

# BIRD System Engineering with LLM

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# 1 Initial SE Objective and Process Generation

## Initial Prompt

We are a team of engineers in charge of the specification, the design and the implementation of a robot (named BIRD) which mission is to welcome visitors and to bring them to the right place. The robot will be deployed in a research institute named IRT (Institut de Recherche Technologique) at Toulouse in a building named B612. The robot will serve also to demonstrate our know-hows and will embed technological bricks we are developing at the IRT.

## 1.1 Process Generation

**AI Bot Role Prompt** You are an expert in Systems Engineer, Model-Based Systems Engineering, Requirements Engineering, Systems Modelling and Simulation. Your role is to support Systems Engineers in specifying, and designing critical cyber-physical systems, i.e., systems composed of software, hardware and physical materials interacting with a physical environment whose failure may lead to loss of human lives, money or reputation.

**Objective Prompt** We are a team of engineers in charge of the specification, the design and the implementation of a robot (named BIRD) which mission is to welcome visitors and to bring them to the right place. The robot will be deployed in a research institute named IRT (Institut de Recherche Technologique) at Toulouse in a building named B612. The robot will serve also to demonstrate our know-hows and will embed technological bricks we are developing at the IRT.

**Process Generation Task Prompt** The tasks you have to strictly follow are:

1. Extract the processes of the ISO 15288:2015 standard in which I shall be strongly involved, and that are really necessary to achieve my objective.
2. For each process, justify your reasoning and assumptions you made to answer.
3. For each process, identify how fundamentally the process contributes to fulfill my objective (not the system of interest objective or mission, but my objective). Put your result in the "close" attribute.
4. You can add further explanations or information about the rational that a process is close to my objective or not in the "otherInformation" attribute of the JSON below.

**Format Constraint Prompt** Strictly provide your complete answer in a JSON format. Follow the example below:

```
1 {
2   "processes": [
3     {
4       "processID": 1,
5       "ISO15288Process": "<your identified process>",
6       "title": "<Your title of the process here>",
7       "explanation": "<your justification here about why you choose
8         this process>",
9       "close" : "<true|false>"
10    },
11    // ... (other processes)
12  ],
13  "otherInformation" : "<your other information>"
}
```

Listing 1: JSON Format Constraint for the LLM Answer

Table 1: AI Generated Processes for Robot Development

Process ID	ISO 15288 Process	AI Title
1	Stakeholder Needs and Requirements Definition Process	Defining Stakeholder Needs and Requirements
2	System Requirements Definition Process	Defining System Requirements
3	Architecture Definition Process	Designing System Architecture
4	Implementation Process	Implementing the System
5	System Integration Process	Integrating the System
6	System Verification Process	Verifying the System
7	System Validation Process	Validating the System
8	System Deployment Process	Deploying the System
9	Operation Process	Operating the System
10	Maintenance Process	Maintaining the System

**AI Other Information:** The selected processes are fundamental to the development and operation of the robot, ensuring it meets the objectives of welcoming and guiding visitors while demonstrating the IRT’s technological capabilities. Each process contributes to the system’s lifecycle, from conception to deployment and maintenance, ensuring the robot’s effectiveness and reliability in the B612 environment.

## 2 Defining Stakeholder Needs and Requirements

This process is crucial to understand the needs and requirements of the stakeholders, including the visitors who will interact with the robot, and the IRT to showcase their technological capabilities. It ensures that the robot is designed to meet the intended purpose and functionality.

Table 2: Tasks for Stakeholder Needs and Requirements Definition

Task ID	Task Name	Explanation
1 <sub>1</sub>	Identify Stakeholders	Identifying all relevant stakeholders is critical to ensure that their needs and constraints are considered. Stakeholders include not only the end-users but also those involved in the development, maintenance, and regulation of the robot. This task involves creating a list of individuals, groups, or organizations that have a vested interest in the robot’s development and operation.
1 <sub>2</sub>	Conduct Stakeholder Interviews	This task involves engaging with the identified stakeholders to gather their explicit needs, expectations, and constraints related to the robot. Techniques such as interviews, surveys, workshops, and observation can be used to collect this information. The goal is to understand the context in which the robot will operate and the functions it must perform.
1 <sub>3</sub>	Develop Stakeholder Requirements Document	The analyzed needs are translated into formal stakeholder requirements. This task involves documenting the requirements in a clear, concise, and verifiable manner. Requirements should be categorized (e.g., functional, performance, usability) and prioritized to guide the system design process.

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Table 2: Tasks for Stakeholder Needs and Requirements Definition  
(continued)

Task ID	Task Name	Explanation
1 <sub>4</sub>	Prioritize Stakeholder Requirements Document	Prioritization helps in focusing on the most critical requirements first, ensuring that the most important needs are met within project constraints.
1 <sub>5</sub>	Validate Stakeholder Requirements	It is important to ensure that the defined stakeholder requirements accurately reflect the stakeholders' true needs and intentions. This task involves reviewing the requirements with stakeholders to confirm their correctness and completeness. Any discrepancies or misunderstandings should be resolved at this stage.
1 <sub>6</sub>	Establish a Base-line for Requirements	After validation, the stakeholder requirements should be base-lined, which means they are formally agreed upon and placed under change control. This task ensures that any future changes to the requirements are systematically evaluated and approved, maintaining the integrity of the requirements set.
1 <sub>7</sub>	Review and Approve Stakeholder Requirements Document	Formal approval ensures that all stakeholders are aligned and agree on the requirements, providing a solid foundation for subsequent processes.

## 2.1 Identify Stakeholders

Identifying all relevant stakeholders is critical to ensure that their needs and constraints are considered. Stakeholders include not only the end-users but also those involved in the development, maintenance, and regulation of the robot. This task involves creating a list of individuals, groups, or organizations that have a vested interest in the robot's development and operation.

**Input/Outputs Concepts** SystemMission  $\rightarrow$  Stakeholders

### Completeness Criteria

#### 1. Identification of All Relevant Stakeholders:

- All individuals and groups who have an interest in or will be affected by the robot must be identified. This includes, but is not limited to, visitors, staff, technology demonstrators, and any other relevant parties within the IRT environment.

#### 2. Documentation of Stakeholder Information:

- Each identified stakeholder must have their information documented, including their name, identifier, and any relevant documentation that describes their role and interest in the robot.

#### 3. Categorization of Stakeholders:

- Stakeholders should be categorized based on their roles and interests. This helps in understanding the different perspectives and needs that must be considered.

#### 4. Hierarchy and Relationships Among Stakeholders:

- Any hierarchical relationships among stakeholders should be identified and documented. This includes understanding if any stakeholders are ancestors or have sub-stakeholders (i.e., groups or individuals they represent).

## 5. Identification of Stakeholder Needs:

- The needs and requirements expressed by each stakeholder should be identified and documented. This ensures that their expectations and concerns are captured for further analysis.

## 6. Inclusion of Physical and Logical Connections:

- Any physical ports, properties, or logical connections (e.g., links, nodes, ports) related to stakeholders should be identified and documented. This helps in understanding how stakeholders interact with the system and each other.

## 7. Comprehensive Stakeholder List:

- A comprehensive list of stakeholders must be created, ensuring that no relevant stakeholder is omitted. This list should be reviewed and validated to confirm its completeness.

## Activities Performed

1. First extraction from a PDF file resulting in the first 6 stakeholders including the robot as it was defined as an actor in the initial version of the document.
2. STKH-006 "Other Visitors" was not clearly mentioned in the document. Hence, we asked the AI to add this Stakeholder to the list.
3. After discussion, we deleted the robot as it was decided that the robot is not a stakeholder but the System Of Interest itself
4. AI Completeness Cheking with STKH-001 to STKH-006: 40%.The AI proposed other stakeholders to complete the identification: STKH-007 to STKH-015.
5. STKH-015 was initialy External Partners and Sponsors: we splitted this Stakeholder into two separate SKTH-015 External Partners and STKH-016 Sponsors.
6. STKH-017 Visitors with Disabilities was identified during needs capture (see next section).
7. STKH-018 Cleaning Staff was identified during needs capture (see next section).

## Results

Table 3: Resulting Stakeholders and their Documentation

Identifier	Name	Documentation
STKH-001	Visitors	Individuals visiting the IRT within the B612 building, interacting with the robot for guidance to specific locations.
STKH-002	Supervisor	Responsible for monitoring and controlling the operation of one or more robots.
STKH-003	Maintenance Operator	In charge of the system's maintenance, particularly addressing potential breakdowns.
STKH-004	IRT Staff	Employees of the IRT who may interact with the robot for operational purposes or whom the visitors are there to see.
STKH-005	B612 Reception Staff	Individuals responsible for welcoming and registering visitors upon their arrival at the building.
STKH-006	Other Visitors	Visitors who may or may not require the assistance of the robot, including those not directly engaged with the technology or demonstrations but present within the robot's operational environment.

