The Large Synoptic Survey Telescope (LSST) is a complete observing system that acquires and archives images, processes and analyzes them, and publishes reduced images and catalogs of sources and objects. The LSST will operate over a ten year period producing a survey of 18,000 square degrees over the entire Southern sky in 6 filters (ugrizy) with each field having been visited several hundred times enabling a wide spectrum of science from fast transients to exploration of dark matter and dark energy. The LSST itself is a complex system of systems consisting of the 8.4m 3-mirror telescope, a 3.2 billion pixel camera, and a petabyte-scale data management system. The LSST project uses a Model Based Systems Engineering (MBSE) methodology to ensure an integrated approach to system design and rigorous definition of system interfaces and specifications. The MBSE methodology is applied throughout modeling of the LSST’s systems with the System Modeling Language (SysML). The SysML modeling recursively establishes the threefold relationship between requirements, logical & physical decomposition and definition, and system and component behavior at successively deeper level of abstraction and detail. The LSST modeling includes the analysis and documenting the flow of command and control information and data between the suite of systems in the LSST observatory that are needed to carry out the activities of the survey. The MBSE approach is applied throughout all stages of the project from design to validation and verification, though to commissioning.

The LSST Science Requirements Document (SRD) is the source for all subsequent derived requirements. Top level functional requirements have been derived in the LSST System Requirements providing a high level description of what the LSST is and must do. These in turn have been used to derive the Observatory System Specifications as refined by ~250 Operational Use Cases and Definitions, which are satisfied by the overall system architecture. These three parts of the System Architecture model provide the highest level description of how the LSST is meeting its functional and performance requirements and provides the foundation from which all subsystems derive their requirements.

System Architecture: Requirements at each level are satisfied by thorough integration and test plans. Subsystem integration and test plans verify that both requirements and ICDs are met and conclude with system acceptance testing. System Integration and Test commences when the camera is installed on the telescope following its acceptance on the summit. The science verification plan is executed during the final year of the 2-year commissioning period where the LSST SRD survey performance specifications are demonstrated.

System Behavior: System Activity: In this example the logical information flow between activities necessary for conducting the survey are modeled. Activities are allocated to structural elements to define operational specifications.

Using SysML for Model Based Systems Engineering

As a project, the LSST is using model based systems engineering (MBSE) methodology for developing the overall system architecture coded with the Systems Modeling Language (SysML). SysML is a graphical object oriented language used to model all aspects of complex systems. With SysML, we use a recursive process to establish three-fold relationships between requirements, logical and physical structural component definitions, and overall behavior (activities and sequences) at successively deeper levels of abstraction and detail. Using this process we have analyzed and refined the LSST system design, ensuring the consistency and completeness of the full set of requirements and their match to associated system structure and behavior. As the recursion process proceeds to deeper levels we derive more detailed requirements and specifications, and ensure their traceability. We also expose, define, and specify critical system interfaces, physical and information flows, and clarify the logic and control flows governing system behavior. The resulting integrated model database is used to generate documentation and specifications and will evolve to support activities from construction through final integration, test, and commissioning, serving as a living representation of the LSST as designed and built.

System Validation: Within the SysML MBSE framework the system design is validated when a three way relationship (left) between requirements, logical and physical structure, and logical and physical behavior is established. The triangulation process proceeds recursively to finer levels of abstraction leading to the definition of the physical system components and their specifications. The recursive process documents the complete traceability of the overall system architecture and design.