

# TRAILS

## Configurability

The ability of the system to be configured to perform a task or reconfigured to perform different tasks. This may range from the ability to re-program the system to be able to alter the physical structure of the system (e.g. by changing a tool).

Level	Level name	Description
0	Static Configuration	The configuration files (software) or mechatronic configuration are set prior to installation and cannot be altered by the user.
1	Start-up Configuration	The configuration files or the mechatronic configuration can be altered by the user prior to each task in order to customise the system in advance of each cycle of operation.
2	User Run-time Configuration	The configuration, both in terms of software operating parameters or mechatronic configuration, can be altered by the user during the cycle of operation.
3	Run-time Self Configuration	The system can alter its own configuration within a pre-determined set of alternative configurations designed into the system.
4	Autonomous Configuration	The system can alter its own configuration in response to external factors, for example altering its morphology in response to the failure of a sensor or actuator. Note that altering configuration must be carefully distinguished from actions taken as a part of the normal autonomous operation of the system.

## Adaptability

The ability of the system to adapt itself different work scenarios, different environments, and conditions (may also include the patient). Adaptation may take place over long or short time scales.

Level	Level name	Description
0	No adaptation	The system does not alter its operating behavior in response to experience gained over time.
1	Recognition of the need for adaptation	The system recognizes the need for parameter/component/task adaptation. The system identifies the problem but does not yet know how to correct it.
2	Adaptation of individual components/parameters/tasks	The system alters individual parameters/components/tasks in any part of the system based on assessments of performance local to the module on which the parameter operates.
3	Process chain adaptation / Multiple parameters adaptation	The system alters several parameters/components/tasks based on the aggregate performance of a set of interconnected or closely coupled modules.
4	Communicated component/parameter adaptation	The process of adaptation is carried out between multiple independent agents. The adaptation is communicated between agents and applied individually within each agent. Agents can be both real and simulated and of different types.

## Dependability

The ability of the system to perform its given task(s) without systematic errors. Dependability specifies the level of trust that can be placed on the system to perform.

Level	Level name	Description
0	No dependability	All useful systems are dependable to some degree, even laboratory prototypes. This level exists for completeness.
1	Mean failure dependability	The dependability of the system is based on the mean time to failure of its components. The dependability is based on the design of the system. The system is not itself able to increase its dependability. For Failure Dependability, this relates to the failure of all component parts of the system including software components. For Functional dependability, this relates to the frequency of failure of the system functions with respect to the task being undertaken, and for environmental dependability, it relates to the failure of the system to correctly interpret the environment. For Interaction dependability, it relates to the failure of the system to interact with a human in a functional or intuitive manner that is appropriate to the task.
2	Fails Safe	The system design is such that there are fail-safe mechanisms built into the system that will halt the operation responsible of the failure and place the system into a safe mode when failures are detected. This includes any failures caused by in-field updates. Dependability is reduced to the ability to fail safely in a proportion of failure modes. Fail-safe dependability relies on being able to detect failure.
3	Failure Recovery	The system is able to recover from a proportion of failures by restarting or resuming its operation.
4	Graceful Degradation	The system is able to recognize the impact of a proportion of failures on its function and operation and is able to compensate for the effect of the failure to maintain dependable operation. Function effectiveness or the ability to achieve optimal working may be impacted.
5	Task dependability	The system is able to recognize the impact of a failure on the overall task it is undertaking and re-task activities in order to minimize the impact of the failure on the task. This may also include self-repair as an alternative task.
6	Mission dependability	The system is able to recognize the impact of a failure on the overall objectives of a mission and communicate the nature of the failure to other systems to minimize the impact on the mission objectives. In turn, the system is able to receive and interpret mission failures from other systems and re-task its actions to compensate.
7	Predictive dependability	The system is able to predict that a planned future action may result in a loss of dependability, or that the effect of the partial failure of a component can be mitigated by altering future actions. Thus the system is able to extend its dependability by taking action in advance of failure in order to reduce the effect on dependability.