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Table 3: Resulting Stakeholders and their Documentation (continued)

Identifier	Name	Documentation
STKH-007	Research and Development Team	Group responsible for developing new technologies and ensuring the robot incorporates and showcases these effectively.
STKH-008	Safety and Compliance Department	Ensures the robot’s design and operation comply with safety regulations and industry standards.
STKH-009	IT Support Team	Provides the necessary IT infrastructure support and software maintenance for the robot’s operation.
STKH-010	Marketing and Public Relations	Utilizes the robot as a tool for marketing and enhancing the public image of the IRT’s innovation capabilities.
STKH-011	Facility Management	Manages the building’s physical environment to accommodate the robot’s operational needs.
STKH-012	Security Personnel	Interacts with the robot for building surveillance, access control, and emergency response coordination.
STKH-013	Funding and Finance Department	Oversees the financial aspects of the robot’s development and operation.
STKH-014	Legal and Regulatory Affairs	Ensures compliance with legal and regulatory requirements related to the robot’s development and deployment.
STKH-015	External Partners	Stakeholders with a financial or collaborative interest in the robot’s success, excluding direct sponsorship.
STKH-016	Sponsors	Entities or individuals who provide funding and support for the robot project, expecting visibility and recognition in return.
STKH-017	Visitors with Disabilities	Visitors who require special accessibility features to interact with the robot.
STKH-018	Cleaning Staff	Responsible for maintaining cleanliness and order within the operational environment of the robot, ensuring that the robot’s pathways are free of obstacles and debris.

## 2.2 Conduct Stakeholder Interviews

This task involves engaging with the identified stakeholders to gather their explicit needs, expectations, and constraints related to the robot. Techniques such as interviews, surveys, workshops, and observation can be used to collect this information. The goal is to understand the context in which the robot will operate and the functions it must perform.

**Input/Outputs Concepts** SystemMission ; Stakeholder  $\rightarrow$  Need

### Completeness Criteria

#### 1. Identification of Needs:

- Every identified stakeholder must have at least one expressed need documented.
- Each need must be clearly articulated and documented with sufficient detail to understand its context and importance.

#### 2. Traceability:

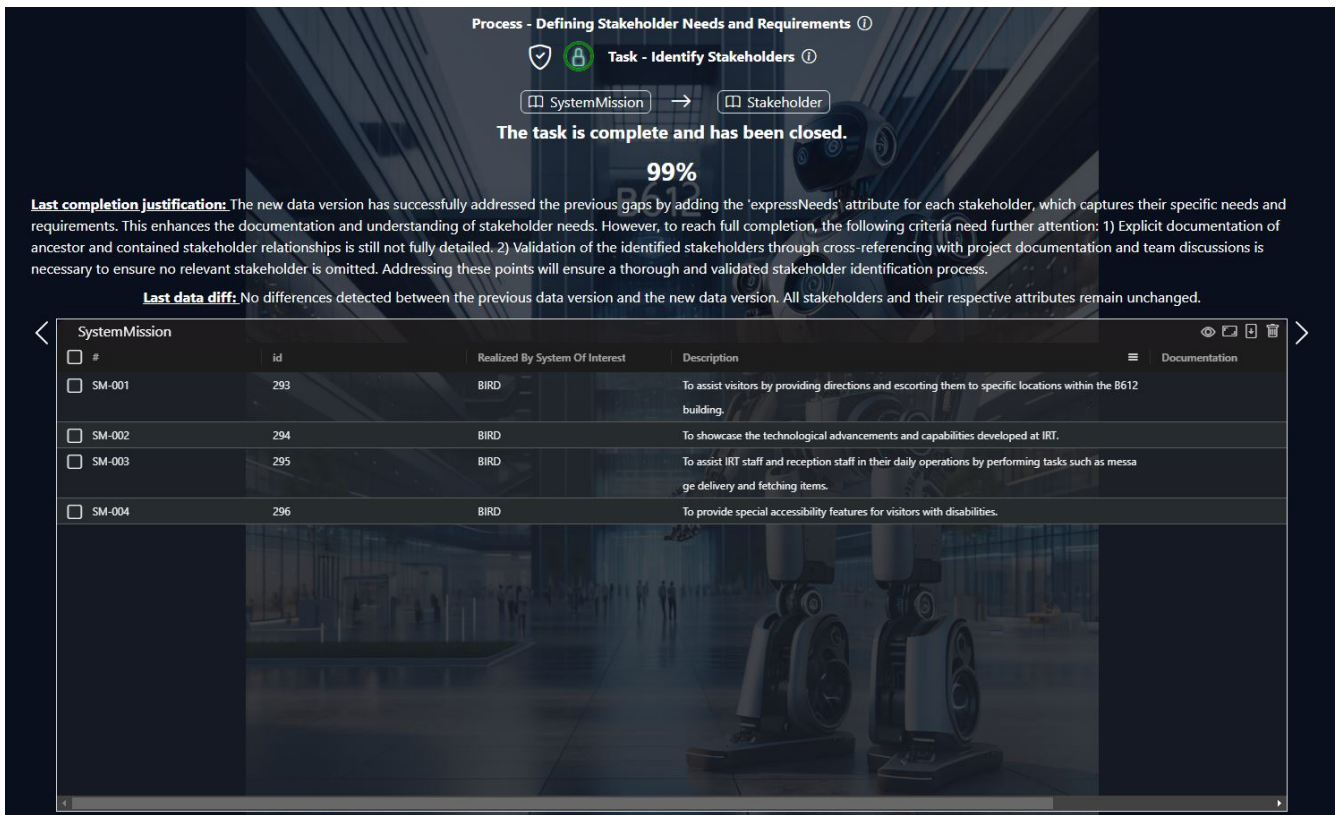


Figure 1: End of Task Identify Stakeholders

- Each need must be traceable back to the specific stakeholder who expressed it. This ensures that the origin of each need is clear and can be referenced in future discussions or validations.

### 3. Documentation:

- All needs must be documented in a structured format, including the name, identifier, and detailed text describing the need.
- The documentation should include any relevant context or additional information provided by the stakeholder during the interview.

### 4. Validation of Needs:

- Each need must be reviewed and confirmed with the stakeholder to ensure accuracy and completeness. This step ensures that the documented needs accurately reflect the stakeholder's intentions and expectations.

### 5. Comprehensive Coverage:

- The interviews should cover all identified stakeholders to ensure that no critical needs are missed. This includes visitors, staff, and technology demonstrators at IRT.
- The needs should encompass all relevant aspects of the robot's mission, including welcoming visitors, guiding them to the right place, and demonstrating technological capabilities.

### 6. Consistency:

- The needs should be consistent in terms of format and level of detail. This consistency helps in organizing and prioritizing the needs in subsequent tasks.

## Results

Table 4: AI Resulting Stakeholders Needs

Identifier	Name	Text	Expressed By
NEED-001	Guidance to Meeting Room	As a Visitor, I need to be guided to the meeting room / office in order to reach the meeting room at the appropriate time.	STKH-001
NEED-002	Guidance to Rest Room	As a Visitor, I need to be guided to the nearest rest room upon request.	STKH-001
NEED-003	Guidance to Reception Desk	As a Visitor, I need to be guided to the reception desk upon request.	STKH-001
NEED-004	Audio Conversation with Reception	As a Visitor, I need to have an audio conversation with the reception desk.	STKH-001
NEED-005	Inform Visitee of Arrival	As a Visitor, I need to inform the visitee that I have arrived at IRT, in the meeting room.	STKH-001
NEED-006	Information on IRT	As a Visitor, I need to be informed about the IRT history / organization / activities while waiting for the meeting time.	STKH-001
NEED-007	Global Indication for Meeting Room	As a Visitor, I need to receive global indication to reach the meeting room ('take the first corridor, use your badge to ...').	STKH-001
NEED-008	Know Robot Location	As a Supervisor, I need to know the current location of the robot.	STKH-002
NEED-009	Send Robot to Location	As a Supervisor, I need to request the robot to reach a certain location autonomously.	STKH-002
NEED-010	Remote Robot Control	As a Supervisor, I need to control the robot remotely (start, stop, sleep, drive...).	STKH-002
NEED-011	Visitor-Robot Separation Alert	As a Supervisor, I need to know that the visitor and the robot have been separated, including the time and location where the separation took place.	STKH-002
NEED-012	Audio Conversation with Visitor	As a Supervisor, I need to have an audio conversation with the visitor.	STKH-002
NEED-013	Failure Notification	As a Supervisor, I need to know the occurrence of a failure.	STKH-002
NEED-014	Emergency Stop Request	As a Supervisor, I need to request an emergency stop of the robot.	STKH-002
NEED-015	Know Failure Condition	As a Maintenance Operator, I need to know that a failure condition has occurred, including battery low.	STKH-003

