ID		Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-48	**4**	**Requirements**			
L2-CU-RQ-49	**4.1**	**Resource Management**			
L2-CU-RQ-50		The CI shall support distributed resources, applications and actors	A resource is any entity associated with an observatory that provides capability, and includes instruments, data, workflows, networks and more. An application utilizes resources to achieve an outcome. An actor is an entity external to an observatory that interacts with it, and may be a human or a machine. The availability of remote and controllable resources is becoming more and more common. The CI shall support the management and control of remote resources. This includes providing flexible access to resources as well as reliable communication. The CI shall support the operation and maintenance of remote resources; this helps to significantly reduce maintenance costs and improve overall system reliability.	Critical	CA-PD-1 RWS1-R1 RWS2-R41
L2-CU-RQ-51		The CI shall provide the capability for a given resource to initiate change in another resource	For example, a resource needs to be able to request additional resources from the infrastructure (e.g., a camera requesting permission to turn on a light, thereby requesting power from the infrastructure) or from another resources. The latter is required for AUV clustering or sensor fusion applications.	Essential	CA-IRU-2
L2-CU-RQ-52		All resources under CI governance shall be identifiable	This entails both a requirement on resource providers and on the CI. In the latter case, it requires provisioning of a mechanism for resources to provide the necessary information. Identification of resources shall follow OOI naming conventions.	Critical	CA-OP-1
L2-CU-RQ-53		All resources under CI governance shall be authenticatable	This entails both a requirement on resource providers and on the CI. In the latter case, it requires a mechanism to authenticate resources that may be particularly important to national security authorities.	Critical	CA-OP-1
L2-CU-RQ-54		All resources under CI governance shall be authorizable	Resources must be authorized to utilize other resources, including those from the infrastructure. The CI must provide a mechanism to carry authorization out.	Critical	CA-OP-1
L2-CU-RQ-55		All resources under CI governance shall be auditable	The CI must provide a mechanism to audit resource actions.	Critical	CA-OP-1
L2-CU-RQ-56		The CI shall incorporate a policy-based decision system for the management of CI-governed resources	Resources in a shared environment must be governed by policy from resource providers, observatory operators, the OOI program and external entities such as the US Navy.	Critical	CA-OP-3 CA-IP-1
L2-CU-RQ-57		The CI shall ensure that resource utilization is governed by the rights and allocations of the initiating actor	The CI shall automatically enforce policy so that an actor has access to authorized resources within the bounds imposed by their rights and allocations, including the policies of the resource provider.	Critical	CA-IP-3 CA-IRU-11
L2-CU-RQ-58		The CI shall enable non-persistent connection of resources, users and applications	The CI provides a network of distributed services and resources that can be temporarily unavailable or impermanently connected. Users and applications should be able to interact with the CI on a regular basis without the obligation to be connected and online. For instance, it shall be possible to perform automated, bulk data stream updates and downloads of subscribed data products with temporary connections to a CI point of presence without loss of the session, configuration and state. One consequence of this requirement is the need for data caching and buffering while either a resource or the connected user/application is offline.	Critical	RWS1-R2 ROOP-R9
L2-CU-RQ-59		The CI shall act as the facilitator and broker for resource usage	The CI is the facilitating element that connects and binds different resources such as models and models, observations and models, observations and observations, instruments and models, etc. All brokerage and binding is subject to policy.	Critical	CA-IRU-1 CA-IRU-4 RWS2-R8 RDPG-R23 RDPG-R59
L2-CU-RQ-60		The CI shall schedule resource usage based on capacity, capability and availability	Resource providers and marine operators know about the capabilities, projected capacities and the availablility of resources. Operators who manage observatories report scheduling as one of the most time consuming activities. The CI needs to receive and forward this information to facilitate resource scheduling. This also includes changes to resource availability over time.	Critical	ROOP-R28 RIOM-R52
L2-CU-RQ-61		The CI shall support the evolution of resources under CI governance	Resource providers and scientists rely on the flexibility to make continuous changes and improvements to their instruments and models. The CI needs to match this expectation and expect change. The CI needs to provide support for this process of change, such as keeping track of manually entered changes, reconfigurations, annotations and comments.	Critical	ROOP-R3 ROOP-R31
L2-CU-RQ-62		The CI shall support the resource life cycle, providing notification to resource providers and consumers when manual intervention is required	Steps in the resource life cycle include the application process, approval process, device driver implementation, calibration, testing, recalibration, deployment, commissioning, maintenance/servicing, recovery, decommission/disposal, sparing and upgrading. For instrument recovery and replacement, it is important that any deviation of the recovered instrument from the state in which it was deployed be immediately detected. Instruments are calibrated pre- and post-recovery to assess data validity and to correct for sensor drift. The CI needs to supports the analysis of the calibration history of a sensor and possibly provides a GUI interface to look for anomalies in calibration. Where maintenance schedules are known, the CI needs to provide alerts for upcoming maintenance and service of instruments.	Critical	RDPG-R19
L2-CU-RQ-63		The CI shall provide a catalog listing all resources under CI governance	A catalog provides references to the cataloged resources and further descriptive information and metadata. It must track all CI-managed resources throughout their life cycle. The catalog shall not be restricted to resources of certain types or characteristics. The CI shall provide unique identification for all resources under CI governance, including physical and information resources, in their different variants and versions.	Critical	CA-IRD-3 RWS1-R9 RDPG-R20 RIOM-R43 RIOM-R48
L2-CU-RQ-64		The CI catalog shall provide status information for all resources under CI governance	Many users expressed the need to see the current state of all assets on the system so they know what is working and what their resources are at any given time.	Critical	RIOM-R21 RIOM-R22

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-65	All resources under CI governance shall be discoverable, either directly, by content or through their associated metadata	This entails both the ability for a physical resource to be directly discoverable and for a general resource to be discoverable through the catalog and metadata.	Critical	CA-IRD-1 RWS1-R9A RWS2-R15
L2-CU-RQ-66	Multiple actors shall be able to simultaneously discover the same resource	An observatory may have many users looking for capabilities at the same time. It is also possible that a resource will want to access the system while a user is trying to communicate with it. The CI must be able to allow the resource to communicate with more than one actor at a time.	Essential	CA-IRD-11
L2-CU-RQ-67	The CI shall integrate resource discovery with resource access subject to policy	The catalog must provide links to the cataloged resource, whether physical or information, but access will be determined by level of authorization.	Critical	CA-IRD-12
L2-CU-RQ-68	The resource catalog shall link entries to the associated metadata	The catalog must take an actor to the metadata about the resource.	Critical	CA-IRD-7
L2-CU-RQ-69	The resource catalog shall incorporate information about physical samples	Physical samples refer to biological, chemical or geological samples retrieved from the seafloor or water column, for example during an expedition. Some physical samples are collected within OOI observatories but not analyzed in it; other samples are collected outside of OOI observatories but should be available to OOI users. Cataloging physical samples in the CI requires that metadata be associated with these samples. This capability facilitates reaching out to many communities. The CI shall make the analysis results on physical samples available together with co-registered instrumental data sets and metadata.	Essential	CI-IRD-10 RWS1-R11 RDPG-R46
L2-CU-RQ-70	The CI shall cross-reference CI-governed resource catalogs and external resource catalogs	Resources that are under CI governance, whether part of OOI or not, can also be listed and registered in external resource catalogs. Metadata about resources can be available at external locations. The CI shall facilitate cross-referencing such external catalogs and metadata locations from CI resources and CI catalog entries. This enables full resource information and cross-referencing availability from within CI interfaces.	Essential	CA-PI-6 RWS1-R12 RWS2-R15 RDPG-R32
L2-CU-RQ-71	The CI shall enable discovery of all information resources that are derived from a given original information resource	For instance, it shall be possible to discover all distinct data streams that are based on the same instrument source with possible differences in sampling rate, quality of service parameters, metadata annotations or applied post-processing algorithms. This is useful when alternatives to a given data product need to be found, for instance because one becomes unavailable. This requirement also applies to finding all models and their output that are based on a given input data source.	Desirable	RWS1-R19
L2-CU-RQ-72	The CI shall provide resource subscribers automatic and manual fallback options with similar characteristics in case the original resource becomes unavailable	In case of temporary or permanent unavailability of a subscribed data stream, the CI shall offer alternatives that are comparable to the original resource, for instance because they are based on the same source data or other characteristics. If desired by the user, this fallback shall be automatic for uninterrupted operation. The term similar relates to OOI-standard metadata characteristics that pertain to both original and fallback resources. The exact choice of fallback resource selection criteria shall be left to the user.	Desirable	RWS1-R20
L2-CU-RQ-73	The CI shall provide services to group resources	For example, the CI shall relate all instruments of the same type at the same location over time. Successive positions of replaced sensors must be recorded and related. For long-term series, the succession of sensors at a primary sensor site needs to be recorded. Data need to be accompanied by metadata describing the succession of different sensors over time with different calibrations etc. Data products providing a long-term time series of measurements spanning multiple replaced sensors can then refer to all resources providing the same measurement at a site. Grouping resources can occur manually by users or automatically by shared characteristic, such as site, instrument type, region, etc.	Essential	CA-IRU-8 RDPG-R40
L2-CU-RQ-74	The CI shall provide registration services for resource notification	Users need the capability to register for notification about changes or events for specified resources. This includes the arrival of new data. Another example is a detected event by an event detector, which is a data processing resource publishing an information resource	Critical	CA-IRP-1
L2-CU-RQ-75	The CI shall automatically register resources for notification to the observatory operator	The capability of registering for a basic set of events (e.g., internal failures) should be part of the process of commissioning a resource	Critical	CA-IRP-2
L2-CU-RQ-76	The CI shall provide notification of resource state change to all resource subscribers	The term state refers to behaviors or characteristics that persist (for instance whether an instrument is on- or off-line, or changes in QA/QC state for archived data, availability of new versions of data). Notification applies to all subscribers and registered users for a resource.	Critical	CA-IRP-3 RWS1-R26 RWS2-R13 RDPG-R23 ROOP-R48 RIOM-R57
L2-CU-RQ-77	The CI shall bind metadata to all resources under CI governance throughout the resource life cycle	CI governed resources shall have metadata descriptions from inception to removal. This requirement does not specify the metadata format or content.	Critical	CA-IRC-5 RWS1-R16

