1 Appendix B: SSM for SimpleSAT SRDB

In this appendix we would like to organize the data objects that we have identified in Appendix-A[1] and put them in their corresponding system elements. This leads to the creation of the Satellite System Model (SSM). Nevertheless, we take advantage of the benefits of the different types of system elements that we have identified in our paper. Accordingly, we will have 4 SSMs where each SSM aims to capture a subset of data objects that we have already identified.

1.1 System element definitions for SSM

Figure 1 depicts the SSM structure which is composed of system element definitions. At this level, each system element handles the data as they are defined in the corresponding ICDs. At this level data is captured as close as possible to its definition in the ICD. At this level we make abstraction of the future usage of the data captured in definition system elements.

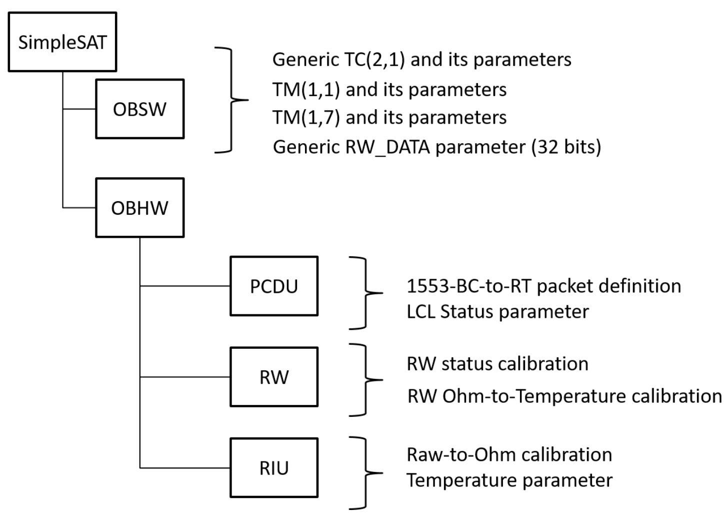

Figure 1: System element definitions in a space system model along with the data put in each system element

This SSM contains the following system elements:

1. **SAT**: this system element plays the role of the main root.
2. **OBSW**: this system element captures the OBSW generic data or commonly known as PUS library in the literature. For SimpleSAT, we will have:

[1] https://github.com/enercom25/SRDBSurvey/blob/main/Appendix-A.pdf

- The definition of the PUS TC packet service 2, subservice 1 as specified in the PUS ICD that we referenced in our paper.
- The textual calibration $C00003$ but without any entry as we are at a generic level.
- The definition of the PUS TM packet service 1, subservice 1.
- The definition of the PUS TM packet service 1, subservice 7.
- The definition of the 32-bit engineering parameter that aims to capture RW data.

3. **OBHW**: this system element plays the role of a root for OBHW components.

4. **PCDU**: this system element captures PCDU data:

   - One PCDU port that could be used to connect the PCDU with OBHW to supply power.
   - PCDU LCL telemetry engineering parameter bringing the status of the LCL of the PCDU port.
   - The calibration $C00000$.
   - The generic definition of the PCDU Mil-Std-1553 TC packet with its header and all its inner parameters.

5. **RIU**: this system element captures RIU data:

   - One RIU port that could be used to connect the RIU with OBHW to gather analog measurement.
   - RIU port telemetry engineering parameter bringing the analog measurement along with its calibration $C00002$.

6. **RW**: this system element captures RW data:

   - One RW port that could be used to connect RW to collect its temperature.
   - One RW port that could be used to connect RW to supply it with power.
   - RW calibration that aims to transform a measured resistance value to degree-Celsius for this RW.

We can make two important observations at this level:

- The choice of the number of system elements to be used depends on the complexity of the project as well as on the number of participants who populate the content of the SRDB. For example, the system element OBSW could be split into multiple sub-system elements. This would be the case if we deem that multiple participants are going to work on OBSW data and this separation will avoid parallel modifications of the content of the same system element and will prevent conflicts. The support of collaborative work by the SRDB has been discussed by the author in [1]

- At the definition level of system elements, OBSW and OBHW components do not recognize each other and do not reference data of each other. This is the role of the SSM with configuration system elements.

1.2 System element configurations for SSM

Figure 2 depicts the SSM structure which is composed of system element configurations. At this level, we address the interconnection between the RIU and the RW and between the PCDU and the RW via the harness. Moreover, we should instantiate TC and TM packets for operations engineers. This leads to the missionization of the OBSW data for SimpleSAT. We illustrate the data that is added in system element configuration:

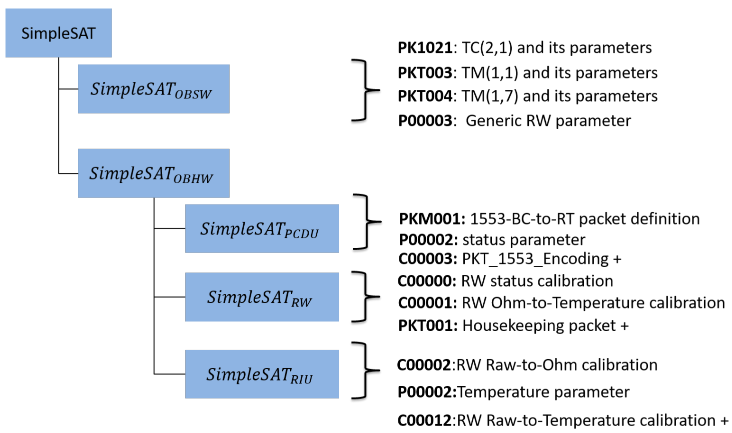

Figure 2: System element configurations in a space system model along with the data put in each system element

- The definition of the housekeeping packet.
- the calibration $C00012$ that aims to transform raw values into temperature values.
- The calibration $C00003$ that aims to transform text into a hexadecimal encoding of Mil-Std-1553 TC instance.