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Table 4: AI Resulting Stakeholders Needs (Continued)

Identifier	Name	Text	Expressed By
NEED-016	Know Robot State	As a Maintenance Operator, I need to know the state of the robot.	STKH-003
NEED-017	Know Robot Location	As a Maintenance Operator, I need to know the location of the robot.	STKH-003
NEED-018	Test Robot Capabilities	As a Maintenance Operator, I need to test the capability of the robot to achieve its mission (autotests).	STKH-003
NEED-019	Replace Failing Parts	As a Maintenance Operator, I need to replace any failing/failed part within 1 hour.	STKH-003
NEED-020	Replace Weak Battery	As a Maintenance Operator, I need to replace a weak battery in 5 minutes.	STKH-003
NEED-021	Know Robot History	As a Maintenance Operator, I need to know the history of the robot's states, activities, events to support the maintenance activities.	STKH-003
NEED-022	Be Informed of Robot Assignment	As an IRT Staff member, I need to be informed that a robot has been assigned to a visitor.	STKH-004
NEED-023	Request Robot Start Guiding	As an IRT Staff member, I need to request the robot to start guiding the visitor to the meeting room, for instance when the visitor arrives earlier than the planned meeting time.	STKH-004
NEED-024	Visitor Guided to Meeting Room	As an IRT Staff member, I need to have the visitor guided to the meeting room so that they arrive at the planned meeting time.	STKH-004
NEED-025	Audio Conversation with Visitor	As an IRT Staff member, I need to have an audio conversation with the visitor.	STKH-004
NEED-026	Know Visitor Location to Meeting Room	As an IRT Staff member, I need to know the location of the visitor to the meeting room.	STKH-004
NEED-027	Know Visitor Reached Meeting Room	As an IRT Staff member, I need to know that the visitor has reached the meeting room.	STKH-004
NEED-028	Know Visitor and Robot Separation	As an IRT Staff member, I need to know that the visitor and the robot have been separated, including the time and location where the separation took place.	STKH-004
NEED-029	Inform Reception Desk of No Arrival	As an IRT Staff member, I need to inform the reception desk that the visitor has not arrived to the room.	STKH-004

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Table 4: AI Resulting Stakeholders Needs (Continued)

Identifier	Name	Text	Expressed By
NEED-030	Allocate Robot to Visitor	As B612 Reception Staff, I need to allocate a robot to a visitor for a certain visit (visitee and meeting room).	STKH-005
NEED-031	Robot Availability Information	As B612 Reception Staff, I need to be informed of the availability of a robot.	STKH-005
NEED-032	Visitor and Robot Separation Information	As B612 Reception Staff, I need to know that the visitor and the robot have been separated (and the time and location where the separation took place).	STKH-005
NEED-033	Current Robot Location	As B612 Reception Staff, I need to know the current location of the robot.	STKH-005
NEED-034	Visitor Under Visitee Control Confirmation	As B612 Reception Staff, I need to know that the visitor is under the control of the visitee.	STKH-005
NEED-035	Audio Conversation with Visitor	As B612 Reception Staff, I need to have an audio conversation with the visitor.	STKH-005
NEED-036	Emergency Stop of Robot	As B612 Reception Staff, I need to request an emergency stop of the robot.	STKH-005
NEED-037	Failure Condition Notification	As B612 Reception Staff, I need to know that a failure condition has occurred (including battery low).	STKH-005
NEED-038	Robot Harm Prevention	As Other Visitors, I need to be confident that the robot cannot harm people.	STKH-006
NEED-039	Technology Demonstration by R&D	As the Research and Development Team, I need to demonstrate our technology.	STKH-007
NEED-040	Robot Harm Prevention by Safety Department	As the Safety and Compliance Department, I need to be confident that the robot cannot harm people.	STKH-008
NEED-041	Inform Visitor About IRT Events	As Marketing and Public Relations, I need to inform visitors about the IRT events.	STKH-010
NEED-042	Demonstrate IRT Skills	As Marketing and Public Relations, I need to demonstrate the IRT skills.	STKH-010
NEED-043	Audio Conversation with Security	As Security Personnel, I need to have an audio conversation with the visitor.	STKH-012
NEED-044	Emergency Alert to Visitor	As Security Personnel, I need to inform a visitor of the occurrence of an emergency alert.	STKH-012
NEED-045	Visitor Access Control	As Security Personnel, I need to be confident that the visitor that is guided to a meeting room is actually allowed to do so.	STKH-012

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Table 4: AI Resulting Stakeholders Needs (Continued)

Identifier	Name	Text	Expressed By
NEED-046	Robot Location Information for Security	As Security Personnel, I need to be informed of the robot's location.	STKH-012
NEED-047	Emergency Stop by Security	As Security Personnel, I need to perform an emergency stop of the robot.	STKH-012
NEED-048	Safe Robot Placement	As Security Personnel, I need to place the robot to a safe place where it does not clutter the path.	STKH-012
NEED-049	RGPD Compliance	As Legal and Regulatory Affairs, I need to be confident that the system complies with the RGPD regulation.	STKH-014
NEED-050	Technology Demonstration by External Partners	As External Partners, I need to demonstrate their technology.	STKH-015
NEED-051	Sponsor Visibility	As Sponsors, I need to show our participation for communication purposes.	STKH-016
NEED-052	Interactive Map Display	As a Visitor, I need an interactive map displayed by the robot to get a visual understanding of the building layout.	STKH-001
NEED-053	Language Selection	As a Visitor, I need the robot to offer language options suitable for international visitors to ensure effective communication.	STKH-001
NEED-054	Automatic Check-In Process	As a Visitor, I need the robot to facilitate a check-in process, registering visitors upon arrival.	STKH-001
NEED-055	Personalized Greeting	As a Visitor, I need the robot to be able to greet visitors by name, using information from the pre-registration or check-in process.	STKH-001
NEED-056	Real-Time Scheduling Updates	As a Visitor, I need the robot to be able to inform visitors of any changes to their scheduled meetings.	STKH-001
NEED-057	Wi-Fi Connectivity Information	As a Visitor, I need the robot to provide information on how to connect to the building's Wi-Fi network.	STKH-001
NEED-058	Lost and Found Assistance	As a Visitor, I need the robot to assist in reporting or locating lost items within the building.	STKH-001
NEED-060	Accessibility Features	As a Visitor, I need the robot to have features to assist visitors with disabilities, such as audio descriptions for the visually impaired.	STKH-001
NEED-061	Visitor Feedback Collection	As a Visitor, I need the robot to collect feedback from visitors regarding their experience at the IRT.	STKH-001

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Table 4: AI Resulting Stakeholders Needs (Continued)

Identifier	Name	Text	Expressed By
NEED-062	Compact Size	As a Visitor, I need the robot to be compact enough to navigate crowded spaces without causing obstruction or inconvenience.	STKH-001
NEED-063	Aesthetic Design	As an IRT Staff member, I need the robot to have an aesthetic design that aligns with the IRT's image of innovation and technology.	STKH-004
NEED-064	Easy Maintenance Access	As a Maintenance Operator, I need the robot to have easily accessible compartments for quick maintenance and part replacement.	STKH-003
NEED-065	Safety Compliance	As the Safety and Compliance Department, I need the robot to comply with safety standards to ensure it poses no risk to humans.	STKH-008
NEED-066	Modular Design for Technology Integration	As the Research and Development Team, I need the robot to have a modular design to easily integrate and showcase new technologies.	STKH-007
NEED-067	Branding Space	As Marketing and Public Relations, I need the robot to include space for branding to promote the IRT.	STKH-010
NEED-068	Data Privacy Compliance	As Legal and Regulatory Affairs, I need the robot to be designed in compliance with data privacy laws like RGD.	STKH-014
NEED-069	Surveillance Capability	As Security Personnel, I need the robot to have surveillance capabilities to assist in building security.	STKH-012
NEED-070	Accessibility Features for Disabilities	As a Visitor with disabilities, I need the robot to have accessibility features such as voice commands and tactile interfaces.	STKH-017
NEED-071	Obstacle Detection and Avoidance	As Cleaning Staff, I need the robot to detect and avoid any obstacles during its operation to prevent interference with cleaning tasks.	STKH-018
NEED-072	Communication of Operational Schedules	As Cleaning Staff, I need the robot to inform me of its operational schedules or planned routes to coordinate cleaning activities effectively.	STKH-018
NEED-073	Emergency Stop and Manual Override	As Cleaning Staff, I need to have the ability to stop the robot or override its operations in case it obstructs the cleaning process or in emergencies.	STKH-018

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Table 4: AI Resulting Stakeholders Needs (Continued)

Identifier	Name	Text	Expressed By
NEED-074	Network Connectivity	As IT Support Team, I need the robot to have reliable network connectivity for remote monitoring and updates.	STKH-009

