HEAVY DUTY COMPLETE EXTENSION SLIDES

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ABSTRACT

The selection from available commercial market of a set of slides to be used in an habitable pressurised module in space, to draw a 660 mm box out of a rack, up to a completely extracted position in a safely supported configuration, seems in principle not to be a complicated task. That was the first approach taken in the design process of the telescopic guides of the Crew Work Bench (CWB) included in the Fluid Science Laboratory (FSL), part of “ESA Microgravity Facilities for Columbus” within the Columbus Orbital Facility (COF) of the International Space Station (ISS). Nevertheless, common space compatible requirements such as materials, specific environmental loads, available envelope, total weight, etc., can make the selection of telescopic slides from commercial market unfeasible.

A specific development to design space compatible telescopic slides for the CWB was undertaken. A set of heavy duty space compatible telescopic slides were designed, manufactured and tested. They should be operative in both, 1-g environment and in orbit, and additionally should withstand an inadvertent astronaut kick or bump of 556 N in any direction.

1. INTRODUCTION

The CWB included in FSL, part of “ESA Microgravity Facilities for Columbus” within the COF of the ISS, is at the same time a drawer containing the laptop computer (plus manuals, diskettes, etc.) and a working place on which equipment, orbital replaceable units (ORU´s) or modules can be restrained for maintenance, refurbishment, or repairing. Additionally, the user of the computer can take advantage of a sliding platform or tray that holds laptop computer in the appropriate position. That tray can be operative independently of the use of the bench. The work bench main feature is to have a standard interface pattern (e.g. threaded holes, retainers, Velcro ® strips) that can support every FSL component that need to be operated in orbit.

The work bench should be totally extracted by means of, in principle, commercial telescopic slides. At launch, the laptop computer and other related items are kept in place inside the drawer by means of foam pieces cut to the adequate shape, and the work bench is secured by means of captive screws. Once in orbit captive screws are released.

Those slides should provide functional support to the Crew Work Bench over a period of ten years in orbit. The expected overall concept was as shown in Figure 1.

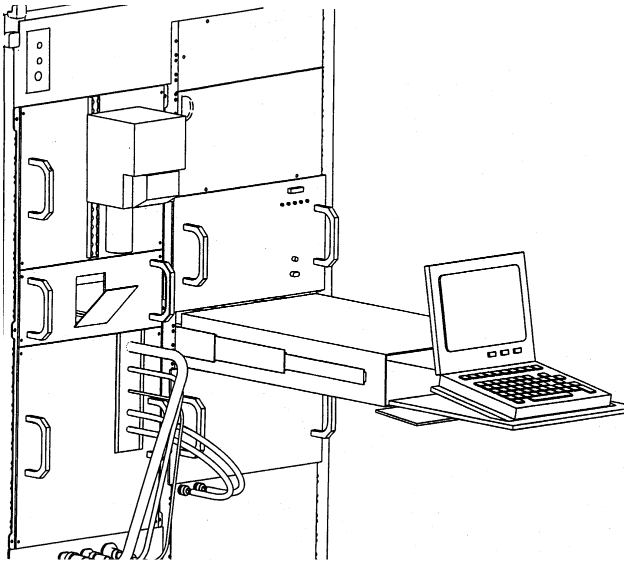

Figure 1. CWB Expected Overall Concept

2. DESIGN REQUIREMENTS

Commercial slides definition is usually driven by the gravity load acting on the equipment, without providing too much reinforcement against lateral loads. If we add some additional requirements such as, being capable of withstanding a load of 556 N in any direction at 925 mm from the rack front plane in completely extracted configuration in orbit, demanding low force to be operated by hand under 1-g conditions (< 20 N) with a 16 kg drawer and under 0-g conditions as well, requiring low wear in order to provide unchanged operational performances after 100 complete operational cycles under 1-g conditions, supplying provisions for latching in stowed and in extracted configuration, all that with a mass < 3.8 kg and in a compact envelope when stowed of about 30 x 122 x 660 mm each side, then the task is not so simple as it seemed to be at the very beginning.

3. DESIGN CONCEPT

For the telescopic slides design the more demanding load case was the inadvertent kick or bump of an astronaut, specified as a load of 556 N. If we apply such a load in the edge of the computer tray, which is located at 925 mm from rack frontal plane when CWB and tray are totally extracted, it means an induced torque of 532 Nm at the plane of the supports closest to the rack frontal plane.