## Autonomy

The ability of the system to act autonomously. Nearly all systems have a degree of autonomy. It ranges from a simple autonomous task (e.g., when it reacts to sensors reading) to the ability to be self-sufficient in a complex environment.

Level	Level name	Description
0	No autonomy	All systems exhibit a degree of autonomy. This level remains for consistency with other abilities.
1	Basic action	A system that executes a pre-defined sequence of actions that are unaffected by the environment and makes decisions based on its current state to proceed to the next action step.
2	Basic decisional autonomy	The system makes decisions based on basic perceptions and user input and chooses its behavior from predefined alternatives.
3	Continuous basic decisional autonomy	The system alters the parameters of behavior in response to continuous input from perceptions or based on input control from a user interacting continuously with the system. The system may be able to override or ignore user input when certain criteria are encountered.
4	Simple autonomy without environment model	The system uses perception to make moment-to-moment decisions about the environment and so controls interaction with the environment in order to achieve a predefined task.
5	Simple autonomy with environment model	The system uses perception to make moment-to-moment decisions about the environment and controls interaction with the environment to achieve a predefined task. The decisions made take into account an internal model of the environment.
6	Task autonomy	The system utilizes its perception of the environment to sequence different sub-tasks to achieve a higher-level task or mission. The events that cause behavioral changes are external and often unpredictable.
7	Constrained task autonomy	The system adapts its behavior to accommodate task constraints. These might be negative impacts in terms of failed sensors, or the need to optimize power utilization or other physical resources the process depends on, (water, chemical agents, etc). Alternatively, these might be constraints imposed by sensing ability, the environment, or the user.
8	Multiple task autonomy	The system chooses between multiple high-level tasks and can alter its strategy as it gathers new knowledge about the environment. The system will also take into account resource limitations and attempts to overcome them.
9	Dynamic autonomy	The system is able to alter its decisions about actions (sub-tasks) within the time frame of dynamic events that occur in the environment so that the execution of the task remains optimal to some degree.
10	Mission oriented autonomy	The system is able to dynamically alter its tasking both within and between several high-level tasks in response to dynamic real-time events in the environment.
11	Distributed autonomy	The source for task and mission decisions can originate from outside of the system. The system is able to balance requests for action with its own tasking and mission priorities and can similarly communicate requests for action.

Interaction

The ability of a system to interact physically, cognitively and socially either with users, operators or other systems around it. The ability to interact may be as simple as the use of a communication protocol, or as advanced as holding an interactive conversation in a social context. The ability to interact is critical to many areas of application. Interaction depends on both the medium of interaction and on the context and flow of the interaction. The ability to interact takes place in three distinct ways physical interaction, cognitive interaction and social interaction. The description of the levels of Interaction Ability include these three types of interaction.

Human-System Interaction

Level	Level name	Description
0	No interaction	It is possible that the system will effectively have no operational interaction with a user.
1	Direct control	The user provides control of the system moment to moment. The system can translate, alter, or block these controls within parameters set by the user or system. The user controls are in the form of parameters that alter the control of the system. These parameters may be continuous quantities, or binary controls.
2	Direct physical interaction	The user controls the system by physically interacting with it. The system reacts to the user interaction by feeding back physical information to the user via the contact point.
3	Task selection	The system is able to execute pre-defined sequence of actions (tasks) autonomously. The user selects the subsequent action at the completion of the sequence of actions.
4	Traded autonomy	The system is able to operate autonomously during some parts of a task or in some tasks. Once this task or sub-task is complete the user will either select the subsequent task or intervene to control the system by direct interaction to carry out a task. This results in alternating sequences of autonomous and direct control of the system by the user.
5	Task sequence control	The system is able to execute sub-tasks autonomously, these sub-tasks will involve a higher level of decisional autonomy than a pre-defined sequence of actions. On completion of the sub task user interaction is required to select the next sub-task resulting in a sequence of actions that make up a completed task.
6	Supervised autonomy	The system is able to execute a task autonomously in most operating conditions. The system is able to recognise when it is unable to proceed or when it requires user input to select alternative strategies or courses of action. These alternatives may involve periods of direct control.
7	Task alternatives selection	The system is able to autonomously execute tasks but requires the user to select between strategic task alternatives in order to execute a mission.
8	Mission Goal setting	The system is able to execute tasks to achieve a mission. The user is able to interact with the system to direct the overall objectives of the mission.