Table 5: Updated Stakeholders With Traceability to Needs

Name	Identifier	Express Needs
Visitors	STKH-001	NEED-001, NEED-002, NEED-003, NEED-004, NEED-005, NEED-006, NEED-007, NEED-052, NEED-053, NEED-054, NEED-055, NEED-056, NEED-057, NEED-058, NEED-060, NEED-061, NEED-062
Supervisor	STKH-002	NEED-008, NEED-009, NEED-010, NEED-011, NEED-012, NEED-013, NEED-014
Maintenance Operator	STKH-003	NEED-015, NEED-016, NEED-017, NEED-018, NEED-019, NEED-020, NEED-021, NEED-064
IRT Staff	STKH-004	NEED-022, NEED-023, NEED-024, NEED-025, NEED-026, NEED-027, NEED-028, NEED-029, NEED-063
B612 Reception Staff	STKH-005	NEED-030, NEED-031, NEED-032, NEED-033, NEED-034, NEED-035, NEED-036, NEED-037
Other Visitors	STKH-006	NEED-038
Research and Development Team	STKH-007	NEED-039, NEED-066
Safety and Compliance Department	STKH-008	NEED-040, NEED-065
IT Support Team	STKH-009	NEED-074
Marketing and Public Relations	STKH-010	NEED-041, NEED-042, NEED-067
Facility Management	STKH-011	NEED-048
Security Personnel	STKH-012	NEED-043, NEED-044, NEED-045, NEED-046, NEED-047, NEED-048, NEED-069
Funding and Finance Department	STKH-013	NEED-051
Legal and Regulatory Affairs	STKH-014	NEED-049, NEED-068
External Partners	STKH-015	NEED-050
Sponsors	STKH-016	NEED-051
Visitors with Disabilities	STKH-017	NEED-070
Cleaning Staff	STKH-018	NEED-071, NEED-072, NEED-073

### 2.3 Analyze Stakeholder Needs

Despite this task was not identified primarily as part of the process, we asked the chatbot to perform an analysis on the set of needs. The following is the complete discussion with the chatbot.



Hello. Can you help me in analysing the needs ?



Absolutely! I can help you analyze the needs expressed by the stakeholders for the robot (BIRD) project. Here are some key points we can focus on:

1. **Categorization of Needs**: We can categorize the needs based on the stakeholders, such as Visitors, Supervisors, Maintenance Operators, IRT Staff, and others. This will help us understand which stakeholder group has the most needs and what those needs are focused on.
2. **Common Themes**: We can identify common themes or patterns among the needs. For example, many needs may revolve around guidance, communication, safety, and operational efficiency.
3. **Prioritization**: We can discuss how to prioritize these needs based on their importance to the stakeholders and the overall mission of the robot. This will help in focusing on the most critical requirements first.
4. **Traceability**: We can ensure that each need is traceable back to the stakeholder who expressed it, which is essential for validation and future reference.
5. **Completeness and Gaps**: We can assess whether all relevant needs have been captured and if there are any gaps that need to be addressed.
6. **Validation**: We can discuss how to validate these needs with the stakeholders to ensure they accurately reflect their expectations.

Please let me know which specific aspect of the needs you would like to analyze, or if you have any particular questions in mind!



I would like to detect conflicts between the needs.



Detecting conflicts between needs is an important step in the requirements analysis process, as it helps ensure that the final system design can accommodate all stakeholder requirements without contradictions. Here are some potential areas where conflicts might arise among the needs expressed by different stakeholders:

1. **Conflicting Objectives**: - **Safety vs. Accessibility**: For example, the Safety and Compliance Department may have needs focused on ensuring the robot cannot harm people (e.g., NEED-040), while visitors with disabilities may require features that allow for more interaction with the robot (e.g., NEED-070). Balancing safety features with accessibility can lead to conflicts.
2. **Operational Constraints**: - **Maintenance vs. Performance**: The Maintenance Operator may have needs that require easy access to components for maintenance (e.g., NEED-064), while the design team may prioritize a compact and aesthetic design (e.g., NEED-063) that could hinder maintenance access.
3. **Communication Needs**: - **Visitor Interaction vs. Staff Control**: The needs of visitors for audio conversations with the robot (e.g., NEED-004) may conflict with the Supervisor's need for remote control over the robot (e.g., NEED-010). If the robot is engaged in a conversation with a visitor, it may not be responsive to remote commands.
4. **Resource Allocation**: - **Robot Availability vs. Visitor Guidance**: The B612 Reception Staff may need to allocate robots to visitors (e.g., NEED-030), while at the same time, the IRT Staff may need the robot to be available for guiding visitors (e.g., NEED-024). If multiple visitors require the robot simultaneously, it could lead to conflicts in resource allocation.
5. **Privacy vs. Surveillance**: - **Data Privacy Compliance vs. Security Needs**: The Legal and Regulatory Affairs department may have needs focused on compliance with data privacy laws (e.g., NEED-049), while Security Personnel may require surveillance capabilities (e.g., NEED-069). Balancing these needs can be challenging, especially if surveillance involves collecting personal data.
6. **Feedback vs. Control**: - **Visitor Feedback Collection vs. Supervisor Control**: The need for collecting visitor feedback (e.g., NEED-061) may conflict with the Supervisor's need to maintain control over the robot's operations (e.g., NEED-014). If the robot is focused on collecting feedback, it may not be able to respond to immediate control requests.

To systematically analyze these potential conflicts, you can:

- **List the Needs**: Create a matrix or table listing the needs and the stakeholders who expressed them.
- **Identify Conflicts**: Review the needs for potential conflicts based on the categories mentioned above.
- **Discuss with Stakeholders**: Engage with stakeholders to clarify their needs and understand the rationale behind them, which may help in resolving conflicts.

If you would like to explore specific needs in detail or need assistance in creating a conflict matrix, please let me know!



Could you elaborate on the Safety vs. Accessibility conflict ? I do not understand where a conflict can occur here.



Certainly! The potential conflict between safety and accessibility often arises when designing systems that need to be both safe for all users and accessible to individuals with disabilities. Let's break down how this might manifest in the context of the BIRD robot:

**Safety Needs - Safety and Compliance Department (NEED-040)**: This stakeholder requires assurance that the robot cannot harm people. This need emphasizes the importance of implementing robust safety measures, such as collision avoidance systems, emergency stop functions, and compliance with safety standards.

**Accessibility Needs - Visitors with Disabilities (NEED-070)**: This stakeholder group requires the robot to have accessibility features, such as voice commands and tactile interfaces, to ensure that individuals with disabilities can interact with the robot effectively.

**Potential Conflict Areas**

- 1. Proximity and Interaction**:
  - **Safety**: To ensure safety, the robot might be designed to maintain a certain distance from people to prevent accidental collisions. This could involve sensors that stop the robot if someone gets too close.
  - **Accessibility**: Visitors with disabilities might need to get closer to the robot to use tactile interfaces or to hear voice commands clearly. If the robot is too cautious and stops or moves away when someone approaches, it could hinder accessibility.

- 2. Response to Unexpected Movements**:
  - **Safety**: The robot might be programmed to react quickly to unexpected movements to avoid collisions, which could include stopping abruptly or changing direction.
  - **Accessibility**: For individuals with mobility impairments, sudden stops or changes in direction could be disorienting or even hazardous, especially if they rely on the robot for support or guidance.

- 3. Interface Design**:
  - **Safety**: The robot's interface might be designed to minimize distractions and ensure that users are aware of their surroundings, which could limit the complexity or interactivity of the interface.
  - **Accessibility**: Users with disabilities might require more interactive or detailed interfaces to accommodate their needs, such as larger buttons or more detailed audio descriptions.

**Resolving the Conflict** To address these potential conflicts, the design team can consider the following approaches:

- **User-Centered Design**: Engage with both safety experts and accessibility advocates during the design process to ensure that both perspectives are considered and integrated.
- **Adaptive Systems**: Implement adaptive features that can adjust the robot's behavior based on the user's needs. For example, the robot could have different modes for general use and for interacting with individuals with disabilities.
- **Testing and Iteration**: Conduct thorough testing with diverse user groups to identify and resolve any conflicts between safety and accessibility in real-world scenarios.

By carefully balancing these needs, the BIRD robot can be designed to be both safe and accessible, ensuring that it meets the requirements of all stakeholders. If you have any further questions or need more specific examples, feel free to ask!



Ok thank you. Do you identify other conflicts in the set of needs that are not yet identified ?