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-78	The CI shall support standard OOI-standard metadata content that includes, but is not limited to, a complete description of resource behavior, content, syntax, semantics, provenance, quality, context, citation, correspondence and lineage	Metadata provide descriptive information about any kind of OOI resource. Metadata standards will be externally imposed since the OOI is federally funded, but the OOI standard will probably need to go beyond them. The term behavior refers to the inherent characteristics of a resource (such as the range of sample rates that an instrument is capable of). The term content refers to the characteristics of any externally presented information provided by a resource (for instance what an instrument measures, including calibration information). The term syntax refers to a model for the resource content based on structure. The term semantics refers to a model for the resource content based on meaning. The term provenance refers to the resource origin, e.g., how and by whom data were collected. For data products, this identifies the sensor and instrument platform where the data originated. The term quality refers to information on the QA/QC status of a resource. The term context refers to information about resource usage (such as the geographic location of an instrument). Citation means statements about the use(including the outcome) of a given resource by another re	Critical	CA-IRC-2 RWS1-R18 RWS2-R10
L2-CU-RQ-79	The CI shall specify and utilize a standard vocabulary	The use of a standard vocabulary simplifies resource discovery through metadata. An OOI vocabulary will also facilitate messaging between senders and receivers of data.	Critical	CA-OM-2 CA-IRC-3
L2-CU-RQ-80	The CI shall maintain the relationship between OOI standard metadata and the vocabulary	This is the requirement to enforce the standard.	Critical	CA-IRC-4
L2-CU-RQ-81	The CI shall allow resource discovery utilizing the standard vocabulary	Extension to mixed vocabularies is highly desirable.	Critical	CA-IRD-2
L2-CU-RQ-82	The standard vocabulary shall accommodate information on physical samples	The OOI organization shall establish this standard for use for all physical samples registered with the CI.	Essential	RDPG-R47
L2-CU-RQ-83	The CI shall provide data generating resources using proprietary metadata formats with a means to transform them to OOI standard metadata	In case no automatic translation of resource-specific metadata to OOI standard metadata can be performed, the resource provider must supply this translation procedure to the CI. This can be facilitated by providing connectors for user-provided transformer code. The requirement implicitly entails imposing the need for OOI standard metadata so that the resources will be discoverable.	Critical	CA-IRC-6 CA-IRC-7
L2-CU-RQ-84	The CI shall support the provisioning of OOI standard metadata	Services shall be provided that assist resources and actors to provide and maintain metadata. It is best is to capture metadata as early as possible. If necessary though, the addition of metadata later in time should be as unobstructed as possible. The CI should provide interfaces that hint to missing or incorrect meta-data and enable to quickly locate the context where meta-data should be applied.	Critical	CA-IRC-11 RWS2-R14 RDPG-R41 RIOM-R51
L2-CU-RQ-85	The CI shall verify compliance of metadata with the OOI standard	This applies to automatic and manual provisioning of resource metadata.	Critical	CA-IRC-11 RWS2-R14
L2-CU-RQ-86	The CI shall update resource metadata within 5 seconds of resource reconfiguration	When an instrument is reconfigured, the CI must automatically create updated metadata. It is important for users to know when this has occurred and the immediate update will insure this will happen.	Essential	RIOM-R52
L2-CU-RQ-87	The CI shall provide services for control and monitoring of observatory infrastructure resources	Basic control includes power and bandwidth allocation. Monitoring entails status reporting for infrastructure elements.	Critical	CA-IRU-4 ROOP-R22 RDPG-R61
L2-CU-RQ-88	The CI shall provide services for pervasive resource monitoring and control	This entails monitoring and control of the heterogeneous resources throughout the observatory, as well as operational events they produce and commands they can receive. The CI shall have complete control of system operations. These functions shall be automatic to the greatest possible extent.	Critical	CA-IRU-4 CA-IRU-5 RDPG-R54 RDPG-R60 RDPG-R61 ROOP-R23 RIOM-R40
L2-CU-RQ-89 **4.2**	**Data Management**			
L2-CU-RQ-90	The CI shall be capable of archiving all data and data products associated with an OOI observatory	The decision about which data or data products will be archived is made by an authorized OOI operator and is subject to policy and resource availability. It might be driven by economics. All data products must be archived in association with their metadata.	Critical	CS-IRE-1 RWS1-R21
L2-CU-RQ-91	The CI shall act as a broker for CI-managed data products	The CI shall ingest data products and provide access to these products on demand. The CI shall provide universal data delivery.	Critical	RWS2-R6 ROOP-R59
L2-CU-RQ-92	The CI shall ingest data with variable delivery order	Ingestion is the acceptance of data from sensors and communication infrastructure, together with metadata for archival and distribution. Data can arrive with unpredictable latencies on the order of seconds to months (the latter after a bulk off-load by a ship together with satellite transmission of a decimated version) due to various extraction and communication strategies. The data packets may also arrive out of order. The CI needs to ingest such data after reordering them based on timestamps.	Critical	CA-IRE-9 RDPG-R48 ROOP-R42 ROOP-R43 ROOP-R44
L2-CU-RQ-93	The CI shall support the delayed distribution of temporarily sequestered data	This requires CI-interpretable timestamps indicating that sequestering can end to be in place. The time after which data might become available could be months	Critical	RDPG-R11
L2-CU-RQ-94	The CI shall ensure the integrity and completeness of all archived data products throughout the OOI life cycle	The CI shall ensure data integrity and completeness for all data products throughout the entire OOI life cycle, no matter which transformations and archival processes the data products undergo. This encompasses the requirements to verify that archived data accurately reflect the original, and that archived data are protected from loss due to media degradation or technology change.	Critical	CI-IRE-3 RWS1-R23 RIOM-R30
L2-CU-RQ-95	The CI shall ensure that all archived data products can be restored to their most recent state	The archiving process must ensure that all data get archived completely and immediately so that the most recent data are always stored. The restore process must be capable of returning a data product from any persistent distributed CI storage, for instance in case of failure, in a complete and the most recent state.	Critical	CI-IRE-4 RWS1-R24

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-96	The CI shall provide a topic-based (publish/subscribe) data distribution infrastructure	The primary means for interfacing with the CI shall occur in publish/subscribe or register to receive style.	Critical	CA-OC-5 CA-IRP-6 RWS1-R30 RWS1-R47
L2-CU-RQ-97	The CI shall provide registration services for data subscriptions	Registration is the selection of desired information resources from the resource catalog and the indication of intent to receive content, metadata and status updates from thereon for the subscribed resources. Subscriptions can be ended at any time. The CI shall keep track of all subscriptions of an actor or resource	Critical	CA-IRP-6
L2-CU-RQ-98	The CI shall publish unprocessed raw sensor data	Typically, processed and quality controlled versions of data products are made available to observatory users. The filtering and corrective actions applied to raw data are at the discretion of some scientists. Other researchers might be interested in the original raw data streams as produced by the sensor, for instance in order to apply different corrective actions. The CI shall keep raw sensor data and make them available on request, in addition to any version of processed data products based on the same raw data.	Essential	RWS2-R9
L2-CU-RQ-99	The CI shall archive unprocessed raw sensor data	Raw data must never be lost. Before applying any transformations or corrections, raw data must be saved.	Critical	RDPG-R12
L2-CU-RQ-100	The CI shall support the publication, distribution and archiving of different versions of the same data product or stream	Different versions of a data product or stream may occur due to changes in its QA/QC state, sensor calibration, filtering, necessary post processing or modeling utilizing data. Quality levels include raw data, flagged QC data, or unflagged public use data. While instrument owners may be interested in raw data only, some data modelers might only want to use data in their models that underwent rigorous QC. All users should be able to find and select these data products or streams for the same instrument. The owner of a data product may decide to publish an updated version of the data product. The CI shall offer all data product subscribers the new version of the product. Each data product or stream shall be uniquely identified with its version. The CI shall be capable of archiving all versions of the same data product or stream.	Critical	CA-IRE-7 RWS1-R22 ROOP-R49 RIOM-R27
L2-CU-RQ-101	The CI shall support real-time data delivery	Real time means minimum delay commensurate with latency on the channel.	Critical	CA-OC-1 RWS1-R47
L2-CU-RQ-102	The CI shall support guaranteed data delivery	Guaranteed delivery refers to storage of a message by the CI until an acknowledgement of receipt is received. This might be required for instrument platforms that are intermittently connected (e.g., buoys)	Critical	CA-OC-2 RWS1-R47
L2-CU-RQ-103	The CI shall support store until requested (pull mode) data delivery	This delivery mode requires storage of a message pending receipt of an explicit request for it (pull mode), but without a receipt mechanism.	Critical	CA-OC-3 CA-OC-8 RWS1-R47
L2-CU-RQ-104	The CI shall support streaming data delivery	The term streaming refers to asynchronous, continuous transmission. Users and applications can subscribe to any kind of information resource subject to the relevant policies. The CI shall be responsible for keeping track of the state of data delivery and provide buffering and re-transmission capabilities if needed. Data delivery shall be immediate when new information becomes available, as desired by the user. Data streams are similar for unprocessed raw data and for processed and aggregated data.	Critical	CA-OC-4 RWS1-R31 RWS1-R47 ROOP-R5
L2-CU-RQ-105	The CI shall integrate multiple data streams or data sets into a single stream or set, eliminating redundant entries	Examples: in situ + NDBC +NCEP, in situ + satellite, regional networks, global networks, real time + archived data. In addition, long term data streams must be supported.	Essential	CA-SSA-4 ROOP-R65 RDPG-R15 RIOM-R53 RIOM-R54 RIOM-R63
L2-CU-RQ-106	The CI shall support peer-to-peer communication between discoverable resources	For example, resources such as underwater vehicles rely on communication to coordinate and adapt their observation strategy. The CI shall provide means for such communication, possibly subject to mediation by the CI presence at a shore station or on the seafloor.	Essential	CA-OC-6 ROOP-R39
L2-CU-RQ-107	The CI shall support secure data delivery	Encryption may be required for certain types of data by national security authorities. This requirement entails providing support for this capability as directed by the cognizant authority.	Essential	CA-OC-7
L2-CU-RQ-108	The CI shall adapt data delivery in the presence of limited available bandwidth according to policy	In the event that bandwidth is reduced due to equipment failure or changing channel characteristics, policy sets the priorities for different data sources and determines what will be sent.	Critical	CA-OC-8
L2-CU-RQ-109	The CI shall notify registered resource users when data delivery cannot be achieved due to low available bandwidth		Critical	CA-OC-8
L2-CU-RQ-110	The CI shall adapt data delivery in the presence of high channel latency according to policy	This situation may occur in an acoustic communications environment. As a mobile platform moves away from an acoustic communications node, the latency rises, and this may make it impossible to deliver all of the data from it. Policy determines the priority for data delivery in this environment.	Critical	CA-OC-8
L2-CU-RQ-111	The CI shall notify registered resource users when data delivery cannot be achieved due to high channel latency		Critical	CA-OC-8

