# Whole Quality of Complex Objects

*How Objects Realize Their Intended Functions*

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# Foreword

A bridge can have parts that meet their individual requirements and still fail to provide the passage it is meant to provide. For example, the bridge may be complete while the road that gives vehicles access to it remains unfinished. A person's body, a support service, or an AI service can also be considered as a whole in relation to what it is intended or required to do. These objects are very different, but they raise a common question: How well does each object realize its Intended Functions and achieve its Intended Results under the conditions in which it actually operates? This question is the starting point for the science of quality. The inquiry also examines vulnerabilities that may be present even when the object appears to work normally and asks how changes in conditions may affect its ability to function or expose people, the object itself, or its surroundings to harm.

An object's Quality is not created by an examination. The object has an actual condition, and its Quality concerns the degree to which it realizes its Intended Functions and Intended Results in accordance with applicable requirements. This is true whether or not anyone has examined it. An examination helps us learn about that reality; it does not make the reality.

Function Realization takes place through the object's life cycle and within an environment. It may depend on the object's own parts and on contributions from outside it. To understand what is being considered, we must identify the object and account for the parts, conditions, and relationships essential to its functions.

The article follows this reasoning one step at a time. It begins with Intended Functions, then considers what their realization requires. From there, it turns to how we learn about the object's actual condition, how Evidence supports Findings, and how those Findings can be brought together and communicated. The conditions an object must meet and the basis for examining whether it meets them are related questions, but they are not the same question. The article keeps them distinct as the discussion develops.

Examples from human health and human-made objects run throughout the article. Other examples—including infrastructure, support services, digital services, and AI services—show how the reasoning can be applied to different objects while preserving their distinct functions and requirements.

# 1 What is an Intended Function?

We begin with a simple question: What is this object intended or required to do? The answer gives direction to the quality question. Without it, we may describe the object's parts or condition, but we do not yet know what those characteristics are meant to accomplish.

An Intended Function is what an object is required or intended to do. A bridge, for example, is intended to provide passage for vehicles and pedestrians. A human heart has the biological function of pumping blood. These are different kinds of objects and functions, but in each case we can ask what the object is meant or required to do.

The word intended does not mean that every object consciously chooses its purpose. A human-made object may be designed for a function. A biological function can be considered without suggesting that an organ has conscious intentions. When we consider a person, the person's own conscious intentions and choices matter; they should not be confused with functions assigned to the person's body by someone else.

The object and its function must also be kept distinct from other objects connected to it. A support service may be intended to help a person participate in an activity. That is a function of the service. The person has their own intentions and goals, which the service may be meant to support. Similarly, an AI service may be intended to answer a certain kind of question, while the data center and other infrastructure supporting it are separate objects with their own functions.

An object can have more than one Intended Function. A bridge may provide passage and carry utility lines. A person's body carries out many biological functions. The function under consideration depends on the question being asked, but it must be stated clearly enough to guide the discussion.

Identifying an Intended Function does not yet tell us how well the object performs it or achieves its associated results. It tells us what to look for next. The next question is what it means for the object to realize its function.

## 2 What does it mean to realize a function?

Section 1 asked what an object is intended or required to do. Function Realization concerns how, and to what degree, the object actually performs that function and achieves its associated Intended Results.

Consider a bridge intended to provide passage for cars and pedestrians. Its function is to provide that passage; an associated result is that people and vehicles can cross. A drawing may show how the bridge is meant to work, but the bridge realizes its function through its actual condition and performance in use.

The same distinction applies to a biological object. The heart's function is to pump blood; an associated result is circulation through the body. Naming the function does not tell us how well the heart realizes it. We would need to consider its actual condition and performance under relevant conditions.

A support service may be intended to provide assistance that enables a person to participate in an activity. Its Function Realization concerns whether the assistance is actually provided and whether it achieves the intended result for the person. A schedule or service plan can describe what should happen, but the function is realized through the actual service.

Intended Results may happen at once or develop over time. Some are continuous; others occur only under particular conditions. A bridge may need to provide passage during different traffic conditions. A service may need to provide support at specific times or through a transition between activities. The relevant results depend on the object and its Intended Functions.

Realization is therefore about what the actual object does and achieves, not simply what its design, description, or plan says it should do. To understand it, we must consider the conditions and stages in which the function is expected to be realized. That leads to the object's life cycle.