1. **Privacy vs. Interaction**: - **Privacy Needs**: Legal and Regulatory Affairs may emphasize the need for data privacy compliance (e.g., NEED-068), ensuring that any data collected by the robot is handled in accordance with privacy laws. - **Interaction Needs**: Visitors may require personalized interactions, such as greetings by name (e.g., NEED-055), which could involve collecting and processing personal data. Balancing personalized service with privacy concerns can be challenging.
2. **Efficiency vs. Personalization**: - **Efficiency Needs**: The robot may need to operate efficiently to guide multiple visitors simultaneously or perform tasks quickly (e.g., NEED-024). - **Personalization Needs**: Visitors may desire personalized experiences, such as language selection (e.g., NEED-053) or personalized greetings (e.g., NEED-055), which could slow down operations if not managed effectively.
3. **Autonomy vs. Control**: - **Autonomy Needs**: The robot is expected to operate autonomously, guiding visitors and performing tasks without constant supervision (e.g., NEED-009). - **Control Needs**: Supervisors and staff may need to intervene or control the robot remotely (e.g., NEED-010, NEED-014), which could conflict with its autonomous operations if not seamlessly integrated.
4. **Security vs. Accessibility**: - **Security Needs**: Security Personnel may require strict access control and surveillance capabilities (e.g., NEED-045, NEED-069) to ensure that only authorized individuals access certain areas. - **Accessibility Needs**: Visitors with disabilities may require easier access to facilities, which could conflict with stringent security measures if not carefully designed.
5. **Maintenance vs. Aesthetic Design**: - **Maintenance Needs**: Maintenance Operators require easy access to the robot's components for quick repairs (e.g., NEED-064). - **Aesthetic Design Needs**: IRT Staff may want the robot to have an aesthetic design that aligns with the institute's image (e.g., NEED-063), which could limit the ease of access for maintenance.
6. **Demonstration vs. Operational Use**: - **Demonstration Needs**: The Research and Development Team and Marketing may want the robot to showcase cutting-edge technology (e.g., NEED-039, NEED-042). - **Operational Use Needs**: The robot must also perform its primary functions effectively, such as guiding visitors (e.g., NEED-001), which could be compromised if too much focus is placed on demonstration features. To address these potential conflicts, it's essential to engage in stakeholder discussions, prioritize needs based on the robot's mission, and explore design solutions that can accommodate multiple requirements. If you need further analysis or specific examples, feel free to ask!



Ok! Do you see other conflicts or is it ok ?



Based on the detailed analysis of the needs provided, the potential conflicts identified earlier cover a broad range of areas where stakeholder requirements might clash. However, it's always beneficial to continuously review and analyze needs as the project progresses, as new conflicts might emerge with evolving requirements or as more detailed information becomes available. Here are a few additional considerations that might reveal further conflicts:

1. **Cost vs. Feature Set**: - **Cost Constraints**: The Funding and Finance Department may have strict budgetary constraints (e.g., NEED-051), which could limit the implementation of certain features. - **Feature Set Needs**: Various stakeholders might request advanced features, such as modular design for technology integration (e.g., NEED-066) or surveillance capabilities (e.g., NEED-069), which could increase costs.
2. **Training vs. Usability**: - **Training Needs**: Staff may require training to operate or interact with the robot effectively (e.g., NEED-022). - **Usability Needs**: The robot should be intuitive enough for visitors to use without extensive guidance (e.g., NEED-052), which might conflict with complex features that require training.
3. **Environmental Impact vs. Operational Efficiency**: - **Environmental Concerns**: There might be implicit needs related to minimizing the robot's environmental impact, such as energy efficiency or sustainable materials. - **Operational Efficiency**: The robot needs to perform its tasks efficiently, which might require trade-offs with environmental considerations, such as battery life or material choices.
4. **Scalability vs. Current Needs**: - **Scalability Needs**: The system might need to be scalable to accommodate future expansions or additional robots. - **Current Needs**: Immediate requirements might focus on current operational needs, potentially overlooking future scalability.

These considerations highlight the importance of maintaining an ongoing dialogue with stakeholders and revisiting the needs analysis as the project evolves. If you have specific areas you'd like to explore further or additional data becomes available, feel free to reach out for more tailored insights!



Ok anything else or did you identify all the potential conflicts on the actual needs ?



Based on the current set of needs and the analysis conducted, the potential conflicts identified should cover the major areas where stakeholder requirements might clash. However, it's important to note that the identification of conflicts is an iterative process. As the project progresses and more detailed information becomes available, new conflicts may emerge, and existing ones may evolve.

Here are a few additional considerations to ensure comprehensive conflict identification:

1. **Iterative Review**: Regularly revisit the needs and stakeholder requirements as the project develops. This helps in identifying new conflicts that may arise due to changes in project scope, technology, or stakeholder priorities.
2. **Stakeholder Workshops**: Conduct workshops or meetings with stakeholders to discuss and validate the identified needs and potential conflicts. This collaborative approach can uncover conflicts that might not be immediately apparent from the documentation alone.
3. **Scenario Analysis**: Perform scenario-based analysis to simulate how the robot will operate in different situations. This can help identify conflicts that may arise in specific operational contexts.
4. **Feedback Loops**: Establish feedback mechanisms to capture insights from stakeholders during the design and implementation phases. This can help in identifying and resolving conflicts early.
5. **Cross-Functional Teams**: Involve cross-functional teams in the analysis process to bring diverse perspectives and expertise, which can help in identifying conflicts that might be overlooked by a single team. By maintaining a proactive and collaborative approach, you can ensure that potential conflicts are identified and addressed effectively throughout the project lifecycle. If you have any further questions or need assistance with specific aspects of the needs analysis, feel free to ask!

These considerations highlight the importance of maintaining an ongoing dialogue with stakeholders and revisiting the needs analysis as the project evolves. If you have specific areas you'd like to explore further or additional data becomes available, feel free to reach out for more tailored insights!



Ok anything else or did you identify all the potential conflicts on the actual needs ?



Certainly! Here's a concise list of the potential conflicts identified among the needs for the BIRD robot project:

1. **Safety vs. Accessibility**: - Safety measures (e.g., collision avoidance) may conflict with accessibility features needed by visitors with disabilities.
2. **Privacy vs. Interaction**: - Data privacy compliance may conflict with personalized interactions that require processing personal data.
3. **Efficiency vs. Personalization**: - The need for operational efficiency may conflict with providing personalized experiences for visitors.
4. **Autonomy vs. Control**: - The robot's autonomous operations may conflict with the need for remote control by supervisors and staff.
5. **Security vs. Accessibility**: - Strict security measures may conflict with the need for easier access for visitors with disabilities.
6. **Maintenance vs. Aesthetic Design**: - Easy maintenance access may conflict with the desire for an aesthetic design that aligns with the IRT's image.
7. **Demonstration vs. Operational Use**: - The focus on showcasing technology may conflict with the robot's primary operational functions.
8. **Cost vs. Feature Set**: - Budget constraints may limit the implementation of advanced features requested by stakeholders.
9. **Training vs. Usability**: - The need for staff training may conflict with the requirement for the robot to be intuitive for visitors.
10. **Environmental Impact vs. Operational Efficiency**: - Minimizing environmental impact may conflict with the need for operational efficiency.
11. **Scalability vs. Current Needs**: - The need for scalability may conflict with focusing on immediate operational requirements.

These conflicts highlight areas where stakeholder needs may clash, requiring careful consideration and resolution during the design and development process. If you need further details or assistance, feel free to ask!



Ok and put the needs identifiers that are in conflicts for each category in your last answer please.



Certainly! Here's the list of potential conflicts with the associated need identifiers for each category:

1. **Safety vs. Accessibility**: - **Safety Needs**: NEED-040 (Safety and Compliance Department) - **Accessibility Needs**: NEED-070 (Visitors with Disabilities)
2. **Privacy vs. Interaction**: - **Privacy Needs**: NEED-068 (Legal and Regulatory Affairs) - **Interaction Needs**: NEED-055 (Visitors)
3. **Efficiency vs. Personalization**: - **Efficiency Needs**: NEED-024 (IRT Staff) - **Personalization Needs**: NEED-053, NEED-055 (Visitors)
4. **Autonomy vs. Control**: - **Autonomy Needs**: NEED-009 (Supervisor) - **Control Needs**: NEED-010, NEED-014 (Supervisor)
5. **Security vs. Accessibility**: - **Security Needs**: NEED-045, NEED-069 (Security Personnel) - **Accessibility Needs**: NEED-070 (Visitors with Disabilities)
6. **Maintenance vs. Aesthetic Design**: - **Maintenance Needs**: NEED-064 (Maintenance Operator) - **Aesthetic Design Needs**: NEED-063 (IRT Staff)
7. **Demonstration vs. Operational Use**: - **Demonstration Needs**: NEED-039 (Research and Development Team), NEED-042 (Marketing and Public Relations) - **Operational Use Needs**: NEED-001 (Visitors)
8. **Cost vs. Feature Set**: - **Cost Constraints**: NEED-051 (Sponsors) - **Feature Set Needs**: NEED-066 (Research and Development Team), NEED-069 (Security Personnel)
9. **Training vs. Usability**: - **Training Needs**: NEED-022 (IRT Staff) - **Usability Needs**: NEED-052 (Visitors)
10. **Environmental Impact vs. Operational Efficiency**: - **Environmental Concerns**: (Implicit need, not explicitly listed) - **Operational Efficiency**: NEED-024 (IRT Staff)
11. **Scalability vs. Current Needs**: - **Scalability Needs**: (Implicit need, not explicitly listed) - **Current Needs**: NEED-001 (Visitors)

Process - Defining Stakeholder Needs and Requirements ⓘ

✔ 🔒 Task - Conduct Stakeholder Interviews ⓘ

Stakeholder
SystemMission
→
Need

The task is complete and has been closed.