Human-System Interaction Feedback

Level	Level name	Description
0	No feedback	The system does not provide any feedback to the user
1	Visual feedback	The user is able to assess the state of the system by direct observation. The system does not provide any means of feeding back information to the user.
2	Vision data feedback	The system feedbacks visual information about the state of the operating environment around the system based on data captured by the system. The user must interpret this visual imagery to assess the state of the system or its environment.
3	Haptic feedback	The system is able to feedback a physical force that represents the forces at the end effector of the system. The force feedback is delivered to the user via a single point of contact, for example a joystick.
4	Tele-presence	The system is able to provide multi-modal feedback to the operator such that they experience tele-presence. Typically this requires close synchronisation between different feedback channels.

System to System Interaction

Level	Level name	Description
0	No interaction	The system operates on its own without communication with another system.
1	Communication of own status	Two or more systems communicate basic status information and task specific status. Status information is pre-defined for the task. The information communicated only relates to the state of the system within the task.
2	Communication of task status	Two or more systems are able to communicate information about the task they are performing in terms of task completion, time to completion, and information about task barriers, resources etc. This information is at a high level and will impact on the planning of a common task, or tasks in a common space.
3	Communication of environment information	Two or more systems share information about their local environments, or share wider scale information that they have acquired or been given. The systems are able to assimilate the information and extract task relevant knowledge from it.
4	Team communication	Two or more systems are able to communicate task level information during execution of the task such that it is possible to implement dynamic planning between the systems in the team. Each system carries out its own tasks with awareness of the other systems in the team.
5	Team coordination	Two or more systems are able to collaborate to achieve a task outcome that could not be achieved by either system alone, or by each system operating independently.
6	Capability Communication	Systems are able to communicate their own task capabilities and utilise cooperative working between teams of heterogeneous systems where there is no prior knowledge of the composition of the team.

Human-System Interaction Safety

Level	Level name	Description
0	Intrinsic safety	The mechanism of the system is safe because by design it cannot damage a person at any time during its operating cycle. The maintenance of this level of safety does not depend on software.
1	Basic safety	The system operates with a basic level of safety appropriate to the task. Maintaining safe operation may depend on the operator being able to stop operation or continuously enable the operating cycle. The maintenance of this level of safety does not depend on software.
2	Basic operator safety	The system is made safe for the operator by physically bounding the operating space of the system. Access gates trigger stop commands to the system. The system will not operate unless the bounding space is closed.
3	User detection	The system is informed when a user enters the work zone. The system operates in an safe way while the user is present in the operating zone.
4	Work space detection	The system operates within a well defined space where a zone of safe operation is identified to the operator and programmed into the system. While the system is occupying the safe zone it will control its motion such that it is safe. The system may also use sensing to detect that the user does not enter the unsafe zone.
5	Dynamic User detection	The system or its support systems detect users within its operating zone and dynamically defines a safe zone that envelopes the user where the system controls its operation to be safe.

Human-System Interaction Safety - Context

Level	Level name	Description
0	Intrinsic safety	The mechanism of the system is safe because by design it cannot damage a person at any time during its operating cycle. The maintenance of this level of safety does not depend on software.
1	Reactive safety	The system is designed to be safe under all reasonable circumstances such that it cannot cause injury to a person during the operation.
2	Context dependent safety	The system is able to recognise circumstances where it needs to behave in a safe way because it is uncertain about the nature of the environment.

