31101 (columns 1 to 2 of Table 1)
2. identification of documents specific to ISO 31101 (columns 1to 2 of Table 1)
3. allocation of documents to be utilised in the robotic service (column 3 of Table 1)
4. review of the main body of documents utilised in the robotic service

The purpose of this phase is to check whether the documents developed by Haneda Innovation City meet the requirements of the standard and to identify issues to be considered for the main body of documentation from the perspective of the standard. First, a list of documents required to be documented from ISO 31101 was made, identifying the specific documents required by this standard and those that are also required by other management systems. It is expected that the integration of ASSMS into existing management systems in organizations that already have a management system in place will facilitate the smooth establishment of the system.

Following the listing of documents, relevant documents were drawn for each requirement, and an extract from the control table obtained through activities 1 to 3 is presented in Table 1.

Following the listing of documents, relevant documents were drawn against each requirement item; Table 1 shows extracts from the comparison table obtained through activities 1 to 3.

Table 1 *Comparison Table of Requirements Document and User Document (Extracted)*

	Documentation also required by other management system standards
	Documentation required by ISO 31101

Clause	Documents (Required)	Documents name (KHI)
4.3	The scope of ASSMS	- Documentation of the scope of ASSMS - Documentation of the scope of ASSMS_ANNEX
・ ・	・ ・	・ ・
6.4	The results of the safety risk assessment	- The results of the safety risk assessment (Catering service robot) - The results of the safety risk assessment (Serving drinks cooperative robot) - The results of the safety risk assessment (Cooking_ (industrial robot)
・ ・	・ ・	・ ・

Review of the documents identified in the comparison table was conducted. The examples extracted and shared in the case study are described here. In this case study, it shows that RSP and ASP were KHI from Figure 7. As a result, these documents made the risk assessment process difficult for third parties to see, since information was smoothly, but also implicitly, communicated within the same organization.

On the other hand, ISO 31101 Clause 6.4 is intended to conduct risk assessments for robotic services provided by ASP. The robots used in the service are based on the limited scope of the specification intended by RSP and risk assessments are carried out. Any remaining risks (residual risks) that result is provided to the robot user as use information form. Therefore, ASP implements the risk analysis by taking into account the intended limited scope of use, including the information on use, and the operational details of the robotic service. In other words, it is possible to conduct risk assessments in accordance with the standard and leave a communication trace, which leads to the certainty of the risk analysis and explains the validity of the risk assessment carried out.

6 EFFECTS AND POINTS TO CONSIDER IN APPLYING ISO 31101 IDENTIFIED IN THE CASE STUDY

According to the case study(5.1), the organization and clarification of the roles of internal and external interested parties related to the ASSMS made it possible to organize the roles and responsibilities of those involved and to establish the necessary communication processes. Furthermore, as ISO 31101 was published in November 2023 and KHI was the first to apply this standard, understanding of the requirements of the standard was deepened through the involvement of AIST as a member of the standard development committee and JQA as a third-party conformity assessment body.

As a result, not only helped to shorten the lead time for establishing a safety management system for robotic services, but also enabled the team to arrange the management items required for robotic services in a way that suited their own style, which gave them a sense of ownership of the management approach. When organizing interested parties at the service planning stage as the timing for organizing interested parties, it is necessary to picture each task and its scope of responsibility from the perspective of the entire service lifecycle. In addition, when the scale and complexity of the service increases, more man-hours will be allocated to organizing the roles, as it is imagined that there will be more people involved and more interactive tasks. Therefore, it should be noted that sufficient resources should be allocated and planned before starting activities.

It is expected that the results obtained from this case study can be used to help the ASP and each interested party to organize the boundary points of responsibilities of each organization in implementing the robotic application service. By being able to link the documentation required by the standard from the case study shown in 5.2 to the

documentation utilised in Haneda Innovation City, which reconfirmed the need for the documents to be utilised during operation. Furthermore, by documenting the processes required for the safety management system in a form that can be explained to third parties, this clarifies the policies, procedures and scope of responsibility within the organization, and is considered to lead to consistent operation based on a common understanding among various interested parties. The involvement of a third-party conformity assessment body in the case study was confirmed to be beneficial in terms of transparency and accountability of the assessment.

It is also considered that, if a management system has already been established based on the classification of the existing management system and the documents required by ISO 31101, a ASSMS can be established in the form of integrating activities related to ISO 31101 into the existing management system. In addition, since robotic services consist of a wide variety of robots, environments and interested parties, it is expected that changes will be required constantly. Rather than building a complete management system specific to robotic services, the first step would therefore be to identify the extent to which existing management systems can be utilised that can respond to changes in the market, and the new documentation required. To prevent the safety management system from becoming a distraction, it is expected that the operation of the safety management system will start from a small start and a sustainable and effective management system will be established by implementing PDCA cycles based on the safety management system, which will lead to the provision of safe robotic services.

7 CONCLUSION

The importance of operations involving people, robots and the environment was socially demonstrated through this case study based on the ISO 31101 standard. For robotic services, it is necessary for APSs to understand and manage the safety requirements for both the robot and the service, as they not only provide safe services, but also facilitate risk communication between the robot manufacturer and the user. However, there may be unknown hazards in robotic services, as they are moving from their infancy to a transitional phase. To address these roles and issues, it is important to establish structures for information on hazards in the field and for continuous improvement, using a management system based on ISO 31101. By establishing a management system, this will enable the same team to share a common understanding and goals, clarify what needs to be addressed in the workplace, and improve operational efficiency, so that they can concentrate on improvement activities and new insights that need to be made. As a result, not only workers' safety and security, but also their joy and happiness at work will be improved, and high-quality services can be provided to the users of the services.

During this activity, tasks and directions for incorporating ISO 31101 safety management systems into existing quality management systems were identified through discussions between "third party conformity assessment body" JQA and "service provider" KHI. Taking this activity as a foothold, it is necessary to promote the diffusion of safe robotic services by increasing the number of examples of the construction of management systems applying ISO 31101, clarifying issues and developing guidelines for robotic services, and so on.

8 REFERENCES

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