# 3 How does Function Realization unfold through a life cycle?

A function is realized over time. A bridge does not provide passage only when it is designed or built. It must continue to provide passage as it is used and maintained. A person's heart realizes its biological function throughout life, while its condition and the demands on it may change.

The stages of an object's life cycle depend on what kind of object it is. For a bridge, they may include planning, design, construction, operation, maintenance, and eventual closure or replacement. For a support service, they may include planning, arranging staff and resources, providing assistance, reviewing how it works, and changing or ending the service.

These stages are connected. Decisions made early can affect what the object can do later. A bridge's design and construction affect its use and maintenance. The way a support service is planned and arranged can affect whether the assistance is available when a person needs it.

The life cycle also helps us be clear about the time we are considering. We might ask whether a bridge provides safe passage today, whether it did so during a past period, or whether it is expected to do so under future conditions. For a person's health, we might consider current function, changes over time, or response to a particular treatment. Each question concerns the object's Function Realization during a defined period and under relevant conditions.

Thinking about the life cycle does not mean that every examination must cover every stage. It helps us recognize which stages and changes matter to the function being considered. To understand those stages, we also need to consider the environments in which Function Realization takes place.

# 4 How does the environment affect Function Realization?

An object realizes its functions within an environment. Some conditions come from within the object; others come from outside it. Both can affect what the object does and the results it achieves.

A bridge depends on its own structure and materials. It is also affected by traffic, weather, the ground beneath it, and the way it is maintained. A person's heart is part of a body whose other organs and systems affect its work. Its function also takes place amid external conditions such as physical activity, temperature, and access to care.

Services show the same relationship. A support service may depend on its staff, schedule, equipment, and communication. It may also depend on the person's surroundings, transportation, and the actions of other organizations. An AI service may depend on its software and data, as well as on computing infrastructure and the people and systems that use its results.

The object's environment is not simply everything around it. We consider the conditions and contributions that matter to its Intended Functions and Intended Results. Some may be part of the object; others may remain outside it while still contributing to what it can achieve.

This raises a practical question: what exactly are we treating as the object, and which parts, conditions, and connections must be considered to understand its Function Realization?

# 5 What exactly are we considering?

To understand Function Realization, we first need to know what object we are considering. The answer depends on the question. A bridge can be considered as a whole, or one part of it can be considered as an object in its own right. The same is true of a human body, an organ, a support service, or an AI service.

When we consider an object as a whole, we include the parts that are essential to its functions. These parts are its Constituents. A bridge's Constituents may include its deck, supports, and foundations. When considering the heart as an object, its tissues and structures may be relevant Constituents. The boundary of the object helps us distinguish it from other objects.

A boundary does not mean that the object works alone. An object may depend on contributions from outside its boundary. The bridge depends on the ground that supports it. A heart functions within a body. A support service may rely on transportation or a separate organization. An AI service may rely on a data center. These relationships matter when they contribute to Function Realization.

Interfaces are the points or means through which an object connects with other objects or with its environment. A bridge connects with roads at its ends. The heart connects with other parts of the body through blood vessels. A support service may connect with a person through scheduled assistance and communication. An AI service may connect with users and computing systems through software interfaces.

The question also has a scale. We might consider a coastline, a bridge, a component of the bridge, or a specific connection. A coastline can be examined across a broad area; a small section can be examined in greater detail. The scale describes how large or small an area or object we are considering.

Methodological Resolution describes how finely we distinguish and examine what is within that scale. A broad view of a bridge may consider its overall ability to provide passage. A more detailed view may examine a joint or support. The same principle applies to the human body: we may consider overall health, the heart, or a particular structure within it. The appropriate resolution depends on the question and the available knowledge and evidence.

These choices shape what can be learned about the object. If we leave out a part, connection, or outside contribution that is essential to its function, our view of the whole may be incomplete. With the object and its relevant relationships in view, we can now ask what its Quality means.

# 6 What is the object's Quality?

We have identified the function, followed it through time and environment, and clarified what object we are considering. We can now ask what the object's Quality is.

Quality concerns how well the actual object realizes its Intended Functions and achieves the associated Intended Results in accordance with applicable requirements. It is a characteristic of the object's actual condition. An examination may help us learn about that condition, but it does not create the object's Quality.

Consider a bridge intended to provide passage for vehicles and pedestrians. Its Quality concerns how well the bridge, as it actually exists and operates, provides that passage and achieves the results required of it. Looking only at one component would not necessarily tell us the Quality of the bridge as a whole.