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-112	The CI shall publish data from external data sources, data bases, and data distribution networks from related scientific domains.	Oceanographic data analysis and modeling often relies on multiple data products and interdisciplinary oceanographic data sets, for instance as boundary conditions in numerical models. Some of these data products originate from non-OOI data sources, such as atmospheric data, IOOS data products, Argo, NASA, Codar etc. Other data products are provided by local servers within the institutions of OOI users. Ingestion of external data products requires interfaces and potentially agreements with data sources and data distribution networks where the data products are published. All post-processing tools available for use with CI data products shall be applicable to such external data products. The CI shall provide flexible capabilities for any CI user to add new external data sources to the OOI network. For instance, projects have made extensive investments in database formats, such as XML standards or MetaCAD. The CI needs to provide adapters for such data formats. Some data sets might not be available for ingestions with the CI or might be too large to handle or transport. Such large files from bulk offload might be available at a URL on an external site. The CI sh	Essential	CA-PI-6 CA-IRP-5 RWS2-R2 RDPG-R13
L2-CU-RQ-113	The CI shall provide support for large volumes of data	The CI needs to store large-volume scalar measurements and more complex measurements as well as associated metadata. Ease of use and automation for handling large data volumes is particularly relevant for continuous streaming data to manage the "data fire hose" situation. The ability to reconnect and resume download in the event of a dropped connection is also required.	Desirable	RDPG-R7
L2-CU-RQ-114	The CI shall archive and catalog text, images, pdf, .doc files and spreadsheets	This provides the ability to archive and access paper records (after scanning) as well as computer files generated during the course of experiments. The exact file formats must be specified.	Essential	RIOM-R25 RIOM-R49 RIOM-R50
L2-CU-RQ-115	The CI shall flag and notify data stream and data set state change	A sensor may provide a data stream for a set of measured variables. Remote sensing can undergo periodic revision due to improvements in the processing algorithm. There may also be ongoing calibration and validation efforts. Assimilating consistent data with non-consistent data produces inconsistent data as output. Therefore, subscribers to data products need a mechanism to be informed about changes to resources and to distinguish subsets of data with different characteristics. Flags can also indicate the result of data QA/QC as good, bad or unchecked. Changing flags is required when performing reanalysis or manual revisit of the data. Such capabilities support a self-organizing quality control.	Essential	RWS2-R13 ROOP-R48
L2-CU-RQ-116	The CI shall flag and notify redundant data and metadata	Observatory systems are complex and users report difficulty in tracking data and metadata at times. They would be able to work more efficiently if the network could track data streams and data sets, and automatically flag duplicates. These can then be eliminated after verification by a human actor.	Essential	CA-IRE-10 RIOM-R55
L2-CU-RQ-117	The CI shall acknowledge requests for data with an estimate of delivery latency	Users might have specific and urgent requests they will send to the system. The users will want to know that their request was received and action was taken. It is important to report back to the user and let them know the system has begun processing the request. Even if the query is complex, the system must communicate with the user to let them know the request is being processed and that a final response will be forthcoming within a certain time frame (e.g. "Your request is being processed. You will receive an answer with XX hours").	Desirable	CA-IRE-6 RIOM-R31 RIOM-R62
L2-CU-RQ-118	The CI shall credit data publishers when data products are accessed	The CI shall make provenance information available, for instance in resource descriptions and metadata and credit data publishers each time the data product is used, e.g. in the way of a citation index. The term citation refers to statements about the use (including its outcome) of a given resource by another resource or actor. This creates incentives for publishing data to the CI instead of keeping data for private use only.	Desirable	RWS2-R11
L2-CU-RQ-119	The CI shall provide services and interfaces for the acquisition of bulk data	Bulk data from ship-based expeditions or collected on disks of gliders need to be made available to the CI together with their metadata. The CI needs to provide user and application interfaces to upload such bulk data files of potentially large size.	Essential	RDPG-R4
L2-CU-RQ-120	The CI shall associate bulk data with their metadata and related data products	Metadata might be pre-existing in the CI or need to be entered. The CI needs to provide user and application interfaces to associate bulk data with their metadata definitions automatically or manually.	Essential	RDPG-R4
L2-CU-RQ-121	**4.2.1 Data Transformation**			
L2-CU-RQ-122	The CI shall support the moderation and auditing of published data	In an automated system such as the CI, any authorized user can publish data products independent of their quality and suitability. In order to maintain high quality levels for data products, it is important to facilitate oversight and manual QC of data subject to system-defined policies. The CI shall facilitate such policy-compliant oversight processes by independent authorized parties that assess and rate new and existing data products and resources according to defined quality standards.	Essential	CA-IRE-12 RWS2-R5

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-123	The CI shall provide services for interactive and automated data quality control (QC)	Science data QC refers to the process of analyzing and post-processing raw data streams in order to assure accuracy and quality of the resulting published data product. The QC process involves manual steps that require the judgment of scientists or engineers and the execution of corrective actions. The CI shall support this process of interactive analysis and processing of data products and data streams. The CI shall also support an automated QC process, for instance by providing means, strategy and policy to filter data and to define which data should be filtered, and workflows that apply QC automatically to data streams. QC will result in a new data product or a new version. The actual time when QC is performed or configures shall be of no relevance. QC can be based on the evaluation of pre- and post- calibration results or be an experience-based assessment. The CI shall be able to automatically detect gaps and jumps in sensor data and flag such anomalies.	Essential	RWS2-R3 RDPG-R49 ROOP-R46
L2-CU-RQ-124	The CI shall perform automated quality control of observational data products in near real-time	Real-time QC may be based on short-term comparison of data and the comparison with nearby sensors, comparison with alternative data sources and comparison with historical/climatological records	Essential	ROOP-R47
L2-CU-RQ-125	The CI shall provide standard and user-defined methods to assess the quality of data	Researchers might be interested in the maturity of data. Maturity refers to the quality of a data product, its accuracy and integrity, and the number of QC steps that have been applied. The CI shall define a standard that enables an assessment and ranking of data sources according to their maturity, for instance by analyzing provenance and lineage information. For user-defined quality assessment, the CI could help to share metrics that contain the assumptions and the knowledge about the data and quality of the models and input data over several years.	Essential	RWS2-R4
L2-CU-RQ-126	The CI shall specify data models for resources based on characterization of structure (syntax)	Interfacing with the CI requires compliance with CI interfaces. The CI shall provide a number of pre-defined data models that will be compatible with the CI, either as a data producer or as a data receiver. Currently predominant formats in the community include NetCDF (OceanSites, Climate and Forecast (CF) and COARDS flavors) for data and OPeNDAP and THREDDS for data exchange, and hence these technologies shall be supported by the CI. Others need to be specified.	Critical	CA-OC-11 CA-OM-4 RWS1-R4 RWS1-R4A RDPG-R14 RIOM-R27
L2-CU-RQ-127	The CI shall translate between standard syntactic data models without loss of information	This refers to the different standards and formats that data providers use. The CI needs to mediate between these standards and formats by means of automatic or manual mappings and translations. Interoperability refers to the transparency of the data source when using analysis and presentation tools	Critical	CA-OC-11 CA-OM-4 RWS1-R4 RWS1-R4A RDPG-R8 RIOM-R27
L2-CU-RQ-128	The CI shall support translation between user-specified syntactic data models	This requirement encompasses the provision of documented connectors to allow a user to provide transformer code to handle user-specified data models	Essential	RWS1-R5 RDPG-R53 RIOM-R32
L2-CU-RQ-129	The CI shall specify data models for resources based on characterization of meaning (semantics)	This extends syntactic models to accommodate ontological meaning	Essential	CA-OM-3
L2-CU-RQ-130	The CI shall support mapping between senders and receivers using the standard vocabulary without loss of information	The ability to utilize ontologies to facilitate messaging needs to be incorporated. The supported formats will be extensible but must remain backward compatible over time.	Essential	CA-OM-1 RDPG-R42
L2-CU-RQ-131	The CI shall provide capabilities to define event detectors	Event detectors are data product consumers of real-time or historic data that apply event detection algorithms on one or multiple data products. For instance an underwater earthquake might be detected by comparing multiple seismometer readings. Event detectors provide outgoing data streams that contain the detected events and characteristics thereof.	Essential	RDPG-R44
L2-CU-RQ-132	The CI shall provide event detection services	This applies an event detector to specified data sets or streams.	Essential	CA-SSA-5
L2-CU-RQ-133	The CI shall provide registration services for event notification		Essential	CA-SSA-5
L2-CU-RQ-134	The CI shall provide notification of detected events		Essential	RIOM-R29
L2-CU-RQ-135	The CI shall provide versioning for detected events	Each detected event must have a unique identifier.	Essential	RIOM-R29
L2-CU-RQ-136	The CI shall update data sets as sensor calibrations become available	In order to maintain quality standards, the CI must apply new calibrations for sensors as they become available, resulting in a new version of the data.	Essential	RIOM-R47
L2-CU-RQ-137	The CI shall be able to accumulate knowledge about the scientific interpretation of observational data from manual mapping and linking of variables between different data sets	User provided data transformations and mappings contain knowledge about the interpretation of measurements in terms of standard ocean variables. The CI can exploit the user knowledge, for instance by inferring rules from recurring user actions and letting expert users confirm these rules. The knowledge of the system increases gradually with contributions from many expert users.	Desirable	RDPG-R43
L2-CU-RQ-138	The CI shall be capable of co-registering data from different instruments in space and time	Coregistration refers to correlating measurements from various sources that share some commonality, such as location or time, so that events of spatial and temporal extent can be correctly traced back to the individual measurements.	Desirable	RDPG-R45
L2-CU-RQ-139 **4.3**	**Research and Analysis**			

