**5 CASE STUDY OP FOR THE CARTRIDGE SUPPORT SOFTWARE**

A case study constructing an operation profile for the Lockheed Martin Tactical Aircraft System’s (LMTAS) Cartridge Support Software (CSS) (Chruscielski and Tian, 1997). The process is an adaptation of Musa’s 5-step approach, Musa-I, described above. This operational profile allowed the LMTAS software engineering team to derive some clear insights about the usage rate of the CSS functions from the customer’s perspective.

**1. Background and participants**

The Cartridge Support Software (CSS) developed by Lockheed Martin Tactical Aircraft Systems (LMTAS) is used by aircraft personnel to load mission planning data to a read writable media. The read/writable media is used by pilots to upload data to the avionic computers residing on an aircraft. The ability to use a personal computer to load mission planning data is a significant convenience to aircraft personnel who would otherwise be relegated to keying in complex data settings via the cockpit interface. The CSS affords aircraft personnel an efficient and highly expedient means of performing the mission planning exercise from the Graphical User Interface (GUI) of a personal computer.

Operational profile development was initiated to gain a better understanding of the CSS product from the user’s perspective and to improve its reliability by re-focusing the testing efforts on high-use functions. The primary personnel involved with the CSS OP development included:

1. ***Software Product Manager(SPM)****:* Responsible for the product planning and marketing function of the CSS. The SPM was instrumental in determining communication paths for the solicitation of user inputs to the Operation Profile.

***2. Software Test Engineers:***Responsible for providing understanding into testable input states per a typical field operation.

***3.******System Engineers:***Responsible for specifying the system requirements, the highlevel design, and the deliverable functions which are verified during the software testing phase.

Both authors of the reported case study (Chruscielski and Tian, 1997) were also involved in a graduate-level class “CSE 53 14: Software Testing and Quality Assurance” at Southern Methodist University, with Chruscielski taking the class and performed the initial work described here as a course project, and Tian teaching the class.

**2. OP development in five steps**

The customers of the CSS are the air forces (US Air Force or Other Air Forces) that use the LMTAS tactical aircrafts. The CSS also has internal users labeled as “Avionic System Test and Flight Test.” For the purposes of the CSS operational profile the investigation into the customer profile did not result in a “weighting” of the customers, as each customer had a similar use of the CSS. However, this exercise did serve as a means of establishing communication paths for the collection of user inputs.

The users of the CSS include the following types of flight personnel and engineering support:

1. ***Air Force Pilots****,* the primary users of the CSS. The pilots are directly involved with the mission planning exercise, however their use can be very infrequent.

***2. Flight Test Support****:* These frequent users of the CSS interface directly with test pilots during the mission planning exercise.

**3. *Avionic System Test****:* These users are involved in integrating the entire suite of avionics residing in the aircraft.

4. ***System Administrators:*** This user group’s functions are performed by Air Force Pilots. Therefore, it is combined into the Air Force Pilot group.

The user groups were weighted as shown in **Table1** In addition to the usage frequencies used in weight assignments, marketing concerns were also considered as an important weighting factor. For example, although the pilots were found to be very infrequent users,

**Table1 CSSuser profile**

|  |  |  |  |
| --- | --- | --- | --- |
| User  Group | Marketing  Concerns | Frequency  of Use | Total  Weighting Factor |
| Air Force Pilot | 0.85 | 0.05 | 0.45 |
| Flight Test Support | 0.10 | 0.80 | 0.45 |
| Avionics System Test | 0.05 | 0.15 | 0.1 |

They are the primary contractual customers of the CSS. Consequently, they were weighted accordingly due to both marketing concerns and usage frequencies.

The system modes for the CSS were determined to fall into the following categories:

1. ***Preflight Mission Planning:*** The Pilot or Flight Test Support personnel plan a mission.

2. ***Avionic System Test:*** The system test engineers use the CSS to stimulate avionics as part of the verification process during system integration.

***3. System Administration:*** The administrator uses the CSS to maintain a database of preflight mission files.

An analysis of the system operational behavior revealed that there is not an appreciable difference accounted for between the: system modes. Therefore a categorization and weighting of identified system modes was not performed. The derivation of the CSS user profile and the associated weighting factors remains the most significant component for determining the CSS operational profile.

For CSS, there is no significant distinction between high-level intended functions and low-level implemented operations. Therefore, the steps of functional profile and operational profile in Musa-1 was collapsed into one in this case study. Each function of the CSS is typically associated with it’s own dialog or window. The user has the ability to enter one or more individual functions and then terminate the mission planning session. The user does not have a defined order in which the functions must be executed. Because of this, an implicit functional profile described in Musa-1 was used, listing only the occurrence probability for each individual function, rather than the end-to-end functional sequences that define an explicit functional profile. These functions were analyzed for the operational profile in **Table2**

**An** indication of how each user group uses the CSS was found to be beneficial to the System Engineers and Test Engineers. The user groups all have a significant contribution during the lifecycle of a tactical aircraft and each user and their requirements have to be satisfied. Therefore, an operational profile was created for each of the user groups. From these individual operational profiles, a comprehensive operational profile was created. In the existing development and testing environment, a small minority of functions is considered to be of prime importance and receive a copious amount of emphasis in the development lifecycle. Those functions i.hat are considered to be of very low importance are given a brief cursory test to determine their functionality.