The same reasoning applies to human health. The Quality of a heart, considered as an object, concerns how well it realizes its biological functions and achieves the associated results in accordance with applicable requirements. The Quality of a person as a whole involves a broader set of functions and results. These are different objects and different questions, so the relevant requirements also differ.

Quality is not a label that an examination adds to an object. A bridge or a person has an actual condition whether or not anyone has examined it. The examination provides a basis for describing that condition; the description may be incomplete or uncertain, but the underlying reality remains.

We can therefore distinguish an object's Quality State—its actual state of Quality at a particular time and under particular conditions—from what an examination has established about it. A bridge's Quality State may change as its condition or operating environment changes. A person's health state may also change over time. In each case, the Quality State exists independently of whether it has been assessed.

This definition brings the discussion back to requirements. To understand whether an object realizes its functions as required, we need to identify the conditions those functions call for. Some requirements may already be established. Others may need to be developed or clarified. That is the next step.

# 7 What conditions does Function Realization require?

An Intended Function tells us what an object is expected to do. Its Intended Results describe what should follow when that function is realized. Together, they help us identify the conditions the object must meet.

For a bridge, providing passage may require enough strength to carry expected loads, a surface vehicles and pedestrians can use, and connections that let people reach it. These conditions relate to the bridge's function and the results it is meant to achieve.

For a person's heart, requirements concern the functions and results relevant to that heart and the person's health. They may include conditions for pumping blood effectively under specified circumstances. The particular requirements depend on what is being considered and the purpose of the assessment.

Requirements can concern more than the object's parts. A bridge may depend on its foundations and connections to roads. A support service may need to be available at agreed times and provide assistance in a way that supports the person's intended activity. An AI service may need to provide a specified service under defined operating conditions. The requirements should address what is essential to the Function Realization being considered.

Some applicable requirements may already be stated in laws, standards, contracts, designs, care plans, or other sources. In other cases, relevant requirements may not yet be stated clearly or may not exist. They can be established by identifying the Intended Functions and Results, considering the conditions in which they must be realized, and determining what the object must meet to realize them.

This step concerns the object: what conditions its Quality must meet. A separate question concerns how we determine whether those conditions are met. The next section introduces a way to organize the first question and guide the examination that addresses the second.

# 8 How do Factors and Indicators help us understand the quality question?

The previous section asked what conditions an object must meet to realize its Intended Functions. Now we need a way to examine those conditions without losing sight of the object as a whole.

The Whole Quality approach organizes this work through Factors and Indicators. A Factor is a broad area of Function Realization that matters to the object's Quality. An Indicator identifies a more specific aspect within that area that can be considered and addressed through requirements.

For a bridge, one Factor might concern its structural condition. Indicators within that area could direct attention to the condition of its deck, supports, or foundations. For a human heart, a Factor might concern its ability to pump blood; Indicators could identify specific aspects of that function to consider. The examples differ because the objects and their functions differ, but the reasoning is similar: begin with an important area, then identify the particular aspects that matter.

Factors and Indicators do not, by themselves, tell us whether an object meets its requirements. They help organize the questions. Requirements state the conditions the object is expected to meet. Some may already exist in standards, designs, care plans, or other sources. Where requirements are missing or unclear, they may need to be established or understood in light of the object's Intended Functions, Intended Results, and circumstances.

The same Factors and Indicators can also guide an examination. They help determine what aspects to examine and what Evidence may be relevant. For example, examining a bridge's supports may require different Evidence from examining the condition of a person's heart. The object's requirements and the Evidence used to assess them are related, but they answer different questions.

A factor-by-factor view also helps keep attention on the whole object. A bridge can meet requirements for several individual parts and still fail to provide the passage it is intended to provide. A person's heart may show a particular measurement, but that result alone may not describe the heart's whole Quality State. The examination must consider relevant aspects in relation to the function of the object as a whole.

The object's Quality State exists whether or not anyone examines it. Factors and Indicators provide an organized way to think about that state and to plan an examination of it. The next question is how unmet requirements may matter beyond the object's Quality, including when they can lead to Harm.

# 9 How can a quality deficiency lead to Harm?

Start with the object's Intended Function. How well does the object actually realize that function and achieve its Intended Results? Then consider the applicable requirements, which establish conditions the object must meet. A shortfall in realizing an Intended Function, achieving an Intended Result, or meeting an applicable requirement is a Quality Deficiency. The deficiency creates a vulnerability that may lead to Harm.