After reviewing an important amount of available commercial slides the decision of the need of a dedicated design was quickly achieved due to five main facts: loading, mass, envelope (including attachment and interfaces), material, and lubrication

Loading: Those commercial slides that were able to withstand the load (at least in vertical direction) were too heavy and too big. Commercial guides are rated according to a uniformly distributed load, therefore an equivalent uniform load causing the same bending moment would require to withstand about 165 kg uniformly distributed under 1-g condition. As the inadvertent astronaut kick could be not centred in the tray but at one of its two corners, the equivalent load would be probably higher. Additionally, commercial slides usually limits the lateral loading to a value lower than the 50 % of the load rated for direct loading.

Dimension: The envelope required by heavy duty commercial slides are not always compatible neither with the available envelope nor with the interfaces available to attach them to the rack structure.

Mass: Usually the heavy duty commercial slides are too heavy as the strongest slides are made of steel.

Materials: Only a small quantity of heavy duty commercial slides can be found manufactured in aluminium alloy, but they contain also zinc plated steel components, and carbon steel balls, although in some cases austenitic stainless steel balls are offered as an option.

Lubrication: Commercial slide manufacturers usually recommend lubrication for a longer life, although it seems not to be mandatory.

All those aspects suggest a design devoted to meet all existing requirements.

The chosen configuration was selected to provide the necessary structural integrity against the referred load in any direction with the minimum mass, the maximum compactness, and the minimum cost impact, allowing a relatively low force operation with negligible wear.

After studying several alternatives, and having in mind the necessity of a cost effective design, the selected concept was based on two pairs of high strength stainless steel tubes, sliding respect to other two pairs of tubes of the same material, and two brackets sliding also on the sliding tubes.

4. DESIGN DESCRIPTION

The Crew Work Bench telescopic guides configuration is based on two sets of slides each set with two pairs of high strength stainless steel tubes ∅ 20 and 1 mm wall thickness. Those tubes have been installed on dedicated supports and brackets that fix the slide system to the rack posts.

One of the most critical aspects in the slide system design was the definition of the characteristics for the sliding surfaces of pieces in contact. The solution should provide sufficient wear resistance as to withstand the expected on ground operation cycles, with high load carrying capability, but providing very low friction with the minimum mass impact. The selected solution for all sliding surfaces was the use of a bonded liner of self-lubricated bearing material with minimum functional degradation under the required number of operational cycles. The selected self-lubricated bearing material is basically a metal mesh encapsulated in a wear resistant PTFE, providing low friction and high load carrying capabilities.

The arrangement of the tubes is such that, for each set, they configure a telescopic slide system, being each side composed of three modules.

- Fixed module. That is the part fixed to the rack. It is composed of two tubes disposed in the outer part of the package. Both tube ends are fixed by dedicated support brackets bolted to the rack.
- Floating module. It is the one that slides on the tubes of the fixed module. It is composed of two tubes disposed in the inner part of the package. They are interconnected in their outer end with a dedicated bracket, and in their inner end by another bracket provided with self-lubricated liner on cylindrical surfaces to slide on the tubes of the fixed module.
- Sliding bracket. It is a milled piece provided with self-lubricated liner on cylindrical surfaces to slide on the tubes of the floating module, and with adequate interfaces to be rigidly attached to the drawer to the extracted.

Each sliding system side contains three “V” shaped leaf springs, each of them with its corresponding cam:

1. Leaf spring in the inner part of the sliding bracket, and cam in the inner part of the floating module. Its function is to maintain the floating module joined to the sliding bracket during extraction up to being latched to the fixed module.

2. Leaf spring in the outer part of the sliding bracket, and cam in the outer part of the floating module. Its function is to join the sliding bracket to the floating module in the extracted position.
3. Leaf spring in the fixed module, and cam in the inner part of the floating module. Its function is to joint the floating module to the fixed module in the extracted position.

Those items latch with different activating forces in order to maintain a sequence for the extraction/insertion.