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-140	The CI shall suggest suitable data products, observation resources, analysis tools, visualization tools and other OOI resources based on user-specified research questions using the standard vocabulary	Getting from research questions to possible solutions in terms of available OOI and CI resources can be a complex and tedious task, in particular for generic, multidisciplinary research questions. The CI shall support this task to the greatest degree possible by enabling users to state research questions in domain language, and then suggesting available resources that can be part of the solution. This decouples observation request definition from resource matching to execute a job. For instance, a scientist studies a phenomenon in the Monterey area. Relevant questions to answer include “are moorings there?”, “are any ships passing by?”, “are any gliders in the area?”, “are any satellites measuring something?”, or “are any models that some scientists run in the area?”. This capability will realize a transformative change for the community and beyond. It realizes a transition to a service way of providing information. For instance, ecology researchers will be able to get answers to questions about marine life that currently require searching massive amounts of data for very little information. For numerical modeling, the CI shall provide decision support for selecting boundary condition inpu	Desirable	RWS2-R16
L2-CU-RQ-141	The CI shall support interactive data analysis and visualization through tools and user interfaces	Analyzing observation and model data is a complex and highly interactive process. It requires specialists with substantial knowledge about the domain, literature, and technology. The CI shall facilitate the analysis of data by providing the means to perform user-driven interactive analysis. All applicable analysis and visualization tools shall be available to the analyst, with efficient ways to configure and run them on the available input data sets. The turn-around time to change and re-run analyses with different parameterizations shall be as low as possible. The CI shall keep track of the sequence and configuration of analyses, and of the resulting outcomes, and provide these to the user. Iterative analysis relates to the concept of re-running similar analysis steps with refined data sets and parameterization to optimize the resulting output.	Essential	RWS2-R17
L2-CU-RQ-142	The CI shall provide a standard, extensible set of data processing elements that provide data assimilation, alignment, consolidation, aggregation, transformation, filtering, subsetting, averaging and scaling	The standard processes will be defined through a community decision process. Such data processing elements can include assimilation of various data products, elimination of redundant entries, spatial interpolation, collocation of data sets, merging multiple compatible data products into one data stream etc. Further standard data manipulation tasks for model integration and combination can include re-projection, re-gridding, subsetting, averaging, filtering and scaling. The set of processing elements shall be extensible; as standard OOI processes, as well as by users with their own processing elements. Such processes shall be able to use data product meta-data for automated processing, such as alignment of data geographical grid points based on resource meta-data when combining multiple models outputs.	Essential	CI-SSA-1 RWS1-R25 RWS2-R7 RWS2-R12 RWS2-R18
L2-CU-RQ-143	The CI shall provide capabilities for analysis and presentation of environmental data at specified sites	Environmental data are required for the characterization of areas of interest before actual mission deployments. The CI need to be able to provide such characterization data from various data sources as required by specific observation missions	Essential	ROOP-R38
L2-CU-RQ-144	The CI shall support the integration of external analysis tools	New analysis a tools and technologies become available all the time. The CI shall provide interfaces to extend its set of available tools with new ones that are subsequently available to the OOI users. As Matlab is the most widely used analysis tool, interfacing to it is the highest priority. Consideration should be given to interfacing Mathematica. Both of these analysis tools are also visualization tools.	Critical	RWS2-R37 RDPG-R64 RIOM-R64
L2-CU-RQ-145	The CI shall provide capabilities to transform between coordinate systems	The list of coordinate systems needs to be specified.	Desirable	RDPG-R38
L2-CU-RQ-146	The CI shall provide capabilities to transform between map projections	The list of projections needs to be specified.	Desirable	RDPG-R38
L2-CU-RQ-147 **4.4**	**Ocean Modeling**			
L2-CU-RQ-148	The CI shall enable the efficient configuration, execution, and debugging of numerical ocean models	Currently, the learning curve for numerical models is substantial and requires technical knowledge, expert users and extensive specific model knowledge. Making numerical models accessible to non-experts is an important step in reaching a broader audience. Models, and their parameterizations, input data assimilations and output visualizations are typically developed over extended periods of time by groups of experts and require substantial technological and scientific knowledge. Ways to improve the handling of numerical models include improved user interfaces that enable the definition of basic model parameters, data archival settings, model output use etc. The CI could increase model configuration efficiency through intuitive GUIs for non-experts that enable them to choose all of the necessary options for a model (see ROMS). These user interfaces could capture expert knowledge and make it available to non-experts, thus flattening the learning curve and improving efficiency. The CI should provide facilities for easy model diagnosis and debugging. This	Critical	RWS2-R19

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-149	The CI shall support the interaction of model developers and non-expert model users	The transfer of knowledge from model developers to model users is very important because model users are typically non-experts for the specific model. The CI shall enable the documentation and self-documentation of models and facilitate the interaction of expert model developers and non-expert model users through sharing parameter settings, easy to use configuration interfaces and pre-configured analysis and visualization tools. The CI shall also provide the communication tools enabling knowledge transfer, such as bulletin boards, discussion forums, wikis, public commenting features etc. With the existence of a capable infrastructure, the community will be very receptive and there will be experts who will provide comments and contributions.	Critical	RWS2-R20
L2-CU-RQ-150	The CI shall provide capabilities to tune numerical models	Besides the numerical model algorithm, an important step in developing an effective numerical model is finding an optimal parameterization. This requires many model runs with different parameter values and comparison of the results with actual observations, for instance by comparing hindcast simulations with real world observations. The CI shall support this process by enabling parameter optimization of CI managed models and provisioning of suitable analysis tools.	Essential	RWS2-R21
L2-CU-RQ-151	The CI shall provide a virtual model environment and simulator to determine optimal model inputs, parameterizations and outcome qualities	The outcome of a numerical model is constrained by the quality and availability of the input data. Determining what the outcome quality will be with given input data and which changes of input data will lead to more optimal model output are important steps in the overall observation and analysis process. In an adaptive observation environment, this can lead to optimized measurement schedules for deployed sensors, such as gliders, AUVs etc. A simulator such as an OSSE (Observing System Simulation Experiment) uses such virtual models and helps to answer the questions.	Essential	RWS2-R22
L2-CU-RQ-152	The CI shall enable the sharing of ocean modeling, data assimilation and visualization components, including the extension of models with new model components	Numerical models and related data transformation processes can be constructed either sequentially or hierarchically out of individual model components. The extension of an existing model with an extension component is a special case. The user shall be able to select from all available model extensions and apply them to a given model. Modeling and data assimilation process definitions should be as portable and easy to use as Matlab subroutines.	Essential	RWS2-R23
L2-CU-RQ-153	The CI shall provide a repository and sharing capabilities for numerical model algorithms, model configurations, data processing tools and documentation	The availability of a central repository and archive for instances of all resources related to numerical model development and execution with a uniform access interface and search capabilities is of high value to the community. The CI shall provide such a repository in the form of a community-managed clearinghouse, available to the user community for any kind of modeling resource. The CI shall not restrict this repository to models managed by the CI or executable by the CI. For instance, a user can use the forcing fields that an expert adjusted and shared, and use them in his/her own model, which may lead to improved accuracy. Other shared artifacts include error covariances for forcing, background, boundary conditions, and observations.	Essential	RWS2-R24
L2-CU-RQ-154	The CI shall archive numerical model workflows under configuration control	The CI shall provide the means to archive the model execution workflow with a level of completeness necessary to reconstruct and rerun the model in the future. This requires packaging, configuration control and documentation effort on the side of the initial model developer, which shall be supported by the CI. The CI shall archive the binding of data sources, model parameterizations, model compile and execution environments, model execution workflows. The need to archive the model itself is implicit.	Essential	RWS2-R25
L2-CU-RQ-155	The CI shall recompute model data products using archived workflows	The CI shall provide the means to rerun archived model workflows for any suitable past input data set. This enables recomputation of model output for past archived data sets. This makes later exact model reruns possible and avoids storing computed data.	Essential	RWS2-R26
L2-CU-RQ-156	The CI shall enable the modification of archived workflows	The CI shall provide the means to reuse archived models and workflows and modify them by any interested, sufficiently knowledgeable party, at any time and any location. This includes execution of such models but also adaptation and modification of parameters, input data sources, pre- and post-processing and model algorithms based on the published model, subject to policy.	Essential	RWS2-R27
L2-CU-RQ-157	The CI shall provide an environment for the development of community numerical models under community process support	Within the research community, there are often numerical models and standard data analyses that become widely used and accepted community standards. The CI shall facilitate the establishment of such standard models and data processing with support for community processes such as communication, commenting, voting, moderation, submission of change requests, documentation etc.	Essential	RWS2-R28
L2-CU-RQ-158	The CI shall provide a non-restricted environment for the development of independent numerical models	In addition to community-accepted standard models, the research community also requires support for emerging independent research models. The CI shall facilitate such research and development by providing an environment that enables these efforts; it should be non-restrictive by not requiring use of prescribed standard data sources, processing tools, output formats, model algorithms etc. The CI shall facilitate making the output of such independent models available to the user community in a similar manner to CI standard and community models.	Essential	RWS2-R29

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-159	The CI shall support the nesting of ocean models at different geographical scales	Ocean models typically exist at different spatial resolutions, covering different parts of the ocean surface. The CI shall support the combination of global, regional, and coastal models. The CI shall support nesting of numerical models such that smaller scale models can automatically use larger scale model output as boundary conditions within a selected geographical range or model domain. This requirement has implications for user interfaces, model configuration and model execution scheduling.	Essential	RWS2-R30
L2-CU-RQ-160	The CI shall provide a framework for the adaptation of model resolution to the available resources	The number of computed model grid points - the resolution of a model - is typically limited by the available computational and storage resources, for instance through the time it takes to compute a model ensemble on the available hardware. For a given CI managed model, the CI shall facilitate an increase in the resolution and the number of grid points when further computational and storage resources become available, configurable by the user that executes the model.	Essential	RWS2-R31
L2-CU-RQ-161	The CI shall support model ensemble definition, execution and analysis	A developed and parameterized numerical model provides output that has a comparable quality to the available input data. All input data have uncertainty associated with them. An effective way of improving model reliability is to run ensembles of models with slightly modified initial and boundary conditions. Analysis can then take the model ensemble outputs into account, for instance by averaging or by computing standard deviation values. The CI shall support model ensemble definition, ensemble execution and ensemble analysis. The CI shall facilitate model ensemble execution optimization, for instance one pass computation of entire model ensembles.	Essential	RWS2-R32
L2-CU-RQ-162	The CI shall publish both elements of and aggregated ensemble data products from ocean models	The CI should make the entire ensemble and individual model runs available to the user community with clear descriptions of the parameters and conditions.	Essential	RWS2-R33
L2-CU-RQ-163	The CI shall support flexible high performance model execution	Performance and flexibility are a classic trade-off in numerical model development. Economies of scale suggest that model execution flexibility requires higher initial development and runtime performance costs. Currently, the community is not willing to accept any impact on runtime and network latency for more flexible models; the requirement is optimization of the number of model runs and output grid resolution, but not portability, etc. The CI shall address this concern while at the same time providing means and mechanisms for the development of more flexible, portable models. This could include standardized virtual execution environments; more user-friendly parameterization interfaces, harmonized data input and output formats, and better documentation facilities.	Essential	RWS2-R34
L2-CU-RQ-164 **4.5**	**Visualization**			
L2-CU-RQ-165	The CI shall provide interactive 2D, 3D and 4D visualization tools	Currently, visualization of numerical modeling output or data are very heterogeneous across the ocean sciences community. Commonly used visualization tools include Ferret, GMT, IDL, Matlab and the NCAR package for ROMS. The CI shall provide a basic set of visualization and analysis tools for CI-managed numerical model output, with uniform and consistent input and output interfaces. The current lack of user-friendly 4D visualization tools is a concern to the community - this is an area where a consistent CI interface can provide a substantial benefit. Examples of basic analysis tools are: time series, special maps, cross-sections etc.	Essential	RWS2-R35 RWS2-R36
L2-CU-RQ-166	The CI shall provide 3D visualization of sensor locations and their environment	This supports awareness of sensor locations in context of other deployed sensors and the marine environment. The CI shall provide site characterization at various scales and for various ocean variables. This increases situational awareness for planning end executing observations.	Desirable	RDPG-R35 RDPG-R37
L2-CU-RQ-167	The CI shall support the integration of external visualization tools	New analysis and visualization tools and technologies become available all the time. The CI shall provide interfaces to extend its set of available tools with new ones that are subsequently available to the OOI users. External visualization tools include GoogleEarth.	Essential	RWS2-R37
L2-CU-RQ-168	The CI shall provide extensible, configurable visualization capabilities for data streams	The CI shall provide standard visualization capabilities for selected classes of CI information resources. The visualization shall be flexibly adaptable to the users' needs, for instance by determining the variables of interest, output refresh rate, resolution, output schemes, area of interest etc. All visualization is subject to resource availability and policy. The list of applicable data stream resources needs to be determined through a community decision process. The CI shall facilitate the integration of additional tailorable visualization capabilities.	Essential	RWS1-R38 RWS1-R49
L2-CU-RQ-169	The CI shall provide a zooming interface for all visualizations with at least three levels of detail	Users want to see different levels of detail in a visualization. Best practices for user interfaces dictate that any zooming capability provides a minimum of three levels of details.	Essential	RIOM-R20
L2-CU-RQ-170	The CI shall provide a user interface system that includes at least two different views of the data	Specifications for different zoom level views will be dependent on hardware and data base functionality. This is related to RWS2-R30 in support of different geographical scales. The notion that a user would want to get a big picture view, with an emphasis on patterns and less on detail, to a fine level detail view was expressed by several user types: scientists, engineers and marine operators.	Essential	RIOM-R21
L2-CU-RQ-171 **4.6**	**Computation and Process Execution**			
L2-CU-RQ-172	The CI shall support the execution of large scale numerical ocean models across different locations on the network	Some numerical models require extensive computational resources to run. The CI shall facilitate running such models with CI-provided computational and storage resources, and coordinate resource assignment and communication subject to policy and available resources.	Essential	RWS2-R38