The science of quality introduces the Whole Quality approach to examining how this happens. It considers the object as a whole, in its actual environment and throughout its life cycle. A vulnerability can exist even when the object appears to work normally. Harm can occur during ordinary use, develop through repeated exposure, or follow a change in conditions. The inquiry considers who or what is exposed, how the object interacts with its surroundings, and what sequence of events could lead to Harm. That pathway may exist before a specific safety requirement has been established to address it.

Consider a bridge intended to provide safe passage for vehicles and pedestrians. If its surface provides too little grip, a pedestrian may slip during ordinary use, and rain may make the surface even more slippery. An applicable requirement for surface grip provides a basis for assessing the shortfall. The lack of grip creates the vulnerability. The risk depends on how likely Harm is and how serious its consequences could be.

The same reasoning applies to human health. A heart's Intended Function includes pumping blood. A deficiency that limits its ability to pump can affect a person during ordinary activities or when the body needs greater blood flow, such as during physical exertion. The risk depends on the person's condition, the demands placed on the heart, and the possible consequences.

Safety is part of Quality because it concerns protection from Harm. Quality also concerns the full range of an object's Intended Functions and Intended Results. A bridge may provide safe passage and still fall short in carrying a utility line it was intended to support. A support service may complete its scheduled activities and still leave a person without assistance when it is needed. These shortfalls are Quality Deficiencies, and their consequences depend on what people or other systems rely on the object to do.

In a digital or AI service, an incorrect result or an unavailable function can create a vulnerability for the people or systems that rely on it. Harm may follow during routine use, depending on who relies on the service and what decisions or actions follow.

To determine whether a Quality Deficiency exists and how it could lead to Harm, we need evidence about the object's actual condition, how it functions, and how people or other systems interact with it. That brings us to the examination.

## 10 How do we learn about the object's actual Quality?

We have described Quality as a reality of the object: how well it realizes its Intended Functions and achieves the associated Intended Results in accordance with applicable requirements. To learn about that reality, we examine the object.

An examination is a planned inquiry. It identifies what we need to learn, what parts or conditions matter, and what information can help answer the question. For a bridge, this may involve reviewing its records, observing how it is used, and inspecting its structure. For a person's heart, it may involve medical history, examination, and appropriate tests.

The examination must fit the object and the question. A visual inspection may help reveal a bridge's surface condition, but it cannot by itself establish the condition of every part. A heart test may provide useful information about a particular function, but its meaning depends on the person and the circumstances in which the test was done.

The examination also has limits. Some conditions cannot be observed directly. Some information may be incomplete, uncertain, or affected by the way it was collected. The examiner therefore needs to consider what each method can show, what it cannot show, and which other sources may be needed.

The purpose is to develop a sound basis for understanding the object's actual condition. The examination does not create the object's Quality; it gathers and considers information about the Quality State that already exists. That information is Evidence, and its quality affects what we can reasonably conclude.

# 11 What can Evidence tell us?

An examination gathers information about an object. Evidence is information used to support or challenge a Finding about the object's Quality State. Before relying on it, we need to ask three questions: Is it truthful? Is it applicable? Is it sufficient for the Finding we need to make?

Truthfulness concerns whether the Evidence faithfully represents what it purports to show. A bridge inspection record should accurately reflect the inspection that took place. A heart-test result should accurately represent the person's test and the conditions under which it was taken.

Applicability concerns whether the Evidence relates to the object and question at hand. A measurement from one bridge component may not apply to a different component. A medical result from an earlier time may not describe a person's present condition. Evidence can be truthful but not applicable to the Finding we need to make.

Sufficiency concerns whether the Evidence provides enough coverage and detail to support that Finding. One photograph may truthfully show a crack in a bridge, but it may not show how far the crack extends or whether other parts are affected. One test may provide truthful, applicable information about a heart, but not enough to support a broader conclusion about its overall condition.

These three questions are separate. A large amount of Evidence does not make it truthful. Truthful Evidence may still concern the wrong object or conditions. Truthful, applicable Evidence may still be too limited to support the Finding.

Evidence does not become a Finding simply because it has been collected. A Finding states what the examination establishes about a specified requirement and condition of the object. It must identify its Evidence basis and remain within the Evidence's limits. If the Evidence does not establish whether the requirement is met, the Finding should say that the condition remains undetermined.

The sufficiency of individual Evidence and Findings also matters when we consider the whole object. Even well-supported Findings about several parts may leave an important function or condition unexamined. We will return to that when we discuss how Findings are brought together.

