54-18

PAYLOAD PLANNING FOR THE INTERNATIONAL SPACE STATION

Tameka J. Johnson

David T. Shannon, Jr.

Space Atmospheric Sciences Program Group

Space Systems And Concepts Division

Utilization Analysis Branch

ABSTRACT

A review of the evolution of the International Space Station (ISS) was performed for the purpose of understanding the project objectives. It was requested than an analysis of the current Office of Space Access and Technology (OSAT) Partnership Utilization Plan (PUP) traffic model be completed to monitor the process through which the scientific experiments called payloads are manifested for flight to the ISS. A viewing analysis of the ISS was also proposed to identify the capability to observe the United States Laboratory (US LAB) during the assembly sequence. Observations of the Drop-Tower experiment and non-destructive testing procedures were also performed to maximize the intern's technical experience. Contributions were made to the meeting in which the 1996 OSAT or Code X PUP traffic model was generated using the software tool, Filemaker Pro. The current OSAT traffic model satisfies the requirement for manifesting and delivering the proposed payloads to station. The current viewing capability of station provides the ability to view the US LAB during station assembly sequence. The Drop Tower experiment successfully simulates the effect of microgravity and conveniently documents the results for later use. The non-destructive test proved effective in determining stress in various components tested.

1.1 INTRODUCTION

The International Space Station is proposed to be a world-class orbiting laboratory used for conducting high-value scientific research. One of the objectives of this project is to develop the ability for humans to live and work in space taking advantage of the microgravity environment. Microgravity is one-one millionth of one unit force of gravity on Earth. The Drop Tower experiment that was observed demonstrated the effects of microgravity on several forces and fluids. It is important that each scientific experiment or payload developer be aware of these effects as they plan for their payload to be integrated with Station. It is also imperative that the process for manifesting these payloads to Station be completed carefully. The traffic model has been arranged so that researchers can benefit from early access to the microgravity environment. This will enable results to be obtained from research on station before it is completely assembled. Non-destructive testing used for monitoring some structural components was observed. This analysis contributed to understanding the importance of monitoring the structure of ISS during the build-up sequence. Also during this sequence, the capability to perform viewing analysis of the US LAB was verified.

1.2. PROJECT DESCRIPTION

The first task was to explore the definition of the ISS, its components and the objectives of the project. The ISS will further develop and use leading-edge technology to reach its goal of providing a top quality laboratory for scientific research in space. Its structure and design mandate that Station be sent up in stages called assembly flights. Integrated into each assembly flight will be payloads. The ability to send the components to orbit will be furnished by a space transportation system (STS). The ISS will orbit earth's surface 190-220 nautical miles. The decay from 220 nm to 190 nm is attributed to atmospheric drag forces.

The International Space Station gets its title from the fact that international partners are involved in its development. The United States, Russia, Canada, Japan, and Europe are collaborating to complete this project.

Figure 1 illustrates the modules contributed by each country. It shows the ISS equipped with photovoltaic arrays that are used to absorb energy from the sun, thermal control radiators that radiate excess heat, a centrifuge facility, and a pre-integrated truss structure to which many of the modules are attached. The truss also houses the control moment gyros and other devices necessary for station operation. It also provides the structure to which the external payloads will be attached including cameras used for monitoring various ISS components.

The ISS's mission objectives were as follows:

- Provide a world-class orbiting laboratory for conducting high value scientific research
- Implement early, on-going access to microgravity resources
- Develop ability to live and work in space for extended periods
- Achieve program that meets technical, schedule and cost targets
- Introduce "new ways of doing business"
- Develop effective international cooperation

The ISS will affect three major areas of science. One is life science in which the research will aid in the study of biological space effects, space environment effects, ecological life support, and life system biology engineering. Secondly, earth science in which the research will aid in the study of atmosphere protection, climate prediction, land mapping, ocean monitoring, and weather now casting. Finally, space science in which the research will aid in the study of solar physics, cosmic physics, astronomy, and astrophysics.

Along with learning about ISS itself, it was requested that an updated database of the payloads be generated. Filemaker Pro is the computer software through which this task was completed. The information for each payload was transferred from the old database to the new database. The database consisted of the payloads projected for flight during the build-up sequence. An example of this database is shown in Figure 2. In addition to understanding the payload planning process, it was imperative that the microgravity conditions under which these experiments will operate be understood. Microgravity is $9.8 * 10^{-6}$ or one millionth as strong as it is on Earth.