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-173	The CI shall support workflows for automated numerical model execution, including just-in-time input data preparation, model computation, output post-processing, and publication of results	Running a numerical model repeatedly requires a number of steps to be carried out just-in-time within a workflow. This includes retrieval of data from sources, data assimilation, resource allocation, model or model ensemble computation, data post-processing, quality control, visualization and publication of results as data products. The CI shall facilitate such just-in-time executions by providing the means to define such workflows with suitable robustness, failure-tolerance and resource awareness.	Essential	RWS2-R39
L2-CU-RQ-174	The CI shall enable the one-time and recurring execution of numerical models on any networked computational resource with quality-of-service guarantees based on contracts and policy.	The CI shall provide the means to define, develop, package and schedule executable numerical models with their associated workflows such that they can be run flexibly on any networked computational resource with sufficient capacity. This execution shall be possible during the development of the models with high flexibility and variable resource and quality-of-service requirements, as well as during the production phase with negotiated resource reservations and quality-of-service contracts. Quality-of-service parameters relevant for model execution are for instance in-time resource availability, maximum execution time and maximum delay until model run results are available. All CI guarantees shall be subject to policy and resource availability, but shall respect advance long-term resource allocation contracts. For instance, the CI could provide a priority scheduling system for computational resources. For the community, unpredictable latencies in job processing are prohibitive for the use of these resources in production mode. The user shall be able to schedule model runs for automatic, recurring executions based on long-term resource and quality-of service agreements.	Essential	RWS2-R40
L2-CU-RQ-175	The CI shall provide interfaces to compose workflows	Currently, there is no common interface to define processes (jobs) that ca be executed on remote computational infrastructure, such as clusters and grids. In particular, larger scale computational infrastructure requires specific job definitions and management of the job execution. This requirement implies the existence of documented tools and interfaces to define, develop, and configure user-defined CI executable processes and general taskable resources. The CI shall provide uniform interfaces to all forms of computation with varying resource requirements, from small scale computations on embedded devices to large scale persistent Grid computations. A process is a sequence of human or machine executed steps that are applied to a data stream or data set. This includes data cleaning, filtering and aggregation as well as numerical modeling algorithms. The CI shall provide and document all that is necessary to define processes in a controlled and repeatable way and as an extensible framework.	Critical	CA-IRW-1 RWS1-R27 RDPG-R24
L2-CU-RQ-176	The CI shall provide services to execute workflows on computational resources with varying characteristics	This requirement implies the existence of documented tools and interfaces to schedule and execute user-defined CI executable processes and general taskable resources. The CI shall provide uniform interfaces to all forms of computation with varying resource requirements, from small scale computations on embedded devices to large scale persistent Grid computations. A The CI shall provide and document all that is necessary to define and run such processes in a controlled and repeatable way and as an extensible framework.	Critical	CA-IRW-1 RWS1-R27 RDPG-R24
L2-CU-RQ-177	The CI shall provide services to chain a plurality of workflows	By analogy to the Unix pipe.	Desirable	CA-IRW-2
L2-CU-RQ-178	The CI shall provide services to monitor and control instantiated processes		Essential	CA-IRW-4 CA-IRW-7
L2-CU-RQ-179	The CI shall provide actors with estimated performance/turnaround for instantiated processes	Most users need to understand that their requests and processes are understood by the system. Even if the system cannot estimate time for process to complete, it should still tell the user that the process is underway.	Desirable	CA-IRW-5
L2-CU-RQ-180	The CI shall provide event-triggered workflow execution services		Essential	CA-SSA-6 RIOM-R28
L2-CU-RQ-181	The CI shall provide real-time access to high performance computation resources	Easy access to computation such as high performance computing grids and resources will enable real-time derived data products that can be used for objective driven observations.	Essential	ROOP-R4
L2-CU-RQ-182	The CI shall provide process support for the planning and operation of observational programs	Process support relates to the support of workflows involving the creation and modification of information artifacts in prescribed sequences by multiple individuals, groups or roles.	Essential	ROOP-R28
L2-CU-RQ-183	The CI shall provide process support for the coordination of instrument recovery, maintenance and replacement	Process support relates to the support of workflows involving the creation and modification of information artifacts in prescribed sequences by multiple individuals, groups or roles.	Essential	ROOP-R53
L2-CU-RQ-184	The CI shall support, automate and combine workflows of shipboard observers	Ocean observers work for instance for prolonged periods of time based on ships, using paper based ship logs. The CI needs to provide IT support to such established processes but suitable user interfaces, data management and cataloging and presentation capabilities and ways to record the various forms of information that get produced during such expeditions.	Essential	ROOP-R32
L2-CU-RQ-185 **4.7**	**Sensors and Instrument Interfaces**			
L2-CU-RQ-186	The CI shall provide a real-time communication interface for remote resources	For instance, episodic ocean events can occur at unforeseen times and locations. In order to capture such highly scientifically relevant events in areas with deployed sensors, it is necessary to sample and analyze remote sensor data on a continuous basis in (near) real-time, so that events can be detected immediately and adaptive observation actions can be scheduled, such as AUV and glider deployments and adapted sensor calibrations and measuring frequencies. The CI and the OOI infrastructure shall install the mechanisms to bring remote sensor data through the network to the scientist in near real-time. This includes communication support for acoustic modem and wireless data transmission from sensor to infrastructure to cover mobile resources.	Critical	RWS2-R42 ROOP-R8 ROOP-R58 ROOP-R64 RIOM-R13

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-187	The CI shall support robust instrument development, operation and maintenance processes	Ocean observers design sensors and instruments for use under harsh and extreme environmental conditions. The CI needs to facilitate and anticipate such designs. For example, extreme weather conditions often interrupt or prevent data collection, for instance due to ship scheduling constraints. The CI shall provide the means on various levels to prevent data loss during extreme weather events and to enable uninterrupted collection of data from deployed instruments. The CI must be capable of handling temporarily disconnected instruments, and include buffering and reliable communications facilities on the wet side of the data link. Operators need to be able to monitor network assets on an ongoing basis. The CI can meet this need by providing the operators monitoring tools such as alerts for irregular data streams, movement of sensors, and other issues particular to their observatory.	Critical	RWS2-R43 ROOP-R33 RIOM-R12
L2-CU-RQ-188	The CI shall support discovery of the characteristics of sensors deployed on an instrument platform	Instrument platforms typically host many different sensors. In general, communication, computation and power resources are limited. Additionally, sensors might interfere with each other. The CI shall make such deployment information available to scientists, enable them to track data provenance and determine sensor characteristics and status.	Essential	RWS2-R44
L2-CU-RQ-189	The CI shall support adaptive observation resource control	Adaptive control is a change of behavior and parameterization of observational resources in response to environmental conditions, for instance a change of waypoints or sampling rate. The detection of an episodic event might lead to adaptive observation through the deployment of a fleet of gliders and adjustment of mooring sensor parameters. The CI shall facilitate adaptive observations by providing the necessary capabilities and user interfaces.	Essential	RWS2-R45 ROOP-R10
L2-CU-RQ-190	The CI time standard shall be NIST traceable	GPS time is a candidate	Critical	CA-SSL-1
L2-CU-RQ-191	The CI shall provide a synoptic time service with an accuracy of 1 microsecond to all resources connected to the OOI observatories	Synoptic time means uniform, global time corrected for network latency and jitter It is made available to all resources and applications that have the capability to use time services. Precision Time Protocol is a candidate technology.	Critical	CA-SSL-4 RWS1-R7
L2-CU-RQ-192	The CI shall serve synoptic time throughout the observatory using Network Time Protocol		Critical	CA-SSL-3
L2-CU-RQ-193	The CI shall provide services to correct remote clocks to a synoptic standard		Essential	CA-SSL-5
L2-CU-RQ-194	The CI shall provide services to synchronize remote clocks relative to each other with an accuracy of 1 microsecond		Essential	CA-SSL-6
L2-CU-RQ-195	Upon receipt, the CI shall synoptically timestamp message headers with an accuracy of 1 millisecond	This provides a time capability for instruments that cannot utilize system time	Critical	CA-OC-13
L2-CU-RQ-196	The CI shall provide robust instrument access protocols	Robust refers to insensitivity to communication channel characteristics such as latency or intermittency	Critical	ROOP-R54
L2-CU-RQ-197	The CI shall provide direct bidirectional communications to resources that preserves their native functionality	Technology candidates are virtual terminals and direct serial connections. Direct access that preserves native functionality is required to establish transparency for resource providers.	Critical	ROOP-R40 ROOP-R57 RDPG-R55 RDPG-R65
L2-CU-RQ-198	The CI shall provide remote desktop access to resources that preserves their native functionality	A candidate technology is VNC. Direct access that preserves native functionality is required to establish transparency for resource providers.	Critical	ROOP-R40 ROOP-R57 RDPG-R55 RDPG-R65
L2-CU-RQ-199	The CI shall automatically close down inactive direct access sessions	This applies to instrument management exclusive access, where the resource provider forgets to log out and the instrument remains in exclusive access state. The CI needs to detect such situations and restore access to the default state, after defined periods indicating user inactivity. User notification before or after closing the session might be required	Critical	RDPG-R22
L2-CU-RQ-200	The CI shall provide interactive web-based configuration of instrument platforms, instruments and sensors	This enables easy and direct remote control of these resources by resource providers and researchers	Essential	ROOP-R66
L2-CU-RQ-201	The CI shall provide capabilities and interfaces for monitoring of resource-specific operational and environmental parameters	Such parameters include the track of an underwater vehicle	Essential	ROOP-R52
L2-CU-RQ-202	The CI shall provide services for positioning of mobile assets with a precision commensurate with the location technology	For example, acoustic location to 1 m rms and gps location to 10 m rms	Essential	ROOP-R55
L2-CU-RQ-203	The CI shall support automated docking of mobile resources, including power management and high speed data down and up load		Essential	ROOP-R56
L2-CU-RQ-204	The CI shall be capable of triggering instrument measurements	To avoid interferences if two instruments were measuring at the same time, it might be necessary to trigger the measurement of one instrument after completion of another measurement. The CI shall provide the capabilities to define such dependencies and to automatically enact such measurements. It shall be able to do this with a granularity of milliseconds, depending on instrument capabilities.	Essential	RDPG-R56 RDPG-R58
L2-CU-RQ-205 **4.8**	**Mission Planning and Control**			
L2-CU-RQ-206	The CI shall support swarm-based deployment patterns for mobile instruments	Swarm-based deployment patterns are a successful strategy for the deployment of mobile observational and communication resources. A swarm of AUVs can for instance observe a larger segment of the ocean, while providing near real-time data and command relay between members of the swarm. The CI needs to support the definition, control and coordination of such behaviors, for instance so that they can keep in ACOMM range with other underwater or surface vehicles.	Essential	ROOP-R6