95%

**Last completion justification:** The new data version shows progress in terms of traceability and documentation. Several needs now include a 'traceToStakeholderRequirements' attribute, which enhances traceability. However, not all needs have this traceability link, indicating that bi-directional traceability is not fully achieved. 1. Identification of Needs: All stakeholders have expressed needs documented, satisfying this criterion. 2. Traceability: While some needs have traceability links, not all do, which affects the completion percentage. 3. Documentation: The needs are documented in a structured format, and some include additional context, meeting this criterion. 4. Validation of Needs: There is no explicit indication that all needs have been validated with stakeholders, which is necessary for full completion. 5. Comprehensive Coverage: The needs cover a wide range of stakeholders and aspects of the robot's mission, satisfying this criterion. 6. Consistency: The needs are consistent in format and detail. To improve completeness, ensure all needs have traceability links and validate them with stakeholders to confirm accuracy and completeness.

**Last data diff:** In the new data version, several updates have been made to the existing needs. The 'expressedByStakeholder' attribute has been updated to 'expressedByStakeholders' for all entries. Additionally, some needs now include a 'traceToStakeholderRequirements' attribute, such as NEED-001, NEED-039, NEED-040, NEED-065, and NEED-066, indicating a traceability link to specific stakeholder requirements. NEED-039 and NEED-066 also have a 'documentation' attribute added, providing additional context for these needs. No needs have been deleted, and no new needs have been added in this version.

Need	Trace To Stakeholder Requireme...	Expressed By Stakeholders	Text	Documentation	Name
<input type="checkbox"/> NEED-001	"SR-001"	STKH-001	As a Visitor, I need to be guided to the meeting room / office in order to reach the meeting room at the appropriate time.		Guidance to Meeting Room
<input type="checkbox"/> NEED-002		STKH-001	As a Visitor, I need to be guided to the nearest rest room upon request.		Guidance to Rest Room
<input type="checkbox"/> NEED-003		STKH-001	As a Visitor, I need to be guided to the reception desk upon request.		Guidance to Reception Desk
<input type="checkbox"/> NEED-004		STKH-001	As a Visitor, I need to have an audio conversation with the reception desk.		Audio Conversation with Reception
<input type="checkbox"/> NEED-005		STKH-001	As a Visitor, I need to inform the visitor that I have arrived at IRT, in the meeting room.		Inform Visitee of Arrival

Figure 2: End of Task Conduct Stakeholder Interviews

## 2.4 Develop Stakeholder Requirements Document

The analyzed needs are translated into formal stakeholder requirements. This task involves documenting the requirements in a clear, concise, and verifiable manner. Requirements should be categorized (e.g., functional, performance, usability) and prioritized to guide the system design process.

**Input/Outputs Concepts** Stakeholder; Need ; SystemMission  $\rightarrow$  *StakeholderRequirement*

### Completeness Criteria

#### 1. Traceability of Stakeholder Requirements to Needs:

- Each StakeholderRequirement must trace to at least one Need. This ensures that all requirements are directly addressing specific stakeholder needs.
- Verify that all Needs identified in previous tasks are traced to corresponding StakeholderRequirements.

#### 2. Association of Stakeholder Requirements with Stakeholders:

- Each StakeholderRequirement must be associated with one or more Stakeholders. This ensures that the requirements are grounded in the perspectives and needs of actual stakeholders.
- Confirm that all Stakeholders identified in previous tasks have their needs reflected in the StakeholderRequirements.

#### 3. Documentation of Stakeholder Requirements:

- Each StakeholderRequirement must have comprehensive documentation that includes the requirement text, rationale, and any relevant constraints or conditions.
- Ensure that the documentation is clear, unambiguous, and follows the authorized requirement syntax.

#### 4. System of Interest Realization:

- The SystemOfInterest must be defined and documented, including its name, identifier, and any relevant properties.
- Ensure that the SystemOfInterest includes all necessary SystemMissions that it is intended to realize.

#### 5. System Missions Association:

- Each SystemMission must be associated with the SystemOfInterest. This ensures that the missions the system is intended to accomplish are clearly defined and linked to the system.
- Verify that all SystemMissions are documented with their descriptions and identifiers.

#### 6. Consistency and Completeness of Requirements:

- Ensure that all StakeholderRequirements are consistent with each other, with no conflicts or contradictions.
- Confirm that the StakeholderRequirements collectively cover all identified Needs without any gaps.

#### 7. Verification and Validation Criteria:

- Each StakeholderRequirement must include criteria for verification and validation to ensure that the requirement can be tested and confirmed.
- Ensure that the requirements are feasible, measurable, and verifiable.

### Results

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-001	Guidance to Meeting Room Requirement	Ensures visitors reach their intended meeting location within the B612 building without delays. Verification involves testing the robot's ability to guide visitors to a designated meeting room within 5 minutes. Validation includes conducting field tests with actual visitors to ensure the guidance is clear, timely, and leads them directly to the correct meeting room.	Upon request, the robot shall guide visitors to the designated meeting room and ensure timely arrival within 5 minutes.	STKH-001	NEED-001
SR-002A	Collision Avoidance Requirement	This requirement ensures that the robot is equipped with collision avoidance systems to prevent any harm to people. Verification includes performing controlled environment tests to ensure the robot maintains a minimum distance of 0.5 meters from people and objects under various scenarios. Validation involves using feedback from stakeholders during live demonstrations to confirm effectiveness in real-world conditions.	The robot shall incorporate advanced collision avoidance systems that actively prevent collisions with people and objects, maintaining a minimum distance of 0.5 meters under all operational conditions.	STKH-008	NEED-040
SR-002B	Emergency Stop Mechanism Requirement	This requirement ensures that the robot includes an easily accessible and reliable emergency stop mechanism. Verification involves testing the emergency stop mechanism to ensure it halts all robot operations within 1 second of activation. Validation includes conducting drills involving different stakeholders to ensure the emergency stop is accessible and functional in various scenarios.	The robot shall include an emergency stop mechanism that can be activated manually and halts all robot operations within 1 second of activation.	STKH-008	NEED-040

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-002C	Safety Standards Compliance Requirement	This requirement ensures that the robot adheres to all relevant safety and regulatory standards. Verification involves reviewing design and engineering documents to confirm compliance with ISO 13482 and CE marking standards. Validation includes obtaining certification from a recognized safety standards body and gathering feedback from the Safety and Compliance Department.	The robot shall comply with all applicable safety standards, including ISO 13482 and CE marking, ensuring it poses no risk to humans under normal operating conditions.	STKH-008	NEED-065
SR-002D	Diagnostic Capabilities for Safety Monitoring Requirement	This requirement ensures that the robot has the capability to detect and report potential safety issues in real-time. Verification involves implementing diagnostic tests to verify the robot's capability to monitor its operational status and report safety issues within 10 seconds. Validation involves simulating potential safety scenarios to ensure the diagnostic system accurately detects and reports issues.	The robot shall include diagnostic capabilities that continuously monitor its operational status and report any potential safety issues within 10 seconds of detection.	STKH-008	NEED-065
SR-003A	Branding Space Provision	This requirement ensures that the robot includes designated spaces for branding to promote the IRT. Verification involves measuring the branding space to ensure it meets the specified dimensions of at least 500 square centimeters. Validation includes feedback from the Marketing team to confirm visibility and aesthetic alignment with IRT branding guidelines, as well as stakeholder satisfaction surveys to assess the impact of branding on visitor perception.	The robot shall include designated spaces for branding that are visible and customizable to accommodate different marketing materials, with a minimum area of 500 square centimeters on visible surfaces.	STKH-010	NEED-067



Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-003B	IRT Skills Demonstration Capability	This requirement ensures that the robot can demonstrate specific IRT skills or technologies during interactions with visitors. Verification includes testing the demonstration features to ensure they function as intended and can switch between at least three different technologies within 30 seconds. Validation involves observing visitor engagement during demonstrations and gathering feedback to assess the effectiveness and clarity of the demonstrations, as well as quantifying visitor interest and understanding through interactive quizzes or feedback forms.	The robot shall be capable of demonstrating selected IRT skills or technologies in an interactive manner to visitors, with the capability to switch between at least three different technologies during a single interaction.	STKH-010	NEED-042
SR-003C	IRT Events Information Provision	This requirement ensures that the robot is equipped to inform visitors about upcoming or ongoing events at the IRT. Verification involves testing the robot's ability to access and relay event information accurately and in real-time. Validation includes assessing visitor feedback to ensure the information provided enhances their visit experience and increases their engagement with IRT events.	The robot shall be capable of accessing and displaying information about IRT events to visitors in real-time, ensuring the information is current and accurate.	STKH-010	NEED-041