## 12 How do we move from Evidence to Findings?

Evidence provides information about an object. A Finding states what that Evidence establishes about a particular condition of the object in relation to an applicable requirement.

Suppose an inspection finds a crack in a bridge support. The crack is an observation; by itself, it does not say whether the support meets its requirement. The examiner must consider whether the Evidence is truthful, applicable to that support and the relevant conditions, and sufficient to assess the requirement. The Finding then states what the Evidence supports.

The same distinction applies to a person's heart. A test produces a result. The Finding explains what that result establishes about a specified function or condition, in relation to the applicable requirement and the circumstances of the test. The result and the Finding are related, but they are not the same thing.

A Finding may establish that a requirement is met, establish that it is not met, or leave the condition undetermined. If the Evidence is too limited to decide, the Finding should say so. It should not claim more certainty than the Evidence can support.

A useful Finding identifies the requirement and the condition considered, explains the Evidence it relies on, and notes any important limitation or uncertainty. This lets another reader understand how the conclusion was reached and what it does—and does not—establish.

Individual Findings answer specific questions about an object. To understand the object's Quality as a whole, we must next bring the relevant Findings together and consider how they relate.

## 13 How do we synthesize Findings about the whole?

A Finding answers a specific question about an object. Synthesis brings relevant Findings together so we can understand what they show about the object's Quality as a whole.

For a bridge, separate Findings might address its deck, supports, foundations, and connections to roads. Each Finding may be well supported, but the bridge's ability to provide passage depends on how these parts work together. Synthesis considers their combined significance for that function.

For a person's heart, Findings about different measurements or functions may each be important. To understand the heart's Quality State, they must be considered in relation to one another and to the functions being examined. A single result should not stand in for the whole.

Synthesis also considers gaps and limits. Some parts or conditions may not have been examined. Some Findings may remain undetermined. A limitation in one area should not disappear simply because other areas have strong results. If an important function or connection lacks adequate Evidence, that affects what can be concluded about the whole object.

This does not mean that every Finding carries equal importance or that good performance in one area can always offset a deficiency in another. The significance of each Finding depends on the object's Intended Functions, applicable requirements, and the relationships among its parts and conditions.

A sound synthesis therefore preserves the basis and limits of the Findings while explaining how they relate to the object as a whole. The next step is to communicate what that synthesis supports—and what it does not.

## 14 How do we communicate what the examination supports?

After Findings have been synthesized, someone may need a clear statement about what the examination supports. A Quality Claim communicates a conclusion about an object's Quality State to a reader or decision-maker.

A Claim should say what object was considered, which functions and requirements were examined, and what the Findings support. For example, a bridge examination might support a claim about the bridge's ability to provide passage under specified conditions during a stated period. A heart examination might support a claim about a particular function based on the tests and circumstances considered.

The Claim should also make its limits clear. If some parts or conditions were outside the examination, or if important Findings remain undetermined, the Claim should not imply that the whole object was fully examined. A Claim about a bridge's inspected supports, for example, is not automatically a Claim about every part of the bridge. A Claim about one aspect of heart function is not automatically a Claim about a person's overall health.

The reader matters too. A statement prepared for an engineer, a clinician, a person receiving a service, or a regulator may need different explanations to make its scope and meaning clear. In every case, the reader should be able to see what the Claim is based on and what decision it can reasonably inform.

The Claim communicates what the examination supports; it does not change the object's Quality State. Its strength depends on whether it faithfully represents the Findings and their limits. The same reasoning can now be followed across very different kinds of objects.

## 15 How do these questions apply to different objects?

The objects we have discussed are different, but the questions can travel from one to another. What is the object intended or required to do? What results should follow? What conditions matter to its function? What Evidence can show how the actual object is doing?

For a bridge, the inquiry may concern passage for vehicles and pedestrians. For a person's heart, it may concern biological functions and related results. For a support service, it may concern assistance that helps a person pursue their own goals. For an AI service, it may concern the results the service is intended to provide and the conditions under which people rely on it.

The shared questions do not make these objects the same. A person is not simply a body, and a person's own intentions and choices matter. A service intended to support a person should be considered in relation to that person's needs and goals. A bridge, an organ, a service, and an AI system each have their own functions, environments, requirements, and forms of Evidence.

The same care is needed when deciding what to examine. Sometimes the question concerns a whole object; sometimes it concerns one part or function. A broad view may help us understand the object's overall Quality State, while a more detailed examination may reveal a specific condition. What matters is that the view is suited to the question and that its limits are clear.

