Modification and design optimization of the BIOLAB Sub-system "Distribution & Cleaning Cassette" on board of the International Space Station

Bachelorarbeit

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Table of contents

1. Introduction

This first chapter specifies the systematic approach and the procedural method of this paper. Like the title “Modification and design optimization of the BIOLAB Subsystem "Distribution & Cleaning Cassette" on board of the International Space Station“ claims, the target of this bachelor thesis is the optimization of the internal design of the subsystem depicted and described in chapter 2.1 while also checking for the possibility of functional modifications. In chapter 2 the project fundamentals, the subsystem itself and its current state are described, hereby looking for possible improvements of the design. A detailed description of the operational methods of the device is given, engrossing the general description given in chapter 2.1.2. The surrounding conditions, e.g. from various space agencies and the contracting entity as well as the functions that have to be sustained whatever changes may result from the analysis are shown in chapter 3.1. Prior to the conclusion and the included actual-theoretical comparison in chapter 5 the objectives are defined in chapter 4. In this chapter also all possible solutions for the already existing problems resulting from chapter 2.6 are compared and evaluated. Furthermore the modification of the general functionality, the use of alternative components and the new internal design of the subsystem are analyzed and appraised in chapter 4 following the general systematic approach given hereafter.

- **Functional changes**

During the analysis of possible functional changes for future design implementations the aim is to develop different scenarios, in which the subsystem can still offer all functions needed for a smooth operation. These necessary functions are identified in chapter 3.1.

So the focus in this section is on the identification of possible operational changes resulting from changes of the functionality of the subsystem.

- **Different components**

This section provides a list of new components for the best solution resulting from the former analysis. These parts and components are meant to replace existing parts on the one hand and add additional functions on the other.

The reason for looking for newer parts is that the current design of the subsystem was created in 1998, so it could be probable to find better and above all smaller components for the same tasks to improve the internal design.

- **Modification of existing components and processes**

In the case that the search for different components is not successful, a modification of already existing parts that may already be in service might be possible.

After four years of operations on orbit some best-practice workarounds have been developed by the people operating the devices and handling the refurbishment. In some cases it might be possible to improve the design of current components in order to simplify some particular operating or refurbishment procedures.

- **Internal design of the assembly**

Upon completion of the first three steps of the systematic approach all findings are combined in the fourth step. Here a new internal design will be developed with respect to both the findings from the examination in chapter 4 and the results of the as-is and the to-be analysis (see chapter 2 and chapter 3).

This final step delivers a theoretical model of the changes including an implementation proposal, a working plan and a prospective maintenance plan.

5. Conclusion

This last chapter of the thesis at hand summarizes the achieved goals and gives an overview on the differences between the original design and the new design proposal. Furthermore a forecast for the future steps necessary for the implementation of the design proposal and different usage scenarios are given.

The following table allows a quick comparison of the two states concerning the most important aspects that where changed and the improvements achieved because of these changes.

Aspect	Current state	Target state	±
Water available	195 ml	275 ml	+ 41%
No. of experiments	100	230	+ 130%
Expected lifetime	1.3 mission increments	3 mission increments	+ 130%
Internal volume	709 µL	359 µL	- 49%
Manual work	Every 3 to 4 months	Every 3 to 4 months	± 0
Operational time pump	19 minutes	7.2 minutes	- 62%
Refurbishment interval	Four months	One year	- 67%

Table 5-1 Actual-theoretical comparison

These numbers show that the proposed design changes have a huge impact on the operability and functionality of the subsystem, for example the possible number of experiments is now more than twice the original value while the refurbishment interval is reduced by more than 50 percent. Also the maximal possible lifetime of the entire system on orbit as well as on ground is increased due to the changed individual components, the internal alignment of these components and the improved contamination problem.

The first step to build a working prototype using the new design is to order samples of the selected components from the respective companies. With these components the exact design changes on the housing can be determined so it can be manufactured. These steps will take about six to eight weeks. After that time the system can be assembled and initially tested. During these tests the software used to control the system also has to be modified – the different type of pump and the removal of two valves require certain changes. When all tests are passed in can be entailed into the standard testing process for all space flight components. Passing these tests is the final qualification to go to the ISS.

In this last section questions about the future prospects of the D&C Cassette are answered and the influence of current decision concerning the ISS itself is described.

With the operational time of the ISS extended from 2015 to at least the year 2020[38] the upcoming development, construction and deployment of the new subsystem make sense as it will be used for a minimum of six more years.

Figure 5-1 MS and SP D&C Cassettes

Another advantage is that the new specifications are not only limited to the MS D&C Cassette. There is an almost identical subsystem, called the Spectrophotometer [*SP*] D&C Cassette. In the figure to the left both D&C Cassettes can be seen. This cassette operates with the exact same functional methods and has the same outer shape and dimensions. The only difference is that the SP cassette does not use FTCs for the survey of the samples. It also does not need the two valves necessary for the selection of one of the two FTCs because of this difference. But it can still benefit from the other design changes like the new injection port, the different type of pump and the higher amount of water available as the remaining internal components are the same on both subsystems.

In conclusion, the "Distribution and Cleaning Cassette" as a subsystem on board of the International Space Station will continue to be an important part of the equipment that contributes to the research of the effects of microgravity on biologic probes and samples.

The design proposal at hand improves the operability and costs of those researches

[38] cf. *http://de.rian.ru/science/20090205/120000451.html* [04.02.2013]