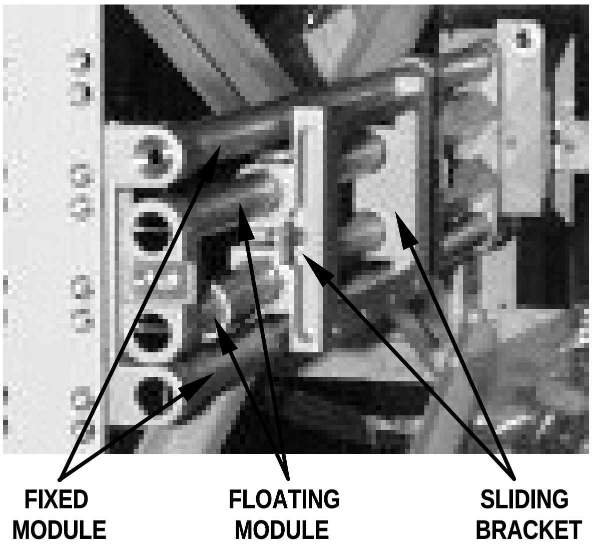

Figure 2. Sliding System (One Side) in FSL Rack

5. TESTS

The telescopic slides have been designed, manufactured, integrated and successfully tested. Tests performed on them are the following:

- Functional test. It was performed to verify the expected extraction and insertion sequence as well as verify the required extraction and insertion forces. Chart of Figure 3 shows the force performed to extract and insert the CWB (measured with a load cell), as well as the instant when the leaf springs with the cams perform the latching ans the unlatching.
- Static load test. It simulates the inadvertent astronaut kick or bump at the tray corner. No degradation, neither structural nor functional where identified after the static load test
- Life test. Two hundred (200) complete operational cycles (extraction and insertion) in gravity conditions were performed to verify the self lubricated liner located in all sliding surfaces, with the CWB completely loaded. The sliding system did not show any sliding degradation as no significant variation of required extraction and insertion forces where detected. Figure 3 shows one cycle.

Extraction process is shown in Figure 4 and Figure 5. They shows the stowed configuration, an intermediate, and the totally extracted configuration (with or without extracted laptop tray).

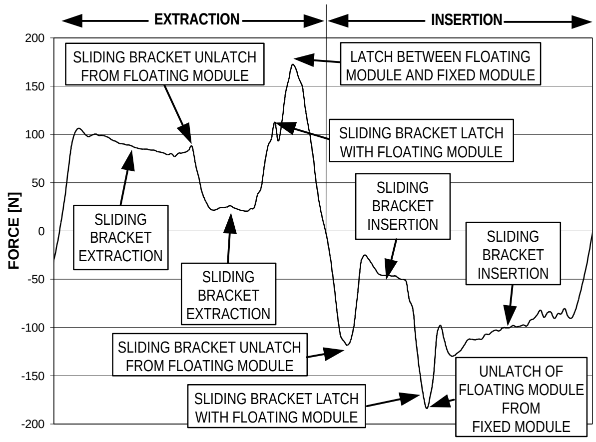

Figure 3. Force to Extract/Insert the CWB

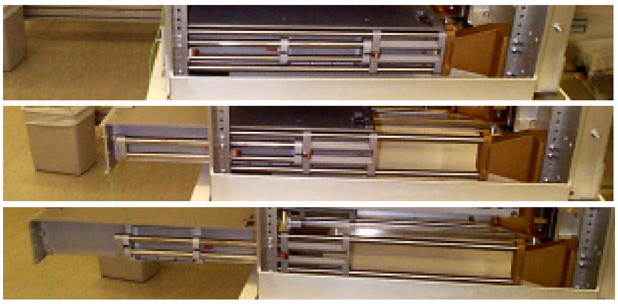

Figure 4. CWB Extraction Sequence

7. CONCLUSION

The design of a mechanism for space use whatever be the environment (Extra Vehicular Activity or Intra Vehicular Activity), although in very early stages could be based in a commercial mechanism, practically never this commercial mechanism is of direct application, and only in very rare cases small modifications of a commercial mechanism makes it compatible with specifications and interfaces used in space programs. Main aspects that makes a commercial mechanism not adequate for direct space use are load cases, mass, envelope (including attachment and interfaces), materials and lubrication.

The case of the sliding guide system of the Crew Work Bench for the Fluid Science Laboratory (to be installed in the International Space Station) is only an example. A specific development was necessary to meet all applicable requirements. The result was the design here presented, which has been successfully tested.