Whole Quality begins with the actual object and what it is intended or required to do. It follows Function Realization through time and environment, identifies the requirements that apply or need to be established, and examines Evidence to develop and synthesize Findings. A Quality Claim then communicates what those Findings support. This reasoning can guide inquiry across many kinds of complex objects while preserving what is distinctive about each one.

Digital services can also be examined using these questions. The object is the service identified by its Intended Functions and Intended Results. Depending on the service, its functions may depend on people, software, data, connected services, or contributions from outside its boundaries. The examination considers how the service operates and the conditions that affect its results.

AI services are one kind of digital service. A model or its output may be examined for a particular purpose, but that alone does not establish the Quality of the service as a whole. DQI standards apply Whole-Quality concepts to digital services and their specific contexts.

# 16 How can the science of quality guide practical decisions?

The quality of any object starts with its Intended Functions. Those functions sit at the head of a stream that runs through the object's life cycle, from how it takes shape to how it develops and functions over time. Following that stream means considering what the object must do, what results it must achieve, and which parts, connections, and conditions make this possible.

Safety is part of that stream from the start. When an object falls short of its quality requirements, people, the object itself, or its environment may be harmed. When a Quality Deficiency creates an intolerable risk of Harm, the quality requirement that addresses it is also a safety requirement.

Understanding the object's actual Quality State can help us decide what needs to change. Findings about deficiencies, their consequences, and the conditions in which they matter can inform repairs, service arrangements, design, and further examination. They can also help direct limited resources toward the most urgent and effective actions.

The following situations illustrate how this reasoning can guide practical decisions.

## Where should pipeline repairs begin?

A network of main pipelines extends for thousands of kilometres. Examinations identify many locations needing repair, but the available crews and funds cannot address all of them at once. Some sections pass near homes or cross rivers that communities depend on. Others lie far from populated areas.

The decision requires more than counting defects or comparing their size. The examination considers each deficiency, how it could contribute to failure, and who or what could be exposed. Operating conditions, the likelihood of failure, and its possible consequences all matter. A deficiency at a river crossing may warrant earlier action than a larger deficiency at another location.

This provides a practical meaning for the expression *funding follows quality*. Evidence about the actual Quality State and the significance of deficiencies helps establish priorities, particularly in areas where failure could have serious consequences. The decision also considers how effectively each proposed repair or protective action can reduce the risk of Harm.

## Can the person enter and leave the bathtub?

A person with limited mobility needs assistance with bathing. An aide arrives on time, and the bathroom has water, bathing supplies, and a bathtub. Yet the bathtub has a high side. Helping the person enter and leave it requires considerable effort, and both the person and the aide fear losing their balance.

A record stating that bathing was completed would leave an important question unanswered: under what conditions was it completed, and at what physical demand and risk?

The examination considers the person's abilities and preferences, the bathtub's dimensions, the available space, and the assistance needed throughout bathing. It also considers the demands placed on the aide. These conditions must be understood together. A bathtub that is usable by one person may be unsuitable for another person's bathing arrangements.

Findings can guide changes to the environment, equipment, or assistance arrangements. The intended result includes bathing that preserves the person's dignity and can be carried out safely, with manageable demands on those involved. Further examination helps establish whether the changes achieve that result.

### Why does a completed bridge remain unused?

Residents have waited years for a bridge that will shorten journeys to work, school, and the hospital. Its structure is complete and meets the requirements examined. But the connecting road is unfinished, so vehicles cannot reach it. Residents continue taking the long route.

Considering the bridge's Intended Function makes the missing connection clear. Passage depends on the structure and on usable approaches. Findings about the structure alone cannot establish that the intended passage is available.

This reasoning can guide action before and after construction. During planning, it helps identify the contributions that must be ready together. During completion, it helps direct attention and resources toward what still prevents the bridge from realizing its function.

### Can a resident depend on the elevator?

An older woman uses a wheelchair and lives on the eighth floor of an apartment building. The building's only elevator repeatedly stops working. When it fails, she may be unable to leave for an appointment or return to her apartment. Her family must rearrange their day, and she worries about becoming stranded again.

The elevator passed its last inspection. That provides evidence about the conditions examined at that time. Understanding its present Quality State also requires evidence about its operation over time.

The examination considers recurring faults, interruptions, repair delays, and the access residents depend on. These Findings help establish the urgency of corrective work and the arrangements needed during outages. After repairs, operating records and residents' experience help show whether dependable access has been restored.