Perception

The ability of the system to perceive its environment. It includes the ability to interpret information and to make informed and accurate deductions about the environment based on sensory data.

Perception

The following levels refer to the generic ability of a system to perceive which are generally speaking categorised by abstracting sensor data in each level.

Level	Level name	Description
0	No external perception	Some systems do not sense their environment but simply carry out sets of pre-programmed actions triggered by a starting event. Although there may be safety systems that cause the system to fail-safe these do not alter the operating cycle behaviour.
1	Direct Single and Multi-parameter sensing	A system uses sensors that provide a single, or multiple parameter output directly. The system utilises these outputs to directly alter behaviour within an operating cycle.
2	Low Level processing parameter sensing	A system may use fixed and known markers in the environment (e.g. Barcodes, QR codes, etc). The detection of these markers provide triggers to alter or switch between behaviours or sequences of behaviours.
3	Multi-Parameter Perception	A system uses multiple single parameter sensors to create a unified model of the environment. Sense data can be collected from multiple types of sensor as well as multiple sensors of the same type. Each sensor contributes information to the model. The model is used to alter the behaviour of the system.
4	Feature based perception	Sense data is gathered from a region of the environment such that the sense data has a spatial mapping. The richness of the sense data information content is such that it is possible to apply feature extraction to the sense data and thereby interpret the content of the sense data as a set or sets of features. The system performs a data reduction with an assumption about the expected features. The presence of features is used to alter behaviour.
5	Grouped feature detection	The sense data gathered from the environment can be processed such that features can be aggregated to capture linkages between features. A group of features may relate to the same real object in the environment, but where the object has not been identified. The characteristics of the feature group can be used to alter the behaviour of the system. For example a set of features of the same colour that move in the same way may relate to a pink ball.
6	Object identification	The system can identify objects or coherent entities that it has detected in the scene through sets of grouped features and can use this identification to alter the system behaviour. The importance in this level is that a data source or a priori object model is required.
7	Property identification	The system is able to deduce the properties of objects in the scene or scene itself and utilise those properties within system behaviour.
8	Hidden state identification	The system is able to infer properties of an object, person or scene that are not directly observable. The scene and objects are not fully available in data sources ahead of time and scene interpretation and classification is required.

Object recognition

This ability may range from being able to recognise instances of a single object, to being able to distinguish between many different objects or even identify objects that fit a generic pattern.

Level	Level name	Description
0	No Recognition	The system does not need to detect or recognise objects in the environment in order to carry out its task.
1	Feature detection	Sense data is gathered from a region of the environment such that the data has a spatial component and can be mapped to a model of that region. The richness of the sense data is such that it is possible to apply a feature detection process to create a set or sets of features that persist.
2	Object detection	Multiple persistent features can be grouped to build models of distinct objects allowing objects to be differentiated from each other and from the environment.
3	Object recognition - single instance	Object models created from sense data can be matched to specific known instances of an object with a reliability that is appropriate to the task.
4	Object recognition - one of many	Object models created from sense data can be matched to one of a number of specific instances of known objects with a reliability that is appropriate to the task.
5	Parameterised object recognition	Object models created from sense data can be matched to a number of known, parameterised object types. The settings for the parameters (e.g. size ratio, curvature, joint position etc) can be deduced from the sensed object model. Note that in conjunction with single instance recognition ability this implies the ability to recognise a known (possibly learned) instance of a generic object.
6	Context based recognition	The system is able to use its knowledge of context or location to improve its ability to recognise objects by reducing ambiguities through expectations based on location or context.
7	Object variable recognition	The system is able to recognise objects where there is a degree of variability in the object that approaches the scale of the object.
8	Novelty recognition	The system is able to recognise novelty in a known object, or parameterised object type.
9	Unknown object categorisation (Rigid)	The system is able to assess an unknown rigid object based on sense data and deduce properties that are relevant to the task.
10	Object property detection	It is possible to use sense data and the derived object model to deduce the properties of an object.
11	Flexible object detection	The system is able to detect the shape and form of objects that are deformable and generate parameterised models of flexible objects. This includes articulated objects and objects with flexible and rigid components.
12	Flexible object classification	The system is able to classify flexible objects by their properties and parameters. It is able to recognise specific known objects relevant to the task with an appropriate level of reliability.
13	Animate objects	The system is able to detect animate objects and provide a classification appropriate to the task.
14	Pose estimation of animate objects	The system is able to estimate the pose of an animate object within the environment.