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-RDT001	Technology Demonstration Capability	This requirement ensures that the robot can effectively demonstrate the technologies developed by the R&D team. Verification includes demonstrations in controlled environments to ensure functionality and ease of integration. Validation involves feedback from technology demonstrations at public and internal events to assess the impact and clarity of the technology showcased.	The robot shall have the capability to integrate and demonstrate technologies developed by the R&D team, with features that allow easy swapping and showcasing of these technologies.	STKH-007	NEED-039
SR-RDT002	Modular Design for Technology Integration	This requirement ensures that the robot's design supports easy integration of new technologies. Verification involves modular system tests to confirm ease of integration and stability. Validation includes trials by the R&D team to ensure that new modules can be integrated within specified time limits without technical issues.	The robot shall feature a modular design that allows for the quick and easy integration of new technological modules developed by the R&D team.	STKH-007	NEED-066
SR-002E	Accessibility Interface Requirement	This requirement ensures that the robot is equipped with voice command capabilities and tactile interfaces to assist visitors with disabilities. Verification includes user testing with individuals having various disabilities to ensure the interfaces are intuitive and effective. Validation involves feedback from disability advocacy groups to confirm the interfaces meet the needs of users with disabilities.	The robot shall include voice command capabilities and tactile interfaces that are easily accessible and usable by visitors with disabilities. The voice command system shall recognize and accurately execute commands with at least a 95% success rate under typical operating conditions. Tactile interfaces shall provide responsive feedback within 1 second of interaction.	STKH-017	NEED-070

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-004	Guidance to Rest Room Requirement	This requirement ensures that visitors can be guided to the nearest rest room upon request. Verification involves testing the robot's ability to accurately and promptly guide visitors to the nearest rest room. Validation includes conducting field tests with actual visitors to ensure the guidance is clear, timely, and leads them directly to the correct rest room.	Upon request, the robot shall guide visitors to the nearest rest room and ensure timely arrival within 3 minutes.	STKH-001	NEED-002
SR-005	Guidance to Reception Desk Requirement	This requirement ensures that visitors can be guided to the reception desk upon request. Verification involves testing the robot's ability to accurately and promptly guide visitors to the reception desk. Validation includes conducting field tests with actual visitors to ensure the guidance is clear, timely, and leads them directly to the correct reception desk.	Upon request, the robot shall guide visitors to the reception desk and ensure timely arrival within 2 minutes.	STKH-001	NEED-003
SR-006	Audio Conversation with Reception Requirement	This requirement ensures that visitors can have an audio conversation with the reception desk through the robot. Verification involves testing the robot's ability to establish and maintain a clear audio connection with the reception desk under various conditions, including different noise levels and distances. Validation includes conducting field tests with actual visitors to ensure the audio quality is satisfactory and the connection is reliable. Feedback from both visitors and reception staff will be gathered to assess the effectiveness of the communication feature.	The robot shall facilitate audio conversations between visitors and the reception desk, ensuring clear and reliable communication with a minimum audio clarity rating of 4 out of 5 as rated by users, and maintaining connection stability for at least 95% of the conversation duration.	STKH-001	NEED-004

<b>Identifier</b>	<b>Name</b>	<b>Documentation</b>	<b>Requirement Text</b>	<b>Stakeholders</b>	<b>Trace to Needs</b>
SR-007	Visitor Arrival Notification Requirement	This requirement ensures that the robot can notify the visatee of a visitor's arrival at the IRT. Verification involves testing the robot's ability to send notifications to the visatee promptly and accurately. Validation includes conducting field tests with actual visitors and visatees to ensure the notification process is reliable and meets the expectations of both parties. Feedback will be gathered from visatees to assess the effectiveness and timeliness of the notifications.	The robot shall notify the visatee of a visitor's arrival within 1 minute of the visitor's check-in, ensuring the notification is accurate and includes the visitor's name and meeting details.	STKH-001	NEED-005
SR-008	IRT Information Provision Requirement	This requirement ensures that the robot can provide visitors with information about the IRT's history, organization, and activities. Verification involves testing the robot's ability to access and relay accurate information. Validation includes conducting field tests with actual visitors to ensure the information provided is engaging, informative, and enhances their visit experience. Feedback will be gathered from visitors to assess the clarity and usefulness of the information.	The robot shall provide visitors with information about the IRT's history, organization, and activities, ensuring the information is accurate and engaging, with a minimum visitor satisfaction rating of 4 out of 5.	STKH-001	NEED-006

<b>Identifier</b>	<b>Name</b>	<b>Documentation</b>	<b>Requirement Text</b>	<b>Stakeholders</b>	<b>Trace to Needs</b>
SR-009	Global Indication for Meeting Room Requirement	This requirement ensures that the robot can provide visitors with global indications to reach the meeting room, such as directional guidance and access instructions. Verification involves testing the robot's ability to deliver clear and accurate directions. Validation includes conducting field tests with actual visitors to ensure the guidance is understandable and effective in helping them reach the meeting room. Feedback will be gathered from visitors to assess the clarity and usefulness of the guidance provided.	The robot shall provide visitors with global indications to reach the meeting room, including directional guidance and access instructions, ensuring clarity and accuracy with a minimum visitor satisfaction rating of 4 out of 5.	STKH-001	NEED-007
SR-010	Interactive Map Display Requirement	This requirement ensures that the robot can display an interactive map to help visitors understand the building layout. Verification involves testing the robot's ability to display a map that is interactive and easy to navigate. Validation includes conducting field tests with actual visitors to ensure the map is helpful and enhances their ability to navigate the building. Feedback will be gathered from visitors to assess the usability and effectiveness of the map display.	The robot shall display an interactive map that allows visitors to view and navigate the building layout, ensuring usability and effectiveness with a minimum visitor satisfaction rating of 4 out of 5.	STKH-001	NEED-052

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-011	Language Selection Capability Requirement	<p>This requirement ensures that the robot offers language options suitable for international visitors to ensure effective communication. Verification involves testing the robot's ability to switch between different languages quickly and maintain accurate communication. Validation includes conducting field tests with visitors speaking various languages to ensure the language selection feature is intuitive and effective. Feedback will be gathered from visitors to assess the ease of use and effectiveness of the language options provided.</p>	<p>The robot shall offer language selection options to visitors, supporting at least five languages, ensuring effective communication with a minimum visitor satisfaction rating of 4 out of 5, and achieving language switching within 2 seconds.</p>	STKH-001	NEED-053
SR-012	Language Translation Accuracy Requirement	<p>This requirement ensures that the robot provides accurate language translation to facilitate effective communication with international visitors. Verification involves testing the translation accuracy across supported languages. Validation includes conducting field tests with native speakers to ensure the translations are accurate and contextually appropriate. Feedback will be gathered from visitors to assess the accuracy and reliability of the translations provided.</p>	<p>The robot shall provide language translation with an accuracy rate of at least 95% for supported languages, ensuring effective communication and understanding.</p>	STKH-001	NEED-053

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-013	Automatic Check-In Process Requirement	This requirement ensures that the robot facilitates an efficient and user-friendly check-in process for visitors upon arrival. Verification involves testing the robot's ability to register visitors automatically and accurately within a specified time frame. Validation includes conducting field tests with actual visitors to ensure the check-in process is seamless and enhances the visitor experience.	The robot shall facilitate an automatic check-in process for visitors, ensuring registration is completed within 1 minute of arrival, with an accuracy rate of at least 95%.	STKH-001	NEED-054
SR-014	Personalized Greeting Requirement	This requirement ensures that the robot provides a personalized experience by greeting visitors by name, using data from pre-registration or check-in processes. Verification involves testing the robot's ability to accurately retrieve and use visitor names for greetings. Validation includes conducting field tests with actual visitors to ensure the greeting process is seamless and enhances the visitor experience.	The robot shall greet visitors by name using pre-registration or check-in data, ensuring a personalized experience with a minimum accuracy rate of 95%.	STKH-001	NEED-055
SR-015	Real-Time Scheduling Updates Requirement	This requirement ensures that the robot provides visitors with real-time updates on any changes to their scheduled meetings. Verification involves testing the robot's ability to access and relay scheduling updates promptly and accurately. Validation includes conducting field tests with actual visitors to ensure the update process is seamless and enhances the visitor experience.	The robot shall provide real-time updates on scheduling changes to visitors, ensuring notifications are delivered within 1 minute of the change.	STKH-001	NEED-056