The Utilization Analysis Branch secured a Drop Tower facility from NASA Lewis Space Center to demonstrate the effects of microgravity. Learning this facility then became one of the tasks outlined for this position. The facility consisted of an eight foot tower apparatus, a small camera, a monitor, a video camera recorder (VCR), a trunk and six specimens as shown in Figure 3. The specimens used were a scale with a mass, oil in a tube, two magnets, a pendulum, oil mixed with water and a lit candle. The mini drop tower or free-fall tower was assembled such that a pulley could hoist the box containing a camera and the specimen to the top of the tower. The pulley was then released, thus allowing box to drop to the bottom of the trunk. During the fall the camera recorded the specimen's activity. Through this demonstration, the use of six objects was observed. A scale with a mass on it was used to show the effects of microgravity on weight or mass of an object. Oil in a tube was used to show the effects of microgravity on pipe flow, two magnets were used to show how magnetic force was effected, a pendulum was used to show how momentum was effected, oil mixed with water was used to show how two different emulsible fluids mix, and a lit candle was used to show the effects of microgravity on convection.

It was requested that a viewing analysis be performed to identify the capability to monitor the US LAB during the build-up sequence. Using the Netscape interactive software tool, results of a viewing study where cameras were used to monitor different parts of the ISS were located. Netscape, first, provided a list of viewing equipment settings. From these findings, the pictures highlighting the US LAB were identified. The picture that provided the best viewing of the US LAB was called lower port camera looking starboard shown in Figure 4. This data was downloaded and included in a report to document that the requested capability existed.

After completing most of the tasks that were required, questions arose about fatigue that may be experienced by the ISS components. Thus, observations of the non-destructive testing of cracks were arranged. The first step in this procedure was polishing small pieces of aluminum with paste and sandpaper. These specimens were then placed in an Instron 8500 with a capacity of 22.48 Kips where they underwent extensive testing.

1.3 RESULTS/CONCLUSION

Each of these tasks, demonstrations, and experiments contributed to payload planning. The updated OSAT traffic model helped to organize Code X payloads for the current PUP. The database generated as a part of this summer program was instrumental in the development of a spreadsheet outlining the percentage of resources allocated to the payloads proposed for Station.

The results of the Drop Tower experiment were as follows. The gravitational forces were reduced as these objects were permitted to fall. The mass briefly became weightless, the oil flowed up the sides of the tube, magnetic force was reduced, momentum was either reduced or increased depending upon the position of the pendulum when it was dropped, beads of oil remained still in the water, and the shape of the flame on the lit candle took on a spherical shape versus an elongated one. These results were all documented on the VCR tape. The demonstration was performed as an exhibit at the Virginia Air and Space Museum.

The viewing analysis task was required to determine if more money needed to be allocated to provide the means to monitor the Lab. The results confirmed that the ability to monitor the US LAB during the assembly sequence already existed. Thus, only modifications to the film format need to be made.

The project involving the non-destructive testing of cracks had not been completed by the time of this report. However, scientists will be to analyze the data collected from the non-destructive testing procedures and predict any fatigue that may be caused on the ISS.