This SSM at the configuration level contains the following system elements:

1. **SimpleSAT**: this system element plays the role of the main root.
2. $SimpleSAT_{OBHW}$: this system element contains the definition of the two interfaces of the harness:
    - The interface connecting the RIU to the RW
    - The interface connecting the PCDU to the RW.

3. $SimpleSAT_{RW}$: this system element captures RW data:

   - One RW port that is used to connect RW to collect its temperature.
   - One RW port that is used to connect RW to supply it with power.

4. $SimpleSAT_{PCDU}$: this system element captures PCDU data but customized for SimpleSAT:

   - One PCDU port that is actually used to connect the PCDU with the RW for power supply.
   - PCDU LCL telemetry engineering parameter (P00002) bringing the status of the RW and calibrated with $C00000$. Notice here that explicitly say that the engineering parameter is associated with the RW.
   - The instance of the PCDU Mil-Std-1553 TC packet to switch on the RW.

5. $SimpleSAT_{RIU}$: this system element captures RIU data but customized for SimpleSAT:

   - One RIU port that is used to connect the RIU with the RW to collect its temperature.
   - RIU port telemetry engineering parameter (P00001) bringing the temperature of the RW and calibrated with $C00012$.

6. $SimpleSAT_{OBSW}$: this system element captures the OBSW data defined in OBSW definition system element and customized for SimpleSAT. This system element will contain:

   - One instance of the PUS TC packet service 2, subservice 1 that could be used by the operations engineer to switch on the RW.
   - The textual calibration $C00003$ populated with the hexadecimal encoding of the Mil-Std-1553 TC instance to switch on the RW.
   - The 32-bit aggregate parameter that aims to bring RW data.
   - One instance of the PUS housekeeping TM packet service 3, subservice 25 that aims to bring the RW data parameter to the satellite operations engineer.

Two observations could be made for configuration level SSM:

- At the configuration level, we could create data that has not been specified at the definition level. This is the example of the harness interfaces which are not mentioned at the definition level.

- Data that does not need to be updated at the configuration level system element does not need to be redefined at the configuration level.

1.3 System element occurrences for SSM

Figure 3 depicts the SSM structure which is composed of system element occurrences.

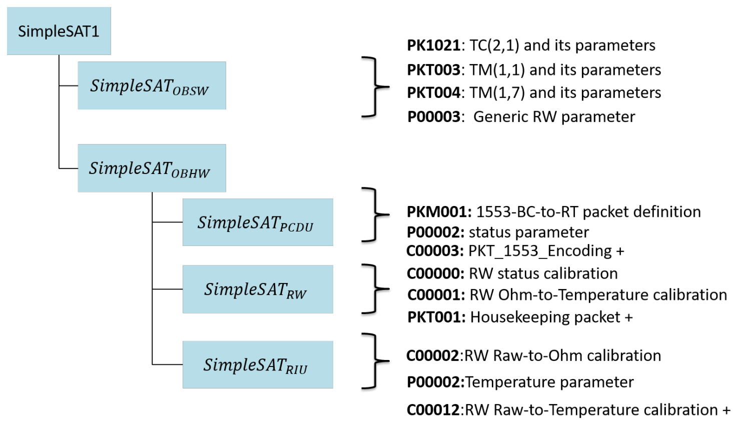

Figure 3: System element occurrences in a space system model along with the data put in each system element

This SSM is created to represent one instance of our SimpleSAT called SimpleSAT1. We could create as many SimpleSAT instances as necessary. All these instances will inherit the data and the properties of SimpleSAT as defined at the configuration level. This is useful for product line-based satellites where the satellite monitoring and control data is defined once and then instantiated multiple times.

1.4 System element realization for RW

We have said that we supposed that we bought one instance of the RW. This component on the shelf has its own serial number and its calibration that transforms Ohm to temperature is already measured. Thus we override the calibration of our original RW with the calibration of the RW which has been bought. Figure 4 depicts the SSM structure which is composed of system element occurrences and the $SimpleSAT_{RW}$ occurrence overridden with **RW XYZ** realization.

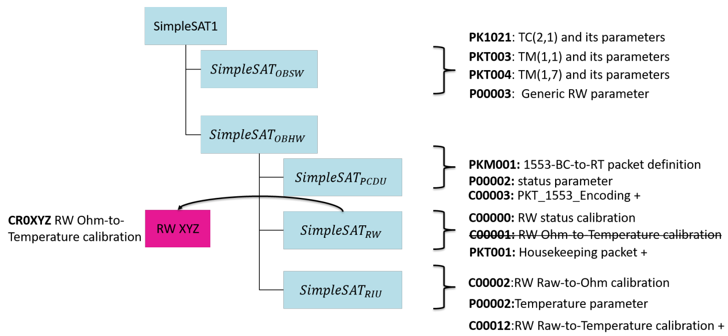

Figure 4: System element realization used in a space system model

This final SSM is the structure that has the full representation of our SimpleSAT1 instance. All tests and operations have to rely on the data defined at this level for the following reasons:

1. TMTC data obtained from specification system elements does not take into account the number of components that exist in the final SimpleSAT satellite. Moreover, OBSW data is not missionized at this level and the harness is not taken into account.

2. TMTC data obtained from configuration system elements does not know whether an existing as-built system element is being used for the RW component or not.

3. TMTC data obtained from as-built system elements do not know whether the as-built system element selected has been used in the final assembly of SimpleSAT or not.

References

[1] M. Khalfallah, "Restrain: Conceptualization of agile process tools integration with reference to the aerospace industry," *Journal of Aerospace Information Systems*, vol. 18, no. 4, pp. 144–156, 2021.