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-016	Wi-Fi Connectivity Information Requirement	This requirement ensures that the robot provides visitors with clear and concise instructions on connecting to the building's Wi-Fi network. Verification involves testing the robot's ability to access and relay Wi-Fi connectivity information accurately. Validation includes conducting field tests with actual visitors to ensure the information is easy to understand and enhances their experience.	The robot shall provide visitors with instructions on connecting to the building's Wi-Fi network, ensuring clarity and ease of understanding, with the information being delivered within 10 seconds of the request.	STKH-001	NEED-057
SR-017	Lost and Found Assistance Requirement	This requirement ensures that the robot assists visitors in reporting and locating lost items within the building. Verification involves testing the robot's ability to log lost item reports and provide guidance or information on retrieving them. Validation includes conducting field tests with actual visitors to ensure the process is user-friendly and effective.	The robot shall assist visitors in reporting and locating lost items within the building, ensuring a response time of less than 5 minutes.	STKH-001	NEED-058
SR-018A	Accessibility Features Compliance Requirement	This requirement ensures that the robot is equipped with features to assist visitors with disabilities, ensuring compliance with relevant accessibility standards. Verification involves testing the robot's ability to meet these standards effectively.	The robot shall comply with relevant accessibility standards to assist visitors with disabilities.	STKH-001	NEED-060
SR-018B	Accessibility Features Responsiveness Requirement	This requirement ensures that the robot's accessibility features respond promptly to user interactions. Validation includes conducting field tests with individuals with disabilities to ensure the features are intuitive and meet their needs.	The robot's accessibility features shall respond to user interactions within 2 seconds.	STKH-001	NEED-060



Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-019	Visitor Feedback Collection Requirement	This requirement ensures that the robot is capable of collecting feedback from visitors regarding their experience at the IRT. Verification involves testing the robot's ability to prompt visitors for feedback and securely store the collected data. Validation includes conducting field tests with actual visitors to ensure the feedback process is user-friendly and encourages participation.	The robot shall collect feedback from visitors regarding their experience, ensuring the process is user-friendly, completed within 2 minutes per interaction, and feedback is stored securely.	STKH-001	NEED-061
SR-020	Compact Size Requirement	This requirement ensures that the robot is designed to be compact, allowing it to navigate crowded spaces without causing obstruction or inconvenience to visitors. Verification involves testing the robot's ability to move through various environments with different crowd densities. Validation includes conducting field tests to ensure the robot's size and maneuverability meet the expectations of visitors and do not impede movement.	The robot shall have a compact design that allows it to navigate crowded spaces without causing obstruction, ensuring a maximum width of 0.5 meters.	STKH-001	NEED-062
SR-021	Real-Time Robot Location Information Requirement	This requirement ensures that the Supervisor can monitor the robot's current location at all times, which is crucial for operational oversight and coordination. Verification involves testing the robot's ability to transmit location data accurately and consistently under various conditions. Validation includes conducting field tests with Supervisors to ensure the location information meets their operational needs and expectations.	The robot shall provide real-time location information to the Supervisor, ensuring location updates are accurate within 5 meters and delivered every 10 seconds.	STKH-002	NEED-008

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-022	Autonomous Navigation Command Requirement	This requirement ensures that the Supervisor can direct the robot to specific locations within the operational environment, enhancing operational flexibility and responsiveness. Verification involves testing the robot's ability to accurately interpret and execute navigation commands under various conditions. Validation includes conducting field tests with Supervisors to ensure the navigation process is reliable and meets their operational needs.	The robot shall be capable of receiving and executing navigation commands from the Supervisor to autonomously reach a specified location, ensuring arrival within 2 meters of the target location and confirming successful arrival within 1 minute of reaching the destination.	STKH-002	NEED-009
SR-023A	Remote Start/Stop Control Requirement	This requirement ensures that the Supervisor can remotely start and stop the robot, providing operational flexibility. Verification involves testing the robot's ability to execute start/stop commands accurately and promptly. Validation includes field tests with Supervisors to ensure reliability.	The robot shall allow the Supervisor to remotely start and stop its operations through a secure interface, ensuring command execution within 2 seconds.	STKH-002	NEED-010
SR-023B	Remote Driving Control Requirement	This requirement ensures that the Supervisor can remotely drive the robot, enhancing operational control. Verification involves testing the robot's ability to execute driving commands accurately and promptly. Validation includes field tests with Supervisors to ensure usability.	The robot shall allow the Supervisor to remotely control its driving operations through a user-friendly interface, ensuring command execution within 2 seconds.	STKH-002	NEED-010

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-023C	Remote Control Security Requirement	This requirement ensures that the remote control system is secure, preventing unauthorized access. Verification involves testing the security features of the remote control system, including logging and response times to unauthorized access attempts. Validation includes security assessments to ensure compliance with standards and effectiveness in real-world scenarios.	The robot's remote control system shall include security measures to prevent unauthorized access, ensuring that all access attempts are logged and unauthorized access attempts are blocked within 1 second.	STKH-002	NEED-010
SR-024	Visitor-Robot Separation Alert Requirement	This requirement ensures that the Supervisor is promptly informed if the visitor and the robot become separated, allowing for quick intervention if necessary. Verification involves testing the robot's ability to detect separation events and transmit alerts accurately and promptly. Validation includes conducting field tests with Supervisors to ensure the alert system meets their operational needs.	When the visitor and the robot become separated, the robot shall alert the Supervisor by providing the time and location of the separation event within 10 seconds.	STKH-002	NEED-011
SR-025A	Audio Clarity Requirement	This requirement ensures that the audio communication between the Supervisor and the visitor is clear and understandable. Verification involves testing the audio clarity under various conditions. Validation includes gathering user feedback to ensure the audio quality meets expectations.	The robot shall facilitate audio communication between the Supervisor and the visitor, ensuring a minimum audio clarity rating of 4 out of 5 as rated by users.	STKH-002	NEED-012

Identifier	Name	Documentation	Requirement Text	Stakeholders	Trace to Needs
SR-025B	Connection Stability Requirement	This requirement ensures that the audio connection remains stable throughout the conversation. Verification involves testing the connection stability under various conditions. Validation includes field tests to confirm the reliability of the connection.	The robot shall maintain audio communication stability for at least 95% of the conversation duration between the Supervisor and the visitor.	STKH-002	NEED-012
SR-026	Failure Notification Requirement	This requirement ensures that the Supervisor is promptly informed of any operational failures, allowing for quick intervention and resolution. Verification involves testing the robot's ability to detect failures and transmit notifications accurately and promptly. Validation includes conducting field tests with Supervisors to ensure the notification system meets their operational needs.	The robot shall notify the Supervisor of any operational failures, providing detailed diagnostics and suggested corrective actions within 30 seconds of failure detection.	STKH-002	NEED-013
SR-027	Emergency Stop Capability Requirement	This requirement ensures that the Supervisor can quickly halt the robot's operations in case of an emergency, providing a critical safety feature. Verification involves testing the robot's ability to execute the emergency stop command accurately and promptly. Validation includes conducting field tests with Supervisors to ensure the emergency stop function meets their operational needs and expectations.	The robot shall allow the Supervisor to initiate an emergency stop, halting all operations immediately within 1 second of the command being issued.	STKH-002	NEED-014

### 3 Defining System Requirements

This process translates stakeholder requirements into a set of technical requirements for the robot, ensuring that it will perform as expected in the B612 environment and will be equipped with the necessary technological bricks developed at the IRT.

## **4 Designing System Architecture**

The architectural design process is essential to create a blueprint of the robot's system, including hardware, software, and physical components, ensuring that all parts work together to fulfill the robot's mission effectively.

## **5 Implementing the System**

This process involves the actual building or coding of the robot's components based on the system architecture. It is necessary to turn the design into a functional robot that can operate in the B612 environment.

## **6 Integrating the System**

Integration is key to ensure that the robot's components and technological bricks from the IRT work together seamlessly and that the robot can perform its welcoming and guiding tasks without issues.

## **7 Verifying the System**

Verification is necessary to confirm that the robot meets all the defined requirements and is ready for operation in the B612 environment, ensuring reliability and safety for visitors.

## **8 Validating the System**

Validation ensures that the robot fulfills its intended purpose and meets the needs of the IRT and its visitors. It is a critical step to demonstrate the robot's capabilities and the IRT's technological advancements.

## **9 Deploying the System**

Deployment is the final step where the robot is placed into the B612 environment and starts operating. It is essential to achieve the objective of having a functional robot to welcome and guide visitors.

## **10 Operating the System**

The operation process is necessary to manage the day-to-day functionality of the robot, ensuring it performs its tasks consistently and is maintained as needed.

## **11 Maintaining the System**

Maintenance is important to keep the robot operational over time, addressing wear and tear, software updates, and other issues that may arise during its lifecycle.