N92-15886

1991

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER
THE UNIVERSITY OF ALABAMA

EMERGENCY EGRESS REQUIREMENTS FOR SPACE STATION FREEDOM

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Contract No:	NGT-01-008-021 The University of Alabama

Introduction

There has been concern regarding the survival of the Space Station Freedom and its crewmembers during an emergency. An emergency can arise from the following: (a) Depressurization due to breach of the station's hull by space debris or meteoroids, seal failure, vent failure, or inadvertent activation of a vent by a crewmember; (b) toxicity created by released chemicals; and (c) a large fire resulting from an electrical short or explosion.

Previous considerations, including nodes at the ends of international modules, egress aids, zoning of equipment, clear aisles, and, most recently, the racetrack configuration, have been discarded. In addition, the issue of crew and station survivability has become more urgent for evaluation due to restructuring of the station. A number of components are to be analyzed for updating the requirements for emergency egress.

Objectives

The objectives of the study were to determine if the pressurized elements and hatchways of the Space Station Freedom support the emergency egress of crewmembers during operation of the station at the stage of Permanently Manned Capacity (PMC).

Emergency Egress

Emergency egress has been defined as the exit from a pressurized element when an event occurs which makes that element uninhabitable.

Assumptions

1. The latest Restructured Space Station Configuration as given in Figure 1.

2. All hatches will remain open during normal operation within the station, between the orbiter and the station, and between the ACRV and the station.

3. Hatches will be operated manually from both sides.

4. The orbiter will always be manned with two crewmembers while docked at the SSF.

5. Crewmembers can maintain a transition speed of 1 ft/sec when moving an injured person and 5 ft/sec when moving through an induced airflow caused by a 4 inch diameter hole in the station's hull. The time values are based on the Skylab experience, tests conducted in KC135, and empirical data obtained from the astronauts.

Emergency Egress Tasks

The emergency egress tasks for the restructured station consist of:

1. Perceiving the emergency alarm siren.
2. Translating to the IMPACT workstation, switching off the alarm, use trackball, and learn the emergency action needed from display.
3. Don mask, help the injured crewmember to don mask, and translate to the safe area.
4. Close hatch and switch off the inter-module ventilation to isolate the affected element.

Structural Design of Egress Translation Path

The pressurized elements studied consist of: Pressurized Docking Adapter (PDA), hatch, redesigned modules (Laboratory and Habitation), birthing mechanism, and resource node. The elements were considered assembled in the restructured configuration as shown in Figure 1.

The rack locations were also considered with respect to the egress path .

Emergency Egress Scenarios and Estimated Times

The possible egress paths for four emergency scenarios considered were: (I) Accident occurs in a module and crewmembers translate to the attached node, (II) accident occurs at a node and crewmembers translate through it to the safe node (half station concept), (III) accident occurs at a module close to a node and crewmembers are not able to translate through the affected area, and (IV) accident occurs at a node and crewmembers cannot translate through it.

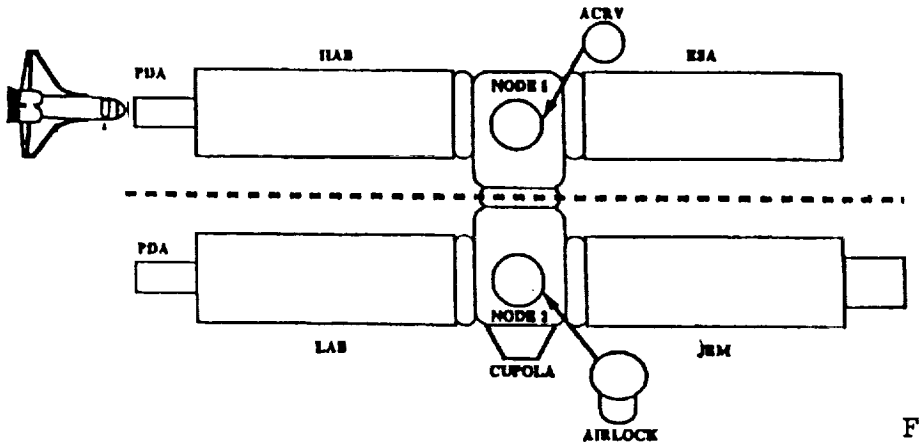

Figure 1

Sketch of Restructured Space Station Configuration

The estimated egress times are:

Case	Egress time (sec)
I	2.44
II	2.96
III	2.62
IV	1.37

In the case of cases III and IV, there is the possibility that the crewmembers may become trapped in the attached module in case of a severe accident occurring at or close to a resource node.

Translation Aids

It has been found that mobility aids, such as handrails, handholds, or footloops, are essential for safe egress during emergencies at free-flight terminal points, while changing direction, for control of body orientation, or for initiation of translation.

Summary

The observations are summarized as follows:

1. The structural design of the pressurized elements and the hatches studied is adequate for the emergency egress translation requirement. However, passage through the PDA may present a problem during the movement of an injured crewmember to the orbiter.

2. The current locations of a few racks, close to the hatches, may cause some obstruction for translation to the orbiter.

3. The egress time required in the worst situation, excluding entrapment, is estimated to be about three minutes.

4. There is a chance of getting crewmembers trapped in a module in case of a sever accident occurring at or close to a resource node.

5. Handholds and footloops around the hatches and kick surfaces along the translation path are required to aid emergency egress translation.

Suggested Additional Studies

- o Evaluation of descriptive vs. graphic display of Emergency Action Information.

- o Stowage locations of emergency equipment (PBA, Handrails, Egress Lighting) and their identification.

- o Evaluation of emergency egress requirements during the build-up of the station through its various stages starting from MB-6.

Recommendations

1. The requirement of a minimum clear egress path of 43 inches in diameter should be modified for non-circular paths (egress through PDA).

2. Locations of racks requiring more frequent maintenance should be away from the hatch to ensure better chance of a clear path for emergency egress.

3. The ACRV should be made capable of docking at the PDA of Laboratory and Habitation modules, including hatch commonalty and move capability. This will provide duel escape paths comparable to that provided by the racetrack configuration.

4. The estimated maximum time of emergency egress is about three minutes. However, the time values used should be verified by appropriate tests under microgravity conditions.

5. Handrails and foot restraints around the hatches and kick surfaces along the egress translation paths should be provided to act as translation aids during emergencies.

6. Suggested additional studies should be conducted prior to finalization of the space station design.