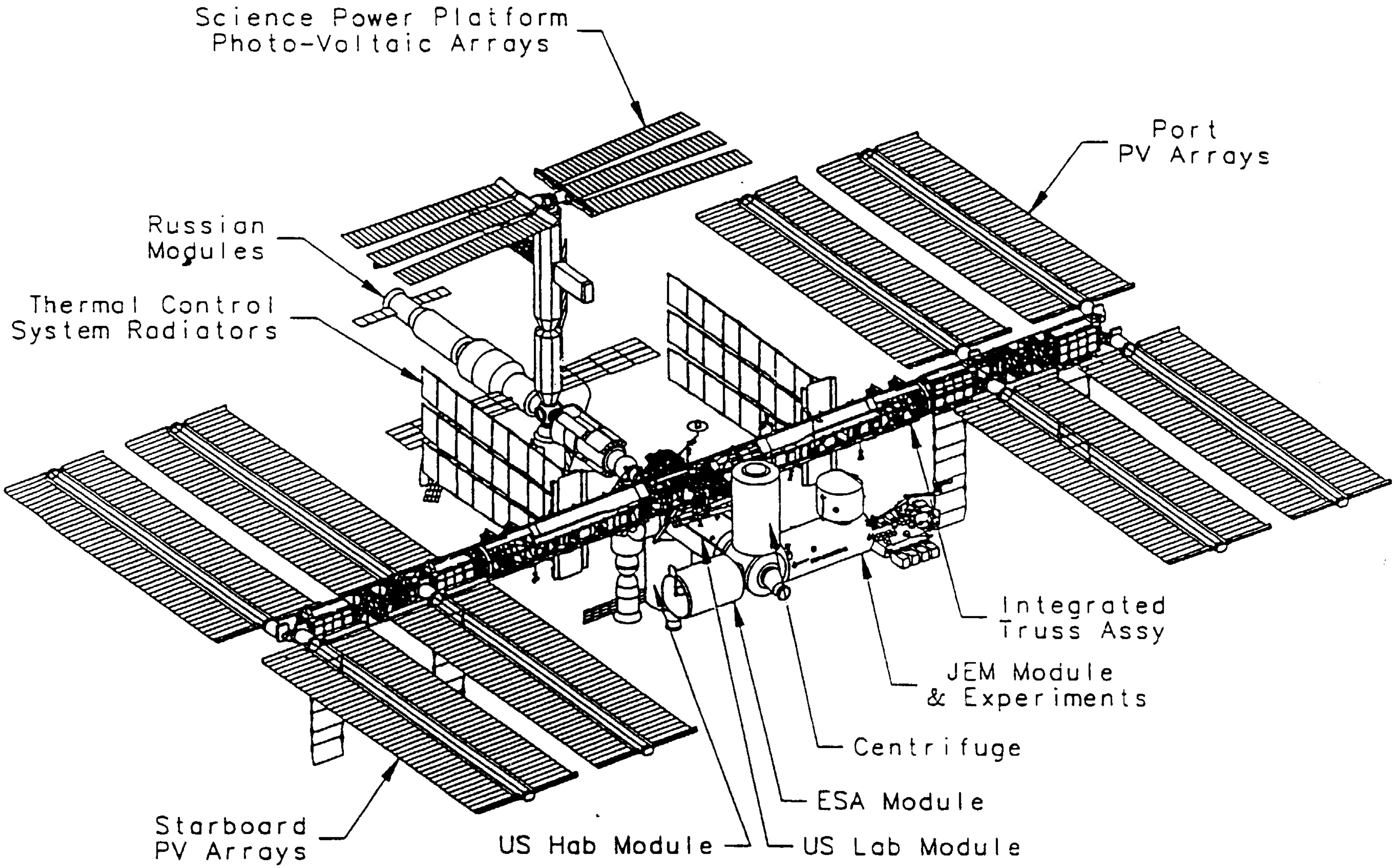

FIGURE 1 COMPONENTS OF ISS

BioServe

BITE Biomedical Isomorphisms Test Equipment

UF-3	UP	July 1, 2000	6.6	runs during increment
UF-4	ON-OR	February 1, 2001	4.4	runs during increment
2E	ON-OR	June 1, 2001	4.4	runs during increment
UF-5	ON-OR	November 1, 2001	5.5	runs during increment
UF-6	ON-OR	April 1, 2002	5.3	runs during increment

GBR Generic Bioprocessing Rack

UF-2	UP	July 1, 1999	18.5	runs during increment
UF-3	ON-OR	July 1, 2000	9.9	runs during increment
UF-4	ON-OR	February 1, 2001	6.6	runs during increment
2E	ON-OR	June 1, 2001	6.6	runs during increment
UF-5	ON-OR	November 1, 2001	8.3	runs during increment
UF-6	ON-OR	April 1, 2002	8.0	runs during increment

TeMPO Test Module for Plants/Organics

UF-3	UP	July 1, 2000	6.6	runs during increment
UF-4	ON-OR	February 1, 2001	4.4	runs during increment
2E	ON-OR	June 1, 2001	4.4	runs during increment
UF-5	DOWN	November 1, 2001	0	runs during increment

CMC

CPCG Commercial Protein Crystal Growth

UF-1	UP	February 1, 1999	3.0	runs during increment
UF-2	ON-OR	July 1, 1999	7.2	runs during increment
UF-3	ON-OR	July 1, 2000	3.9	runs during increment
UF-4	ON-OR	February 1, 2001	2.6	runs during increment
2E	ON-OR	June 1, 2001	2.6	runs during increment
UF-5	ON-OR	November 1, 2001	3.3	runs during increment
UF-6	ON-OR	April 1, 2002	3.1	runs during increment