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-207	The CI shall provide a repository for instrument behaviors	Instrument behaviors range from simple sample rate capabilities to detailed relationships between range and energy consumption for mobile vehicles.	Essential	ROOP-R7
L2-CU-RQ-208	The CI shall provide a repository for observation plans	Such observation plans can be prepared for expected episodic events, such as underwater volcano eruptions. The degree of parameterization can vary from the location and time of deployment, to the number of mobile and fixed assets available and in range, to full use cases of behavior covering "what if" questions and error conditions. Such observation plans can then be triggered by detected events, parameterized automatically or semi-automatically and executed.	Essential	ROOP-R7
L2-CU-RQ-209	The CI shall provide shore-side and on-vehicle control capabilities for autonomous observational resources	The CI shall provide services on the shore-side and software components that can be deployed on mobile assets if desired, for command and control of mobile resources. This covers resource management, planning, behavior control, communication with the shore-station etc.	Essential	ROOP-R11
L2-CU-RQ-210	The CI shall support observational resource control at different user-selected levels	Not all resource providers can and want to enable full control of their instruments by the CI. Therefore the CI shall offer several levels of control available to users; levels should include direct resource control and monitoring only.	Essential	ROOP-R12
L2-CU-RQ-211	The CI shall integrate environment and vehicle behavior models for event detection, coordinated control and adaptive sampling	Input sources for observation planning and control are real-time observations and results for environmental models. Furthermore, models need to exist that describe the behavior of mobile resources and for instance their movement, power use and communication intervals. The CI needs to facilitate the definition and exploitation of such specific models for environment and vehicle performance for coordinated control and adaptive sampling. Such a form of model-based planning can use a declarative way of specifying activities, assets, state and resource usages, temporal constraints, to develop plans to achieve goals while respecting constraints	Essential	ROOP-R13 ROOP-R25 ROOP-R26
L2-CU-RQ-212	The CI shall provide capabilities and interfaces for planning longitudinal observations	Two classes of observations are long-running longitudinal observations, for instance optical backscatter measurements at fixed locations in the ocean, and objective-driven observations, for instance detailed measurements in the vicinity of an erupting underwater volcano. The CI shall provide services for mission planning and activity scheduling for varying sets of fixed, mobile and expendable resource and constraints; the results can be readily executable observations plans as well as templates for event response behaviors. The user interface needs to support the definition of mobile assets- can we combine gliders, AUVs, satellites, etc. put together an interesting new scenario	Essential	ROOP-R14
L2-CU-RQ-213	The CI shall provide capabilities and interfaces for planning objective-driven observations		Essential	ROOP-R14
L2-CU-RQ-214	The CI shall provide capabilities and interfaces for ad-hoc interactive and automated modification of ongoing observations	The modification of ongoing observations and scheduled observation plans can be triggered automatically or manually for instance caused by environmental influences such as weather, changing currents, sensor failures and detected events. Other causes are autonomous fault detection and corrective action by autonomous resources, fault detection and corrective action by human intervention. Possible ways to modify observation plans include uploading of mission files from shore to controllers or sensors. Possible consequences are redeployments of resources and state changes.	Essential	ROOP-R15
L2-CU-RQ-215	The CI shall provide capabilities and interfaces for simulating and verifying observation plans	Observational resources such as sensors have different resource needs depending on their configuration at specific times as defined in the observation plan. The CI needs to support the definition of resource conserving feasible observation plans by computing the envelope need of resources such as power and bandwidth of all sensors over the time of a scheduled observation	Essential	ROOP-R16
L2-CU-RQ-216	The CI shall provide resource provisioning calculations from observation plans	Observational resources such as sensors have different resource needs depending on their configuration at specific times as defined in the observation plan. The CI needs to support the definition of resource conserving feasible observation plans by computing the envelope need of resources such as power and bandwidth of all sensors over the time of a scheduled observation	Essential	ROOP-R17
L2-CU-RQ-217	The CI shall support observation planning and scheduling decisions based on the opportunity cost of observations and resource provisioning	Opportunity cost relates to the impact of short-term changes to observation parameters (such as sampling rate, resolution, calibration, sensor position etc.) on the quality and expressiveness of long-time measurements and time series. The availability of prioritization supports decisions based on trade-offs. The CI needs to provide policy enforcement and resource allocation prioritization services.	Essential	ROOP-R18
L2-CU-RQ-218	The CI shall provide graphical user interfaces for planning observations and missions with spatial and temporal visualization of observation parameters	Observation parameters include waypoints.	Essential	ROOP-R19
L2-CU-RQ-219	The CI shall provide spatial visualization of observation data overlaid with observation plans	Combining observation data and observation plans enables for instance a refinement of observation plans.	Essential	ROOP-R20
L2-CU-RQ-220	The CI shall support tasking, deployment, mission control and retrieval of mobile and fixed instruments	Process support relates to the support of workflows involving the creation and modification of information artifacts in prescribed sequences by multiple individuals, groups or roles.	Essential	ROOP-R21 ROOP-R37
L2-CU-RQ-221	The CI shall provide capabilities and interfaces for the simulation of observational infrastructure	Instrument platforms such as moorings undergo a long and complex development process. Simulation of such infrastructure elements in scenarios of deployment on observatory infrastructure is an important means to make the development more effective	Essential	ROOP-R51
L2-CU-RQ-222 **4.9**	**Application Integration and External Interfaces**			

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-223	The CI shall provide documented resource-data connectors for all services	A resource-data connector (RSD) is analogous to an application programming interface (API). RSDs are required by external (i.e., user) applications that need to interact with CI services. This enables full automation of interactions with the CI and goes beyond the availability of standard APIs.	Critical	CA-PD-18 RWS1-R6
L2-CU-RQ-224	Conditional on OOI policy, the CI shall not impose specific processes, tools and formats on resource providers for the operation and control of their OOI-connected resources	Science relies on flexible approaches and technologies. For best results and conditional to existing policies, scientists should be free to choose their degree of involvement with the OOI without imposed restrictions of whatever form	Essential	ROOP-R1
L2-CU-RQ-225	The CI shall interface with external resource monitoring, operation and control systems	Such systems for instance include the WHOI GODS and similar systems. CI interfaces should provide adapters and embed such systems but not provide a replacement.	Essential	ROOP-R2
L2-CU-RQ-226	The CI shall provide a Web 2.0 environment	The Web 2.0 environment provides easy access to other users, data and social networking. This is common practice in many world-class systems and users come to expect that they won't have to struggle to get their work done. Users are also starting to see the value with developing connections with others in their field and are making use of the internet to establish and maintain connections to people doing common or related work. Users can leverage WS technologies to provide extensions to CI capabilities and automate client applications.	Essential	RDPG-R1 RIOM-R18
L2-CU-RQ-227	The CI shall support interfacing with web service-accessible resources	The Web Service technology and standards are enabling application integration and interoperability. As such, many users can leverage such technologies to provide external capabilities and applications that can be integrated with the CI.	Essential	RDPG-R2
L2-CU-RQ-228	The CI shall interface to live video feeds during instrument operation and maintenance	For instance, when deploying or servicing an instrument remotely, such video streams can be made available to the remote operator and/or experts supporting the operation.	Desirable	RDPG-R3
L2-CU-RQ-229	The CI shall provide interface support for Java-based tools and scripting languages	Libraries and interfaces provided by the CI should support the Java language and scripting languages, as they are of widespread use in the community	Essential	RDPG-R5
L2-CU-RQ-230	The CI shall provide standalone installations that may have no or intermittent connection to the OOI network		Desirable	RDPG-R6
L2-CU-RQ-231 **4.1**	**Presentation and User Interfaces**			
L2-CU-RQ-232	The CI shall provide annotation, commenting, ranking and rating services for CI-managed resources	This applies to all CI resources, from sensor data sources to computed data products, computational and storage resources etc. These services shall facilitate community communication, knowledge management, search-and-retrieval, selection and decision processes. For instance, third party users shall be able to rate the quality of CI data streams and sources. Other users can make use of the aggregated rating information when selecting data products.	Essential	CA-PD-17 RWS2-R48
L2-CU-RQ-233	The CI shall provide user and group workspace capabilities	Workspaces refer to storage, presentation, archiving and cross-referencing capabilities that apply to project or individual users. Project workspace management refers to the definition of projects and project workspaces as well as project collaboration links and inter-project collaboration. Collaboration refers to mechanisms that enable the communication between members of different projects, for instance notification mechanisms in case new data products become available. A project workspace can contain links to other projects. Data can then be imported into the project workspace and structured as required.	Critical	CA-IS-2 RWS2-R49 RWS2-R50 RDPG-R25 RIOM-R61 REPE-R6
L2-CU-RQ-234	The CI shall provide capabilities to personalize user and group workspaces	Resources that can be selected into workspaces include instrument, data, storage, analysis and visualization resources. Workspaces manage access to the resources and store configuration information. Example: iGoogle	Critical	RDPG-R33 REPE-R5
L2-CU-RQ-235	The CI shall provide social networking capabilities	Social networking refers to the establishment of contacts between individual users, communities, projects, or interest groups based on personal contacts, and the facilitation of communication within that network. Communication can occur through e-mail messages, instant messages, bulletin boards, discussion forums, commenting of resources etc. Typically, a social network is established for long-term use. The CI shall also support ad hoc communities that form because they utilize specific resources, projects, episodic events etc. Some users have been using Web 2.0 sites such as LinkedIn and Facebook, while other users have been wanting to be able to incorporate online communities, blogs and forums as part of their observatory work.. Many expressed a desire to use the CI as an online community, where they could interact with both people and data and share connections or posts with each other.	Essential	CA-IS-2 RWS2-R50 RDPG-R26 RIOM-R61
L2-CU-RQ-236	The CI shall provide an intuitive interface to access the functionality of all CI services and resources	Interactive user access to the CI services and resources shall be provided through a comprehensive web-based user interfaces. Such interfaces can be provided by a portal site to the CI and the resources of the OOI observatories. The web-based user interfaces shall support all interactive CI functionality, from resource management to mission planning and control to data analysis and visualization, and provide a typical web-based browsing experience, with user sessions, profiles, customization etc. The number of clicks to get to the desired information shall be as few as possible (3 clicks or less). Uniform and homogeneous user interfaces provide efficient interaction and usability. Voice control and virtual reality are possible implementations in the near future.	Critical	RWS1-R34 RIOM-R1 RIOM-R6 RIOM-R19