Scene perception

In many applications systems will need to be able to interpret the context of a wider scene, identifying static elements in the scene such as walls doors ceilings floor etc. as well as the delineation of objects. This scene interpretation is not related to the recognition of specific objects but to the wider identification of spaces and objects within a working environment.

Level	Level name	Description
0	No scene perception	The system does not need to be able to interpret the environment in order to carry out its task.
1	Basic feature detection	The system is able to detect features in the environment that relate to static structures in that environment.
2	Static Structures	The system is able to identify static structures in the environment in a way that is appropriate to the task.
3	Combined Structures	The system is able to provide a consistent interpretation of the static structures in the environment over time.
4	Multiple object detection	The system is able to delineate multiple objects from the static environment where there may be partially occluded with respect to the sense data gathered.
5	Object arrangement detection	The system is able to detect arrangements of objects, for example objects in a stack or mixed in a receptacle and identify the relationships between objects with a success appropriate to the task.
6	Dynamic object detection	The system is able to detect an object that is moving within a static environment.

Cognitive

The ability to interpret the task and environment such that tasks can be effectively and efficiently executed even where there exists environmental and/or task uncertainty. The ability to interpret human commands delivered in natural language or gestures. The ability to interpret the function and interrelationships between different objects in the environment and understand how to use or manipulate them. The ability to plan and execute tasks in response to high-level commands. The ability to work interactively with people as if like a person. Currently, different aspects and faculties of the Cognitive Ability as a whole have different degrees of maturity and pose different challenges. Attempting to combine these differences into a single rating or overarching target is likely to lead to invalid or misleading conclusions. The assessment of cognitive ability is therefore divided into several components or faculties. The assumption is that the cognitive ability of a system can be assembled and described more accurately by referring to a mixture of component abilities.

Action

It concerns the ability of the system to act purposefully within its environment and the degree to which it is able to carry out actions and plan those actions. These abilities build on perception and decisional autonomy abilities. Action ability also co-depends on the other cognitive abilities.

Level	Level name	Description
0	No Action Ability	Systems are defined by having some level of action on the environment. This level remains for compatibility.
1	Defined action	The system executes fully pre-defined actions as a sequence of sub-actions. This sequence can repeat until stopped by an operator or other system event.
2	Decision based action	The system is able to alter its course of action based on perceptions or system events. It is able to select between a set of pre-defined actions based on its decisional autonomy
3	Sense driven action	The system is able to modulate its action in proportion to parameters derived from its perceptions. The perceptions are used to drive the selection of pre-defined actions or the parameters of pre-defined actions.
4	Optimized action	The system is able to alter the sub-task sequence it applies to the execution of a task in response to perceptions or a need to optimize a defined task parameter.
5	Knowledge driven action	The system is able to utilize knowledge gained from perceptions of the environment including objects within it, to inform actions or sequences of action. Knowledge is gained either by accumulation over time or through the embedding of knowledge from external sources, including user inputs that associate properties with perceptions.
6	Plan driven action	The system is able to use accumulated information about tasks to inform its plans for action.
7	Dynamic planning	The system is able to monitor its actions and alter its plans in response to its assessment of success.
8	Task action suggestions	The system is able to suggest tasks that contribute to the goals of a specific mission.
9	Mission proposals	The system is able to propose missions that align with high-level objectives.