XRDA X-Ray Diffraction Apparatus

UF-5	UP	November 1, 2001	55.7	runs during increment
UF-6	ON-OR	April 1, 2002	53.7	runs during increment

CMDS

Foam Foam Structure SS Demonstration

TBD	UP	December 31, 2006	0.5	runs during increment

MD/CBAP Materials Dispersion and Cell Bioprocessing Applications Project

UF-1	UP	February 1, 1999	15.3	runs during increment
UF-2	ON-OR	July 1, 1999	37.6	runs during increment
UF-3	ON-OR	July 1, 2000	37.6	runs during increment
UF-4	ON-OR	February 1, 2001	37.6	runs during increment

FIGURE 2 EXAMPLE OF PAYLOAD DATABASE

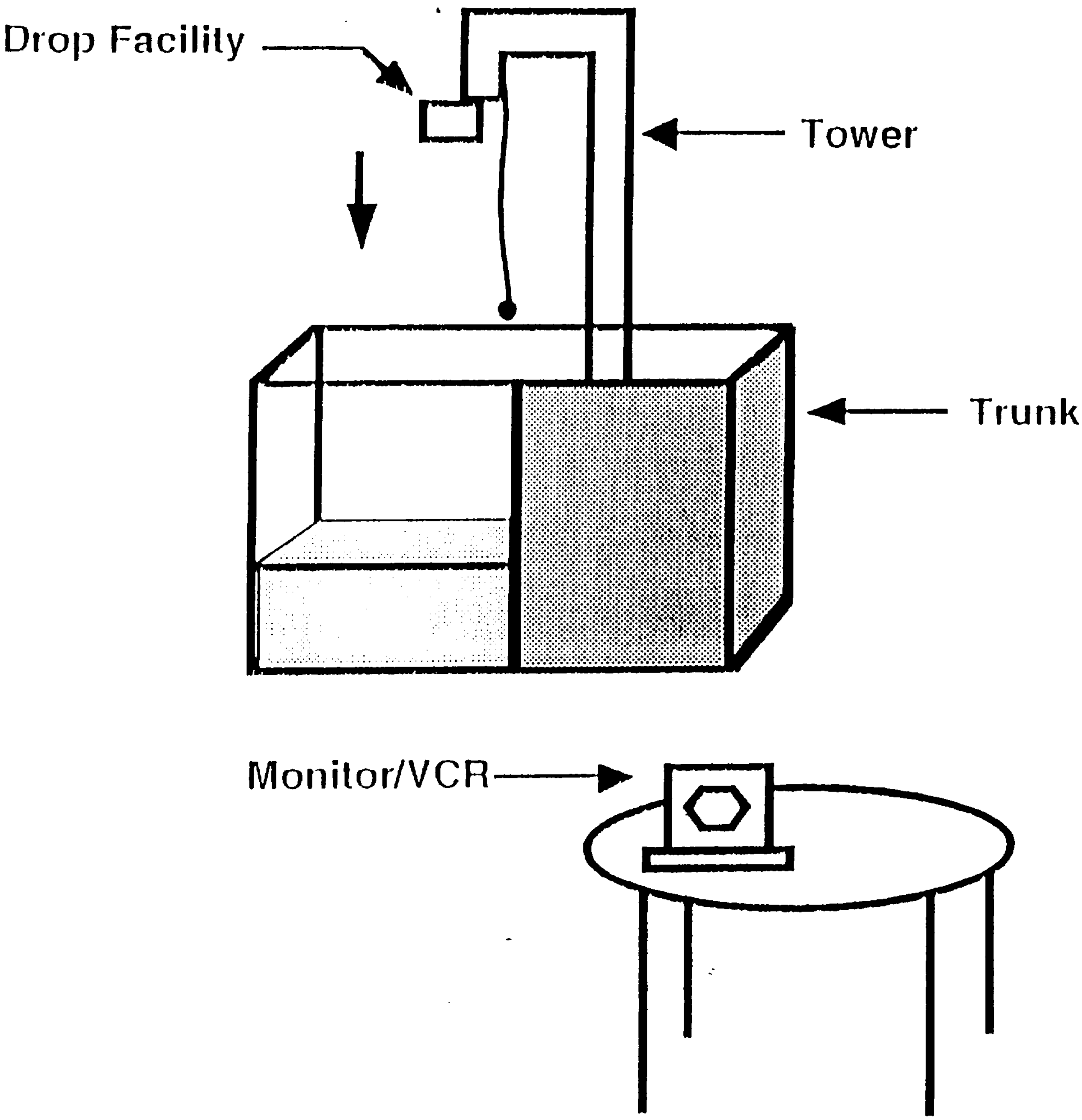

FIGURE 3 DROP TOWER FACILITY

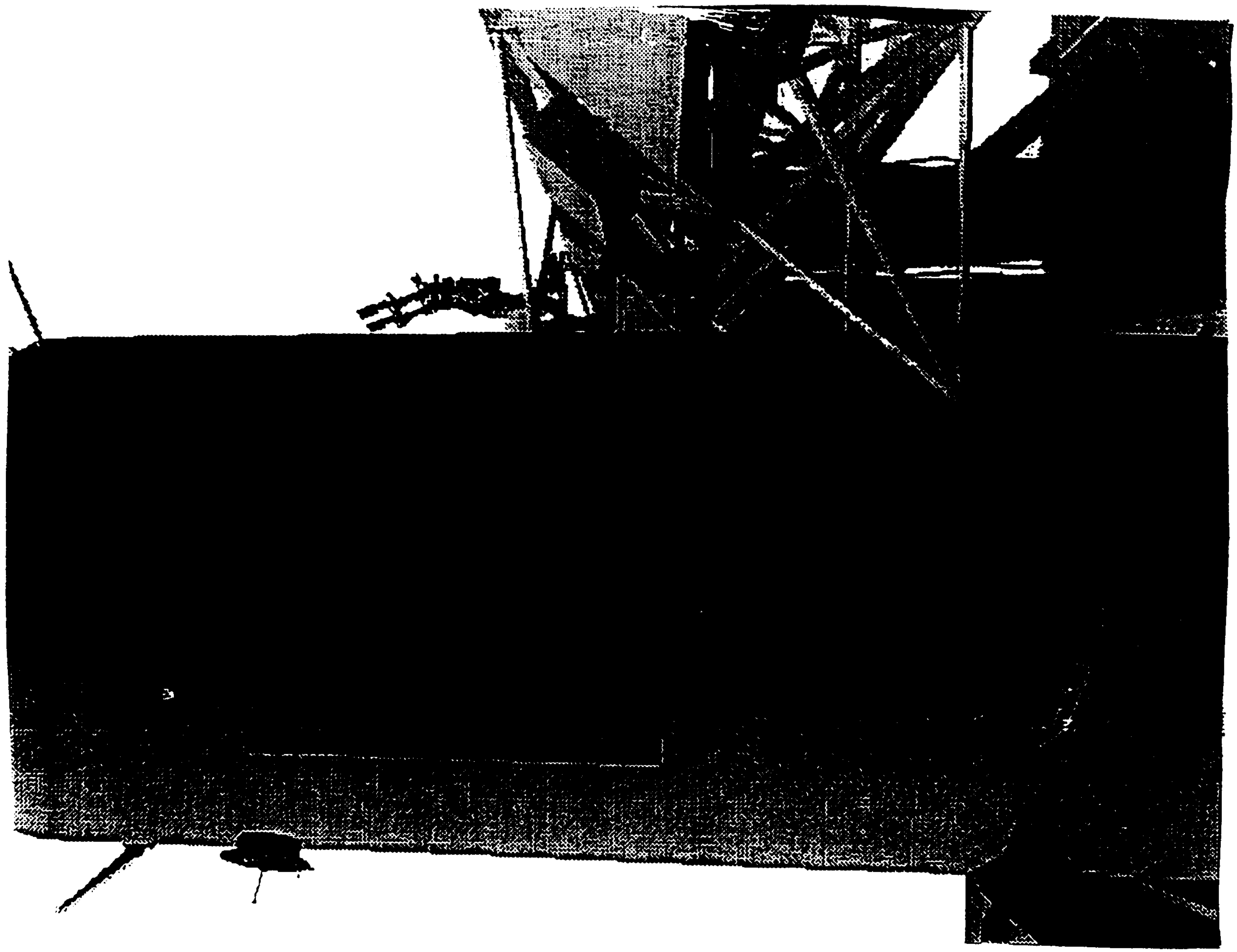

FIGURE 4 LOWER PORT CAMERA LOOKING STARBOARD