

The SMAP Dictionary Management System

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The Soil Moisture Active Passive (SMAP) Dictionary Management System is a web-based tool to develop and store a mission dictionary. A mission dictionary defines the interface between a ground system and a spacecraft. In recent years, mission dictionaries have grown in size and scope, making it difficult for engineers across multiple disciplines to coordinate the dictionary development effort. The Dictionary Management System addresses these issues by placing all dictionary information in one place, taking advantage of the efficiencies inherent in co-locating what were once disparate dictionary development efforts.

I. Introduction

The mission dictionary defines the interface between a ground system and a spacecraft. It defines commands, engineering telemetry, and any higher-level elements needed by a mission. It is the result of a collaboration between many engineers of varying disciplines, produced for the benefit of mission development, integration, test, and operations activities.

A basic dictionary contains only command and engineering telemetry element definitions. If a mission's operations concept is simple, only a few higher-level elements (e.g. telemetry alarm definitions) need to be added on top of the basic elements to produce a complete dictionary. However, if a mission's operations concept is complex, many higher-level elements are required. They include: derived channels, data products, event verification records, fault protection monitors, fault protection responses, and default flight system parameters. These elements contain references to both basic command and telemetry elements and to each other. This interdependency requires that flight systems, mission systems, ground data systems, and flight software engineering teams work together when defining the dictionary. Ultimately, all of the elements these teams define must add up to a unified dictionary that implements the mission operations concept without contradiction. Manually coordinating this effort can be challenging, time-consuming, and prone to error.

II. The evolving definition of a dictionary

The mission dictionary is composed of many documents. Each document defines all instances of an element type. Previous efforts were structured so that files defining certain element types were developed and delivered by separate teams. The effort was fragmented. Only when all of the files were delivered to a highly-skilled engineer called the "dictionary owner" could they be manually compiled into a unified product.

Early in its development, SMAP realized that dictionary management would become a problem if it continued to develop dictionaries in such a fragmented manner. Therefore the project decided to treat the dictionary as a unified product, making every dictionary element type available to all engineers via a new web application called the Dictionary Management System (DMS). By co-locating every element type in the same system, the effort necessary to define, verify, and validate a complete dictionary would be dramatically reduced.

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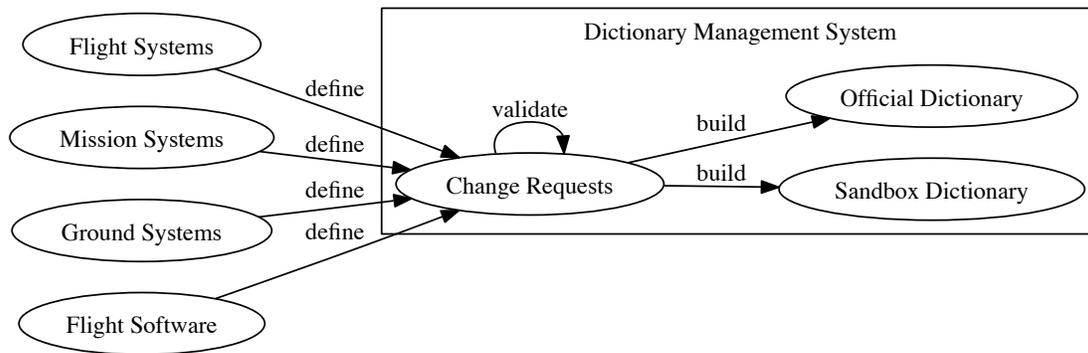


Figure 1. The Dictionary Management System co-locates information and stakeholders to reduce the amount of time and effort necessary to define, validate, and build a mission dictionary.

III. Efficiencies gained by co-locating dictionary development

Dictionary development can be made more efficient by co-locating all dictionary element types in a central location. DMS enables these efficiencies by providing: ubiquitous validation, unified change management, automated compilation, element metadata integration, and increased visibility into others' work.

Ubiquitous Validation. Every dictionary has an underlying structure used to validate its form, called a schema. All dictionary entries created or modified by DMS are validated against this schema. This ensures that each dictionary element is well-formed the moment it is created or modified. Moreover, schema validation also ensures that references to and from the element are well-formed as well. For instance, an alarm element may make reference to a telemetry element that triggers it. DMS checks that 1) the alarm entry is valid, 2) the telemetry it references actually exists, and 3) the alarm limits are valid given the datatype of the referenced telemetry. Any validation errors are fed back to the user for immediate resolution.

Unified Change Management. All additions and updates to the dictionary are coordinated by public change requests, greatly increasing the visibility and traceability of the development process. Change requests can be initiated by any authorized user of the system and continuously edited until that user targets a request for the next dictionary release. Some element types require multiple users collaborate on the same change request to complete a dictionary definition. By applying a trust-but-verify philosophy, multiple engineers may edit the same change request such that every user's edits are publicly visible in a change request change log. This public change log enables users to check other users' edits for accuracy and for the configuration management authority to verify a change request's provenance before deciding to include it in the next release of the dictionary. A subscription service also sends out messages to users whenever a change request has been modified within their area of cognizance.

Automated Compilation. A centralized system makes it possible to automatically compile existing dictionaries and dictionary change requests into a unified dictionary. Traditional dictionary management required the dictionary owner manually aggregate all dictionary element types from engineering teams, validate them, and merge them together to form a unified dictionary. DMS simply asks the user to specify a version to compile before kicking off an automated process. This process: picks out change requests targeted to the specified version, merges them with the latest official dictionary, validates the result, and—if the validation is successful—stores the new dictionary for permanent reference.

Automated compilation also enables the creation of a “sandbox” dictionary. A sandbox dictionary is a preliminary release of a dictionary containing new developments that are not yet accepted by the dictionary configuration management authority, but are of use to software engineering teams working in their own domain. These teams use sandbox dictionaries as the input for automatic code generation and for testing their completed code. If mistakes are found in the sandbox dictionary, fixes are fed right back into DMS as change requests. Most importantly, immediate access to sandbox dictionaries eliminates all waiting, enabling software development to keep an even pace with dictionary development.

Element Metadata Integration. Like functional requirements, mission dictionaries often have a slew of supporting metadata. This can include: planning and scheduling information; points of contact; developer assignments; and records of verification tests performed. Traditionally, this information was tracked in different formats by different organizations. By centralizing in DMS and linking it to the relevant elements within the dictionary, broad efficiencies were gained across the SMAP project. An excellent example of this would be the time required to trace the verification history of a given command. Prior to DMS, the only way to find a verification record was to search multiple large Microsoft Excel spreadsheets. Now, each dictionary element displays verification records next to its definition for immediate reference.

Increased Visibility. A central system can make a dictionary much more visible than a decentralized one. SMAP decided to intentionally make all dictionaries—including their change requests—visible to every authorized user of the system. Users may check in on other’s works in progress without having to directly contact them for status. By doing so, they may spot a problem that the originator did not catch, or think about creating a related definition that did not occur to them before. The result is better communication between parties and the elimination of duplicate effort. This level of transparency puts all relevant information to the definition of a dictionary only a few clicks away.

IV. Conclusion

The SMAP Dictionary Management System is an improvement over traditional dictionary management techniques. By centralizing all dictionary data into one location, it makes the dictionary development process more efficient. Compared to prior missions using the traditional process, SMAP was able to reduce the effort required to manage dictionary development by 75% while producing a dictionary of greater scope and content. Additional time savings on the part of the systems and software engineering teams are also implied, but have not been formally quantified.

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