Interpretive

The interpretation of sense data is key to the ability to identify, recognise, classify and parameterize objects in the environment. It particularly refers to the ability to amalgamate multi-modal data into unified high-level object descriptions that create knowledge for tasks to draw on. The ability to interpret also engages knowledge sources to build increasingly complex interpretations of the environment and human interaction, in particular building frameworks of relationships between the environment and objects and between objects.

Level	Level name	Description
0	No interpretive Ability	The system does not need to interpret the environment or user interface actions.
1	Fixed sensory interpretation	The system has a fixed interpretation of the perceptions that occur because they are pre-categorized.
2	Basic environment interpretation	The system uses sensor data to interpret the environment into fixed notions of environmental data that are pre-categorized.
3	Object delineation	The system is able to disambiguate objects from an interpretation of its static environment. The disambiguation of objects is based on built-in notions of objects and the environment. These notions may only be valid within a narrow operating context.
4	Object category interpretation	The system is able to interpret the shapes and forms of objects based on categories of objects that are task-relevant. It is able to interpret sense data to identify coherent instances of an object over a time scale appropriate to the task. Note that this ability level is particularly affected by the Cognition Ability Parameters.
5	Structural interpretation	The system is able to interpret perceptions so as to extract structural information from the environment. It is able to identify the structural relationships between objects in the environment.
6	Basic semantic interpretation	The system is able to apply semantic tags to locations and objects allowing it to plan actions based on functional objectives that depend on the semantics of objects and locations.
7	Property interpretation	The system is able to interpret perceptions to determine the properties of objects or locations in the environment.
8	Novelty interpretation	The system is able to interpret perceptions to identify novelty in objects or locations.
9	Environmental affordance	The system is able to interpret the environment in terms of what it affords.

Envisioning

Envisioning refers to the ability of the system to assess the impact of actions in the future. This may reduce to prediction but in the higher levels involves an assessment of the impact of observed external events.

Level	Level name	Description
0	No envisioning ability	The system is not able to predict subsequent states.
1	Function projection	The system is able to project the effect of its function onto the local environment in order to be able to assess its effectiveness.
2	Basic environment envisioning	The system is able to observe events in the environment that relate to the task and envision their impact on the actions of the system itself.
3	Envisioning safety	The system is able to assess the safety implications on users of observed events occurring in the working environment.
4	Envisioning user responses	The system is able to envision the actions of a user responding to events in the environment.

Acquired knowledge

Operating environments will always contain a number of unknowns. In many proposed application areas systems will encounter unknown situations as a normal part of task execution. The acquisition of knowledge about the new situations is fundamental to the success of these new application areas.

Level	Level name	Description
0	No Acquired Knowledge	The system does not acquire knowledge during its operation. Required knowledge is embedded in the system.
1	Sense data and property knowledge	The system is able to acquire knowledge about its environment and properties of objects in the environment based on sense data gathered moment to moment.
2	Persistent sense data knowledge	The system is able to accumulate knowledge about its environment based on sense data that persists during the execution of the current task.
3	Deliberate acquisition	The system is able to acquire knowledge about the composition of its operating environment by executing actions that are deliberately designed to increase knowledge through exploration.
4	Place knowledge	The system is able to accumulate knowledge about the location and types of objects and environmental features in terms of matching objects to pre-defined and known types.
5	Knowledge scaffolding	The system has the ability to integrate embedded knowledge of objects and places with related knowledge gained from the environment.
6	Requested knowledge	The system is able to recognise that it has insufficient knowledge about an object or place relevant to the task and can formulate a question to gain that knowledge either from a person, or an external data source such as the internet or another system.
7	Distributed knowledge	The system is able to communicate its gained knowledge to other systems and can receive and integrate knowledge from other systems.
8	Interaction acquisition	The system is able to acquire knowledge about its environment and objects within it through planned interactions with the environment and objects.
9	Object function	The system is able to acquire knowledge about the function of objects in the environment. This knowledge may be acquired directly or indirectly through observation.
10	User knowledge	The system is able to acquire knowledge about the user by observation.
11	Critical feedback	The system is able to acquire knowledge about its actions by analysis of critical feedback that follows completion of the action.
12	Long term observation	The system is able to distinguish between long term and short term changes in the environment and the objects within it.
13	Patterns of behaviour	The system is able to acquire knowledge about the patterns of behaviour of the user that relate to the task.
14	Observation learning	The system is able to acquiring knowledge indirectly from observing other systems or people carrying out tasks.