### What happens when an AI answer is outdated?

A person asks an AI service which documents are needed for an application. The answer is clear and confident. The person gathers the listed documents, takes time away from work, and travels to the office. On arrival, they learn that the requirements have changed and must return another day.

The service produced an answer, but the answer did not achieve the intended result of helping the person prepare correctly. Examining that failure requires attention to the service's information sources, how current they are, and how the answer was presented.

Findings can guide changes to information updates, source references, and the communication of uncertainty. They can also help identify when the service should direct a user to a source or person able to confirm the current requirements. The relevant question is whether the actual service provides sufficiently supported assistance under the conditions in which people rely on it.

## Will a digital service remain available during a heat wave?

A person tries to use an online service before a deadline, but it is unavailable. Elsewhere, staff are trying to restore equipment in a data center during a prolonged heat wave. Cooling that was sufficient under ordinary conditions can no longer maintain the conditions required for operation.

The person using the service may know nothing about the data center. Yet the service's availability depends on that infrastructure and its ability to function under relevant conditions.

An examination can consider this dependency before an interruption occurs. It asks whether cooling, power, maintenance, and other essential contributions can sustain the required functions during specified conditions. Findings can guide preparation and improvements. They also help distinguish what has been demonstrated in ordinary operation from what remains uncertain under more demanding conditions.

## Who makes sure that assistance actually begins?

A person returns home from the hospital expecting help with essential daily activities. The discharge team believes the home-care provider has arranged the first visit. The provider is still waiting for confirmation. The person and family discover the gap when nobody arrives.

Each organization may have completed its own recorded tasks, while the intended continuity of assistance has failed. Examining the transition as a whole brings the handoff into view: who confirms the arrangements, what information must be received, and how everyone knows that help will be available when needed.

Findings can reveal missing or unclear requirements at this connection. They can guide arrangements that make responsibility and confirmation explicit, so the person receiving assistance does not have to discover the failure alone.

## Did the repair solve the problem?

People repeatedly complain that a building entrance becomes slippery when it rains. A surface treatment is applied, and the repair is recorded as complete. During the next rainfall, water still collects at the doorway, and people continue struggling for secure footing.

Completion of the work establishes that an action was taken. Whether it corrected the deficiency requires examination of the entrance's actual condition and use.

Follow-up examination considers surface grip, accumulated water, and passage under wet conditions. It may show that the treatment was insufficient or that drainage also needs attention. These Findings guide further action and help establish whether the entrance now provides the required passage.

The science of quality is a powerful practical tool for understanding how well complex objects do what people rely on them to do under actual conditions. It draws on mathematics, physics, computer science, biology, the medical sciences, and other relevant knowledge. The Whole Quality approach brings that knowledge together to examine how an object functions as a whole, where it is vulnerable, and how its functions may be affected during ordinary use or when conditions change.

Quality standards for complex objects give this approach practical expression. They establish requirements for realizing Intended Functions and achieving Intended Results in particular contexts.

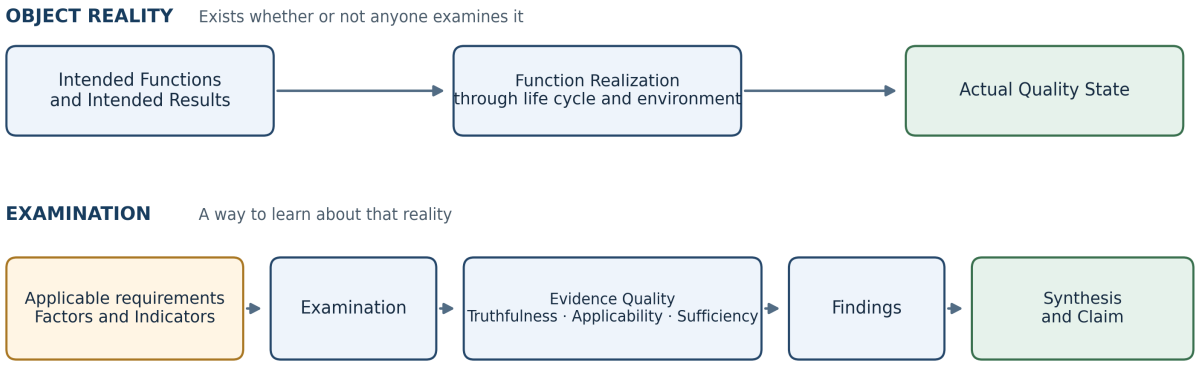
These requirements provide a basis for examining actual Quality States, identifying deficiencies, and guiding improvement. The same approach can also help reveal essential conditions for which requirements are missing or unclear.