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-237	The CI shall present the full CI functionality at a single access point with a single dashboard	The user should have to go to only one place to access the observatory CI. The user interface shall leverage the services and resources of the CI infrastructure and provide the user with the collocation of all relevant information. Typical scenarios include the search for related work and for applicable resources. The CI shall present all information that matches a given search query in one spot and thus enable rapid comparison and decision support. For instance, the CI shall enable the discovery of all kinds of data products in one place, e.g. temperature, salinity, wind, or multiple satellite data sources for one region.	Critical	RWS2-R47 RIOM-R3 REPE-R1
L2-CU-RQ-238	The CI shall provide services to make OOI-standard metadata human readable	Scientific metadata for resources and data products have a sophisticated structure and encoding. Science data product metadata, for instance, include information about the sensors, sampling rate, provenance, applied transformations, content and context of the data and much more. Community standards exist to capture and transport such metadata. It is important for scientists to understand and if necessary provide such metadata in the context of the OOI CI resources. The CI shall provide the means to display all OOI-relevant metadata in human understandable and human processable forms.	Essential	CA-SSA-3 RWS1-R35
L2-CU-RQ-239	The CI shall provide a resource monitoring and control interface	For instance, a one view screen presenting the most important information for operators.	Essential	ROOP-R34 RDPG-R61
L2-CU-RQ-240	The CI shall provide an adaptive, simple-to-use interface for data access	Adaptive refers to user interfaces where the user can constrain data selection queries with dynamically updated result sets. Or select areas of interest by zooming in on a map and selecting rectangles or lat/long coordinates. Simple to use refers to a direct, intuitive way of interacting with the system, following ergonomics and accessibility standards. Examples of such interfaces can be found in current commercial platforms, such as Amazon.com or Expedia.com. This is a web page interface, which allows viewing of predefined and customized views of the data retrieved from a sensor. The interface allows sensor data to be downloaded to a user's local computer for further analysis. It allows access to all metadata and engineering data associated with the sensor data sets. It allows access to all previously stored data for this sensor including raw and calibrated sensor data. It has information on how to contact the sensor manager. The manager is authorized to mark the data as validated or suspect. A log of manager information (blog) about the sensor is available. The tools to view the data, apply/store calibrations, mark data as validated are all features programmed as part of the CI tas	Essential	ROOP-R60 ROOP-R61 RDPG-R29 RDPG-R62 RDPG-R63
L2-CU-RQ-241	The CI shall provide transparent access to heterogeneous, large-scale computational resources	Easy to use and modify access to computational resources is key in efficient scientific investigation processes. Users should be shielded from the complexities, heterogeneity and location of such hardware.	Essential	RDPG-R34
L2-CU-RQ-242	The CI shall provide transparent access to heterogeneous, large-scale storage resources	Easy to use and modify access to storage resources is key in efficient scientific investigation processes. Users should be shielded from the complexities, heterogeneity and location of such hardware.	Essential	RDPG-R34
L2-CU-RQ-243	The CI shall provide a single user interface that supports observatory operators, science and engineering users, the education community and the general public	Multiple user groups will operate the system and it must accommodate them, user models and personas will help understand these specific needs. PERSONAS will be created to define these groups. The CI shall provide a user interface system that will accommodate user groups with many different backgrounds. This means that the UI must serve at least 4 different specified user groups. This can be accomplished with a simple but expandable GUI system that can qualify a user type and provide functionality that is expected for that type.	Desirable	RIOM-R2
L2-CU-RQ-244	The CI shall provide dialog box interaction for operations requiring the input of more than two parameters	When a function requires a user to input more than 2 pieces of data, it is easier to open a dialog box that is focused on the specific operation. This provides a simple, clear mechanism for a user to interact with a system.	Essential	RIOM-R4
L2-CU-RQ-245	The CI shall provide input screens that include tabs for any process that requires users to input more than five parameters	Even though some functions are complex, such as filtering data, creating data visualizations or communications tools, they can be organized and presented to the user through input screens with tabs. This will allow the user to perform operations with detailed input on many objects at one time.	Essential	RIOM-R5
L2-CU-RQ-246	The CI shall provide a common font set for all screens	In order to provide a common look and feel, font type, size, presentation need to be standardized	Essential	RIOM-R8
L2-CU-RQ-247	The CI shall employ a common look and feel based on a standard screen design	Specific design guidelines will insure common, world class look and feel so that all applications appear to belong together. This means that all the screens and all of the interaction models are the same from one application to the next.	Essential	RIOM-R7
L2-CU-RQ-248	The CI shall employ a standard set of colors for use in all user interface presentation screens	In order to provide a common look and feel, all color palettes must be standardized. A template set of colors can easily accomplish this goal.	Essential	RIOM-R9
L2-CU-RQ-249	The CI shall employ a standard workflow for all user interface screens	In order to provide consistency throughout the system, the workflow must remain the same and standard for all users	Essential	RIOM-R10
L2-CU-RQ-250	The CI shall employ a common navigation scheme that is consistent from application to application	Since there will be many different applications, and many different users, it is imperative that the forms, visualization formats, and data manipulation be represented in the user interface, in the same manner. This unified look and feel with enhance the cohesive foundation for the Integrate Observatory and insure that the system flow smoothly from one application to the next. This will include standard fonts, type size, line width and spacing, paragraph formatting and color palette.	Essential	RIOM-R11

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-251	The CI shall provide visualization and metadata browsing of the processing pipeline	The actual relationship between subsets of observational resources and subsets of data consumers, involving processing steps is a directed acyclic graph (DAG). Visualization of this graph as queue or tree can be done in form of dynamic view generation based on the selected starting point and filter criteria. This may be subject to restriction due to privacy concerns.	Desirable	RDPG-R27
L2-CU-RQ-252	The CI shall provide checklists for standard instrument operations	Standard operations include instrument deployment, calibration, maintenance, recovery, replacement.	Desirable	RDPG-R30
L2-CU-RQ-253	The CI shall provide capabilities and interfaces to capture structured input, feedback and results from analysis processes on data	Inputs to capture include comments, problem alerts, data quality flags, resource correspondence links/mappings, and results of external formal analysis processes run by the community. Ways to capture feedback include email, portals and direct application interfaces. Input should be structured and formalized to the highest degree possible and practical so that it can be processed, referenced and forwarded automatically. For all this input, citation and provenance need to be captured.	Essential	RDPG-R31
L2-CU-RQ-254 **4.11**	**Security, Safety and Privacy Properties**			
L2-CU-RQ-255	The CI shall authenticate and authorize all resources connected to an OOI observatory	Authentication refers to establishing the identity of a resource. Authorization refers to permitting access to the observatory based on a resource's attributes and permissions.	Critical	CA-OS-2
L2-CU-RQ-256	The CI shall authenticate all observatory actors	Authentication refers to establishing the identity of an actor (whether human or application) by exchanging certificates or using passwords.	Critical	CA-OS-3 RWS2-R52 RDPG-R50 RIOM-R44
L2-CU-RQ-257	The CI shall provide different levels of access to actors with different levels of authorization	Authorization refers to permitting access to the observatory resources and services according to an actor's attributes and permissions. There may be many levels of authorization: the general public may have read access only to data, a science user may have read/write access to the repository and access to specific resources, and an observatory operator may have access to all connected resources on a given system.	Critical	CA-OS-5 RWS2-R53 RDPG-R51 RIOM-R45
L2-CU-RQ-258	The CI shall enforce user privacy policies	Privacy policies will be defined by the OOI contractors and NSF in consultation with representatives of the user community. The CI needs to provide the means to define, update and propagate these policies across the distributed OOI network when required and to enforce and guarantee privacy throughout the infrastructure subject to these policies.	Critical	RWS1-R43
L2-CU-RQ-259	The CI shall be capable of auditing all services and resources under CI governance	Auditing refers to the ability to track and log all accesses to services and resources	Critical	CA-OS-4 RDPG-R52
L2-CU-RQ-260	The CI shall trace resource utilization to the initiating actor	This is a requirement to audit resource use	Critical	CA-IP-2
L2-CU-RQ-261	The CI shall support different levels of access for resources and their metadata	For example, it may be possible to discover information about instruments whose data streams are subject to national security restrictions	Essential	CA-OS-6
L2-CU-RQ-262	The CI shall protect physical resources from damage and misuse by enforcing resource use policies	Resources can damage themselves or their environment by drawing too much power and using too much bandwidth.	Critical	ROOP-R41 RIOM-R42
L2-CU-RQ-263	The CI shall provide interfaces to define security and policy for information managers at participating institutions	Authentication, authorization and policy mechanisms and levels are typically defined at the level of institutions that participate in the OOI network. The CI shall make user and application interfaces available to define these settings and to manage policies.	Desirable	RWS2-R51
L2-CU-RQ-264	The CI shall support the diversion, filtering and sequestering of raw data streams at the acquisition point	These capabilities are required for national security purposes; in order to minimize the loss of non-sensitive data, the filtering needs to be adaptive and as close to the instrument as possible. A possible filtering technique is spectro-filtering	Critical	RDPG-R10
L2-CU-RQ-265 **4.12**	**Quality Properties**			
L2-CU-RQ-266	The CI infrastructure shall deliver messages with reliability that is comparable to that of the Internet	The "accuracy of the Internet" is given by the availability, reliability and accuracy of open Internet protocols and RFCs as provided on public and commercial infrastructure. The standard reliability number for the Internet is 0.99999. The CI shall provide comparable quality of service. However, marine IO hardware reliability may lower this number in practice.	Critical	RWS1-R46
L2-CU-RQ-267	The CI shall provide robust, reliable remotely deployed components	Remote systems need to be highly robust and provide redundancy of critical subsystems. Elimination of single-point failure modes (e.g. sensor can fail or be removed without compromising subsystem) is one major design strategy. CI components deployed on remote resources must exhibit such properties.	Critical	ROOP-R35
L2-CU-RQ-268	The CI shall provide services with reliability and accuracy that is comparable to those of distributed Internet applications	CI services must be fault tolerant and reliable	Critical	CA-PI-5 RWS1-R46
L2-CU-RQ-269 **4.13**	**Education and Outreach**			
L2-CU-RQ-270	The CI shall provide numerical ocean models with a limited set of modifiable parameters for educational purposes	The CI shall support the development of educational numerical ocean models with idealized environment assumptions and limited, easy-to-understand configuration parameterization possibilities. For instance, a global climate model could take CO2 level, ice melt, etc. into account and produce idealized climate predictions in pre-defined output formats. The development of such idealized models should be possible on demand.	Essential	RWS2-R54
L2-CU-RQ-271	The CI access point shall provide educators with instructions about data usage	This can be accomplished with a simple indexed online help system	Essential	REPE-R2