The formation of the CSS operational profile was intended to appraise this current approach that is used in software testing. Because of this specific usage concerns for operational profiles, the raw comprehensive operational profile were grouped into high, medium-high, medium-low, and low use categories in Table 8.8 as the final operational profile. These classifications correspond to the software management concern for the prioritization of defect resolution.

**Table2 CSS OP: CSS functions classified according to usage probabilities**

|  |  |  |  |
| --- | --- | --- | --- |
| High | Medium-high | Medium-low | Low |
| DTC Load | DTC Read | Wpn Prof | RetrCanned |
| Inventory | Delete | Hot Keys | Save Canned |
| Save | Retrieve Route | Comm | DTC Test |
| Route Planning |  | Retr/Save SCL |  |
| Print |  | Help |  |
|  |  | Base Default |  |
|  |  | FCR |  |
|  |  | Mstr Mode |  |
| High usage  = 100% - 75% | Medium-high usage  = 74.9% - 50% | Medium-low usage  = 49.9% - 25% | Low usage  = 24.9% - 0% |

**3. Metrics collection, result validation, and lessons learned**

The generation of the CSS operational profile required the participation of the Software Product Manager (SPM) to outline the marketing aspects of the software product. Several short interviews with the SPM over the span of a few weeks identified key areas of the CSS and several communication paths to the users. Follow-up discussions with the SPM helped to define the requirements for the user profile and functional profile. Much of the existing system design of the CSS guided the generation of the functional list. Consultations with system engineers and test engineers, during a two week period, were instrumental in the development of the survey form that was sent out to the CSS users.

The numbers for the operational profile were derived from e-mail and fax copies of user surveys through the identified communication channels. The advantage of using electronic communications was that it allowed for a quick transmission of the surveys to remote locations.

The desirable prospect of this approach was that one user would “forward’ the survey to other users thus creating a “chain letter” effect, and thereby increasing user participation in the survey. The disadvantage of this approach was that the status of the survey replies was a difficult factor to correctly determine. The projected response to the survey was 30-50 users. The actual response was 12 users. However, the participants who did engage in the survey were considered to be significantly reflective of their user groups. The final results evaluation required each member of the software engineering team to interpret the operation profile.

Individual interviews with each member of the software engineering team was beneficial in capturing unique perspectives on the operational profile. Initially, team members were not aware of how the data could be used in practical situations. Over the course of the interview each member began to suggest possible explanations for the results of the data. This led the review team to contrast current testing strategies with the identified needs of the customers. Individuals then offered action plans to accommodate customer needs and improve software reliability.

The LMTAS software engineering team, including the SPM, System Engineer, and Test engineers. reviewed and evaluated the operational profile results and the usage probability classifications shown in Table 8.8. The test engineers felt that the operational profile confirmed some of the expectations of their customers. In particular, validation the current software engineering efforts towards these “high” use functions provides confirmation that LMTAS’s efforts are on target. However, there were several unexpected results that lead to related actions:

* The medium use classification of the Hot Keys Function was found as a completely unexpected result. This function has been considered to be of low importance to the customer. The user’s continued reliance on Hot Keys should require modifications of current testing strategies.
* The classification of the Help function as a “medium to low” use function was another unexpected result. The CSS developers had believed that most users are familiar with the overall operation of the software functions, and as such, would require a minimal amount of help.

Prior to the generation of the CSS operational profile there had never been a comprehensive review of the CSS product from the customer perspective. A higher appreciation for communicating with the customer and an increased opportunity for improving the CSS testing strategy were direct results of the operational profile. The increased emphasis on the customer perspective also affected the system and high-level design effort. As demonstarted by this case study, an operational profile can be developed for the LMTAS ***CSS*** with a reasonable amount of effort by following and adapting Musa- 1 steps. Cross-validation through peer review was also found to be valuable not only in validating the results but also help derived specific follow-up actions based on these results. On the practical side, a simple classification of usage frequencies also adds value in highlighting the findings and helping initiate discussions and follow-up actions.

From the OP development procedure perspective, we can see that the *5* steps in Musa- 1 may not necessarily lead to a complete profile each step along the way. **In** this case study, customer and system mode profiles were not generated because the homogeneous usage of CSS by customers under different systems modes. The similarity between high-level intended functions and low-level implemented operations for CSS also reduced functional and operational profiles into one step. However, even for such reduced steps, the specific activities carried out were beneficial, for example, in identifying customers and communication channels to them.