Reasoning

Reasoning ability is the glue that holds the cognitive structures together. Perception, knowledge acquisition, interpretation and envisioning all rely to a certain extent on the ability to reason from uncertain data. As application tasks become more complex the need to provide task and mission level reasoning increases.

Level	Level name	Description
0	No Reasoning	There are numerous simple systems that do not carry out any form of reasoning but simply execute a pre-determined pattern of activity.
1	Reasoning from sense data	The system is able to make basic judgements of sense data sufficient to allow actions to be controlled.
2	Pre-defined reasoning	The system is able to use basic predefined knowledge about structures and objects in the environment to guide action and interaction.
3	Basic environment reasoning	The system is able to use knowledge of the environment gained from perception in conjunction with stored knowledge to reason about the environment.
4	Reasoning with conflicts	The system is able to reason about the environment and objects when there is conflicting or incomplete information.
5	Dynamic reasoning	The system is able to reason about the perceived dynamics in the environment.
6	Safety reasoning	The system is able to reason about safety in the environment.
7	Task reasoning	The system is able to reason about the appropriate courses of action to achieve a task where there are alternative actions that can be undertaken. Typically the system will be able to identify the course of action which matches the desired task parameters, typically these involve time to completion, resource usage, or a desired performance level.
8	Task hypothesis	The system is able to reason about the priorities of different tasks within a mission and propose priorities based on its knowledge of the mission and the tasks. The system will be able to fix on a task that must be achieved but make decisions about how tasks will sequence to achieve mission objectives.

Human interaction

The following set of levels relate to different levels of human interaction with a system that have a cognitive element. They specifically relate to the interaction between a human and a single system. Where multiple systems are involved a corresponding set of levels applies.

Level	Level name	Description
0	No Cognitive Human Interaction	Many systems will be able to operate successfully without cognitive interaction with the user.
1	Fixed interaction	Interaction between the user and the system follows a fixed pattern. Typically this takes place via a user interface with well defined inputs and outputs. Fixed interaction also includes interaction via a computer based user interface where interactions directly control the system according to pre-defined sets of commands with specific meaning. The connection between the user and the system may involve a wireless link. Any interpretation of commands is fixed and embedded.
2	Task context interaction	The system is able to interpret commands from the user that utilise task context semantics within a domain specific communication framework appropriate to the range of the task. The system is able to relay task status to the user using task context semantics suitable for the task.
3	Object and location interaction	The system is able to interpret user interactions that refer to objects, locations or actions in as is appropriate to the task. This includes the ability to interpret user interactions that identify objects locations and actions as well as processing commands that reference locations, objects and actions relevant to the task. Dialogues are initiated by the user.
4	System triggered interaction	The system is able to start a dialogue with the user in a socially appropriate manner relevant to its task or mission. The system has a basic understanding of the social interaction appropriate to the task/mission domain. Interaction may continue throughout the operating cycle for each task as is appropriate to the task/mission.
5	Social interaction	The system is able to maintain dialogues that cover more than one type of social interaction, or domain task. The system is able to manage the interaction provided it remains within the defined context of the task or mission.
6	Complex social interaction	Dialogues cover multiple social interactions and tasks, where the system is able to instruct the user to carry out tasks, or enter into a negotiation about how a task is specified. The interaction is typified by a bi-directional exchange of commands.
7	Intuitive Interaction	The system is able to intuit the needs of a user with or without explicit command or dialogue. The user may communicate to the system without issuing explicit commands. The system will intuit from the current context and historical information the implied command.