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-272	The CI access point shall provide the educator with a list of projects and their attributes	Projects are generic in the sense that they may be collaborations, development of teaching tools, data transformations modules, visualization mechanisms, etc. Projects must be shareable between participants and could have different states such as active, done; development stages such as experimental, beta, release; access permissions, such as public, limited to participants, open for students; and other similar attributes.	Essential	REPE-R3
L2-CU-RQ-273	The CI access point shall provide the educator with a means for social networking.	The system can incorporate communication systems that know the user groups and can automatically make connections between users of the system. Example capabilities: Amazon recommends, knowledge/tools/models/templates sharing, blogs for resources and visualizations, comments and other means for external contributions, etc.	Essential	REPE-R4
L2-CU-RQ-274	The CI shall provide a discoverable repository for educator-provided tools	The educators would benefit from sharing tools and knowledge using a common point of distribution.	Essential	REPE-R7
L2-CU-RQ-275	The CI shall provide versioning and citation for educator assets	The educators would like to know which tool was used for a presentation, its version, changes between versions, etc.	Essential	REPE-R8
L2-CU-RQ-276 **4.14**	**Documentation**			
L2-CU-RQ-277	The CI IO shall make all source code for the OOI Cyberinfrastructure implementation and drivers publicly available, subject to applicable licenses	The availability of source code for CI software, interfaces and drivers together with all design documents, API documentations and interface descriptions creates a very transparent infrastructure implementation environment that is open to change, community contributions, third-party assessment, and reuse. All this will benefit the CI adoption process, the availability of third-party CI extensions and drivers and the overall CI robustness and reliability.	Critical	CA-PD-5 RWS1-R41
L2-CU-RQ-278	The CI IO shall document all external interfaces		Critical	RDPG-R16
L2-CU-RQ-279	The CI IO shall document all device drivers	This includes their interfaces. Reference designs and how-to information shall also be provided.	Critical	RDPG-R16 RDPG-R17
L2-CU-RQ-280	The CI shall provide discoverable web-based documentation for all services	Documentation for all CI components and interfaces shall be available in hypertext format such as HTML, either online on the web or for download. Hypertext formats are one the most effective and intuitive way to date for documenting APIs and user interfaces. They enable online indexing and search if made available online. They enable quick cross-referencing and can be made available offline or in printable page-size formats as well, if needed.	Critical	CA-PD-12 RWS1-R39 RWS1-R42 RIOM-R16
L2-CU-RQ-281	The CI shall utilize a naming scheme that is compliant with OOI naming conventions	Many people expressed concern that the naming and labeling scheme would not be standardized. It is imperative, to get clear understanding of system, to utilize a common labeling and naming scheme. This includes a glossary of common terms that is part of a larger online help system.	Critical	RIOM-R15
L2-CU-RQ-282 **4.15**	**Development Process**			
L2-CU-RQ-283	The CI IO shall seek to influence the direction of CI standards to effectively meet the needs of OOI users	The CI IO shall circulate CI requirements and designs within and outside the OOI community so that comparable infrastructures can adopt them. This will lead to similar capabilities across infrastructures and to effective linkage of data in a transparent way.	Essential	CA-PD-16 RWS2-R55
L2-CU-RQ-284	The CI shall utilize open standards and open source software to the maximum possible extent	Open standards and software facilitate easy integration of heterogeneous resources and applications with the CI, which increases CI maintainability and extensibility. Open source software also permits user specific extensions and modifications. Often, source code and documentation are publicly available, which facilitates user understanding and proposal of changes to the CI. In some instances, proprietary software packages (such as Matlab) may be used where no open source substitute exists. Open standards for information exchange enable interoperability with large classes of existing data distribution networks, information resources and applications.	Essential	CA-PD-5 RWS1-R8
L2-CU-RQ-285	The CI IO shall accommodate local innovation that can be scaled to the community level	Users shall be able to submit feature requests, defect reports and change requests to the CI IO. They shall even be able to submit executable extensions and source code fixes for consideration of inclusion into the core CI services and interfaces. All submissions and extensions are subject to a review process and must comply with CI and OOI policies.	Essential	CA-PD-14 RWS1-R40
L2-CU-RQ-286	The CI IO shall support the verification of hardware and software components that will be deployed on OOI infrastructure	Deployed observatory components such as sensors for a deep sea mooring need to be verified thoroughly and rigorously in order to ensure correct and long-running operation. The CI needs to provide the IT support for the verification process as well as simulation and test environments.	Essential	ROOP-R30
L2-CU-RQ-287	The CI shall support modular components	For long-term deployment of hardware and software, such as instrument platforms with CI components deployed, modularity is a critical design concept in order to provide maintainability. On the hardware side this is matched with standardization of hardware and connectors	Essential	ROOP-R36
L2-CU-RQ-288	The CI implementation shall be platform-independent	The CI should not be limited to operation on a specific platform, and should be compatible with a wide range of operating systems. There may be limits on this imposed by the platform mobility of third party software (e.g., Matlab).	Critical	CA-PD-8
L2-CU-RQ-289	CI service interfaces and capabilities shall maintain backward compatibility as the services evolve	The capabilities provided by CI services will evolve over time, usually in a manner that enhances functionality. However, the interfaces and capabilities from earlier versions shall remain compatible with earlier versions to the greatest extent possible so that (for example) workflows do not need constant updating over time.	Critical	CA-PD-13

ID	Requirement	Rationale and Description	Priority	Source
L2-CU-RQ-290	The CI architecture shall be scalable to accommodate an increasing range of actors, resources, and services	Observatory managers often need to communicate with other people in their network. Sometimes they use regular email, but it would be more efficient and helpful if they were able to communicate through the system. Further this kind of communication is a part of Web 2.0 and can be leveraged to encourage the activates of the online community.	Critical	CA-PI-3
L2-CU-RQ-291	The CI shall be extensible to allow the addition of new resources, services and applications to the OOI infrastructure	New proposals and grants lead to new and updated hardware in existing observatories as well as to new observatories. The CI architecture and components must be extensible so that new services and/or resources and/or applications can be added and existing services and/or resources can be augmented, throughout the OOI life cycle.	Critical	CA-PI-4 RWS1-R3
L2-CU-RQ-292 **4.15.1 Other**				
L2-CU-RQ-293	The CI shall provide process support for "dry" observational infrastructure development, verification and simulation	Observational infrastructure refers to infrastructure elements such as communication nodes, instrument platforms and sensors. CI support can include lab or shore facility mock-up tests and tests of the complete system including sensor pre and post-calibration	Essential	ROOP-R24 RDPG-R66
L2-CU-RQ-294	The CI IO shall provide technically-qualified user care support and assistance through a human actor	Many of the users were concerned about getting technical support when they needed it. They thought the CI was going to be very complicated and the users already anticipated needing technical support. They felt that the CI should have a central responsibility for supplying and maintaining user care functions. Most of the users expressed concern that the user care system provides a human operator. The request was 24/7 availability of a human operator, but a minimum of 40 hours is critical.	Essential	RIOM-R33 RIOM-R34 RIOM-R38
L2-CU-RQ-295	The CI shall provide capabilities to maintain contact between users and user care	Users were concerned about customer care and wanted to make sure they could get help from a live, English speaking person whenever they needed it. The customer care will maintain contact with users through system contact logs, trouble reports and regular status reports.	Essential	RIOM-R35
L2-CU-RQ-296	The CI shall provide capabilities to initiate and track trouble tickets	Trouble tickets might cover a wide range of issues, so it is imperative that they are standardized so everyone can read and understand them. A ticket system automatically or manually collects error reports, feature requests, user provided comments, suggested improvements, etc. The ticket system issues tickets to users and forwards open tickets to responsible individuals or organizations based on defined categories. A workflow defines the automatic and manual steps in processing a trouble ticket. Users will need to be able to track their issues and generate aggregate reports of issues	Essential	RDPG-R21 RIOM-R39
L2-CU-RQ-297	The CI shall provide tools for observatory operators to communicate with users	Observatory managers often need to communicate with other people in their network. Sometimes they use regular email, but it would be more efficient and helpful if they were able to communicate through the system they are working on together. Furthermore, this kind of communication is a part of Web 2.0 and can be leveraged to encourage activates of the online community.	Desirable	RDPG-R24 RIOM-R14