Presented design can be adapted to be used for other similar application, and is ready to be used under vacuum conditions.

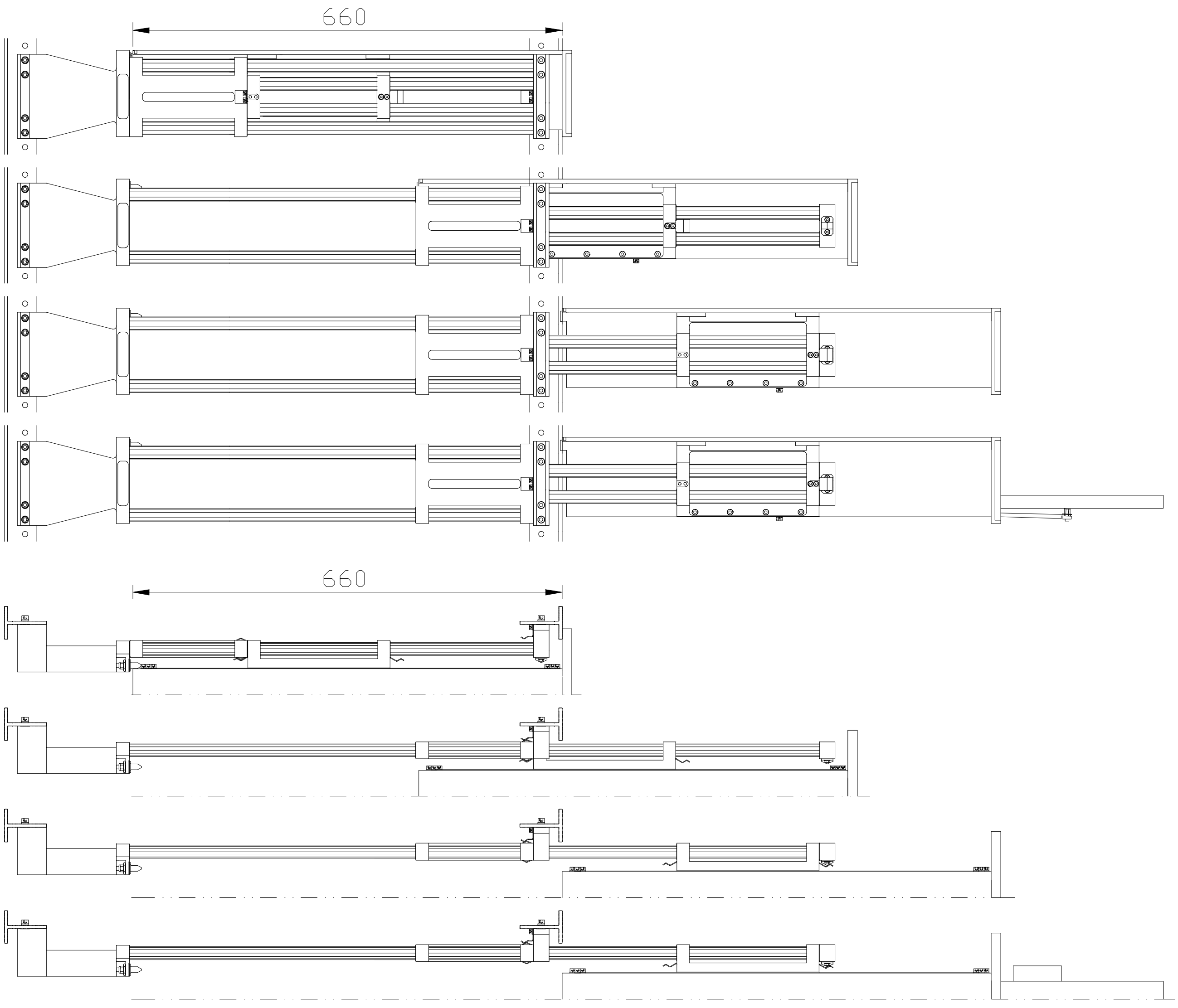

Figure 5. Sliding System (Half) Extraction Process. Lateral and Top Views.

Figure 6. Crew Work Bench Final Design, with Developed Telescopic Slides, Completely Extracted.