This understanding guides action. It helps identify deficiencies before Harm occurs, establish priorities, and direct limited resources toward effective improvements. It also helps determine whether repairs, design changes, or new service arrangements have achieved their Intended Results. A vulnerability may exist while an object appears to work normally, and a pathway to Harm may exist before a specific safety requirement has been written to address it.

The practical purpose is to improve the actual conditions on which people depend: a pipeline that transports its contents without endangering a community, bathing assistance that protects both the person and the aide, an elevator that provides dependable access to a home, and an AI service that supports an informed decision. Through the Whole Quality approach and its application in quality standards for complex objects, the science of quality connects knowledge to decisions that improve Function Realization, reduce the risk of Harm, and protect the people and environments that depend on these objects.

# Supporting Annex A. From Function to Claim

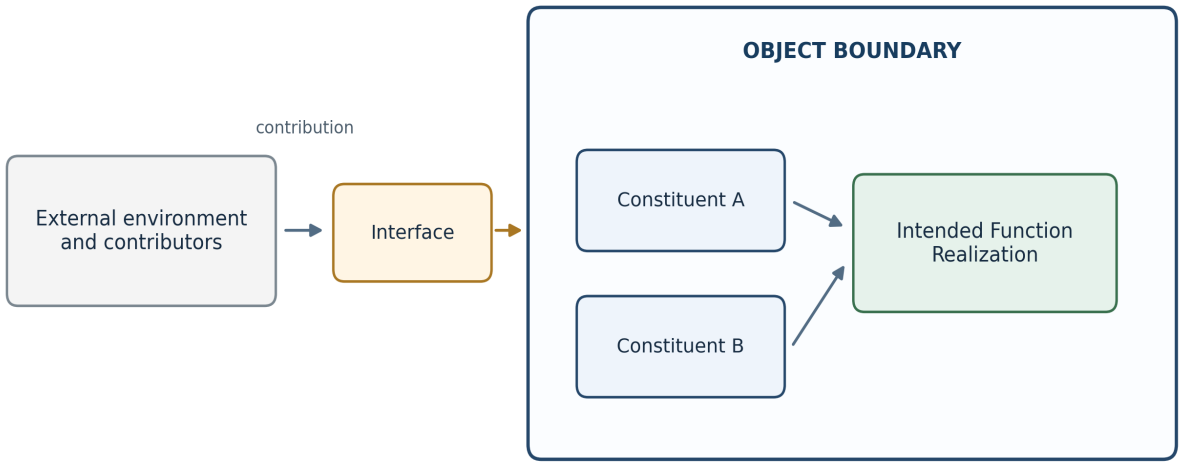
This diagram distinguishes the object's actual Quality State from the examination that helps us learn about it. The upper path describes the object's reality. The lower path describes inquiry about that reality.




The object realizes its functions and has a Quality State whether or not it is examined. Examination considers Evidence, develops Findings, brings them together, and communicates what they support.

## Supporting Annex B. Object, Constituents, and Environment

An object may contain Constituents that work together and may depend on contributions from outside its boundary. Interfaces are the connections through which those relationships can matter to Function Realization.




The boundary distinguishes the object; it does not make the object independent.

For a bridge, the deck, supports, and foundations may be Constituents; roads and traffic conditions can affect passage through connections and surroundings. A heart can be considered as an object within the larger human body. An AI service may depend on a data center outside its boundary. What belongs within the object and what remains outside depends on the question, while essential contributions and connections still need to be considered.

## Supporting Annex C. Scale and Methodological Resolution

Scale describes the extent of the object or area being considered. Methodological Resolution describes how finely we distinguish and examine features within that extent. They are related, but they answer different questions.

| Example | Scale: what extent is considered? | Methodological Resolution: how finely is it examined? |
|---|---|---|
| England's coastline | The coastline of England as a whole | A broad map or a detailed survey of small coastal features |
| A bridge | The whole bridge | Overall performance, individual structures, or a particular joint |
| A human body | The person's body | Overall health, the heart, or a specific heart function |

A broad examination can use fine resolution, and a small object can be examined at different levels of detail. The appropriate choice depends on the question. A conclusion should make clear both the extent examined and the level of detail used.

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