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1. INTRODUCTION

NASA and the Russian Space Agency are involved in a cooperative venture in which the Shuttle will rendezvous with the Mir Space Station during several missions from 1995 to 1998. This sequence of nine missions will serve as a precursor to the two nations' involvement in the International Space Station. The joint missions provide NASA scientists and engineers an opportunity to study the orbital, dynamic, and environmental conditions of long duration spacecraft, as well as develop evaluation and risk mitigation techniques which have direct application to the International Space Station.

STS-79 launched on September 16, 1996, and was docked to the Mir Space Station from the 19th through the 24th. The eleven-day mission ended on September 26, 1996, at Kennedy Space Center. This was the Shuttle's fourth docking mission and its fifth rendezvous with the Mir Space Station. As part of Detailed Test Objective 1118 (DTO-1118), approximately 1250 photographs and 17 hours of video of the Mir Space Station were acquired during the mission. This report documents results from survey-related imagery analysis tasks.

Results of Detailed Test Objective (DTO-1118) imagery analysis from STS-63, STS-71, STS-74 and STS-76 were documented in earlier reports. The STS-63 JSC/RSC-E Mir Survey Joint Report (JSC # 27246) was released in September 1995, the STS-71 JSC/RSC-E Mir Survey Joint Report (JSC # 27355) was released in January 1996, and the STS-74 JSC/RSC-E Mir Survey Joint Report (JSC # 27649) was released in November 1996. These reports include evaluation of the Mir imagery by RSC-Energia. The STS-76 JSC Mir Survey Report (JSC #27525) was released in February 1996. The joint report for STS-76 is currently in review.

1.1 Overview of Mir Photo/TV Survey

DTO-1118 integrates the requirements for photographic and video imagery of the Mir Space Station generated by the engineering and science communities within NASA. Although mission requirements vary, the principal objectives of the Mir Photo/TV Survey are as follows:

- Study the effects of the space environment on a long-duration orbiting platform.
- Assess the overall condition of the Mir.
- Provide assurance of crew and Orbiter safety while in the proximity of the Mir Space Station.
- Understand the impact of plume impingement during proximity operations.
- Evaluate the equipment and procedures used to gather survey data.

The Image Science & Analysis Group (IS&AG) conducted several analysis tasks (based on user requirements) using the returned imagery data from STS-79. They were to:

- Verify the configuration of the Mir complex.
- Assess the effect of micrometeoroid impacts and other visible damage on Mir surfaces.
- Compare the condition of Station surfaces to that seen on past missions.

- Measure the motion of the Mir Cooperative Solar Array during Shuttle docking.
- Measure the motion of the Base Block SP#2, as observed during the time the Orbiter was docked to Mir.
- Document the condition of the docking mechanism.
- Characterize debris seen during and after docking operations.
- Survey the Docking Module and the attached Reusable Solar Array (RSA).
- Assess the quality of video and photographic data.

1.2 Summary of Findings

This mission report contains the results of analysis of still photography and video from STS-79. The significant findings from this mission are as follows:

- Found large areas of paint peeling off the Reusable Solar Array (RSA) carrier which may represent a safety concern.
- Identified new areas of discoloration attributed to outgassing or contamination on the Base Block and Cargo Transfer Boom.
- Measured the sizes of three possible micrometeoroid/debris impacts on Base Block SP#2.
- Observed no changes on the Mir Environmental Effects Payload (MEEP) panels.
- Characterized the motion of the CSA at docking.
- Augmented STS-74 analysis of Base Block SP#2 motion based on new data from STS-79.
- Identified two anomalous solar cells on the newly-deployed Cooperative Solar Array (CSA).
- Identified three spars on the support structure of the Priroda SAR antenna which had not fully deployed.
- Identified smudges and probable blemishes on Base Block window # 2. An assessment of the Base Block window is located in Appendix B. (A detailed survey of Mir window surfaces is planned for NASA 5.)
- Validated the utility of the Nikon with the 300 mm lens at the 170 ft station-keep on approach and during fly-around.
- Characterized the visibility of the detached laminate on the stand-off target cross arms.

1.2.1 Mir Configuration

The configuration of the Mir Space Station for STS-79 was essentially the same as it was for STS-76. However, the Priroda Module was deployed to the $+X_B$ axial port of the docking node in April 1996 (between STS-76 and STS-79), and the Cooperative Solar Array (CSA) was destowed from the Docking Module and deployed on the $-Z_B$ axis of Kvant in May 1996.

Information on the Mir configuration is important for proximity operations requiring visual navigation and for conducting loads simulations of docked configurations. Available drawings of the Mir Space Station were compared to photography acquired during the rendezvous. The backaway view in Figure 1-A identifies different Mir modules photographed during STS-79.

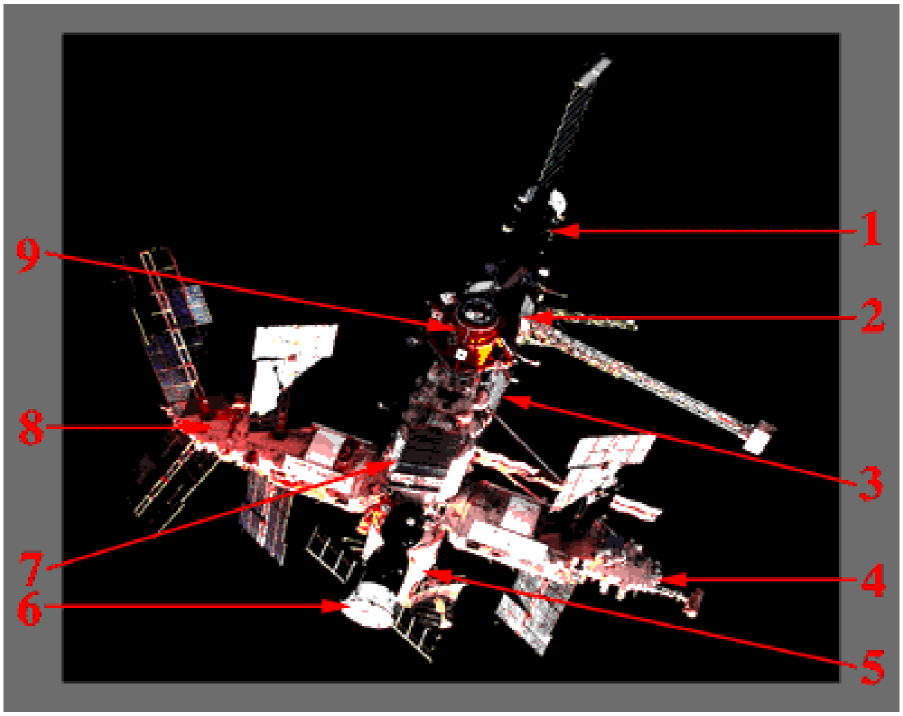

Figure 1-A Mir Space Station

1. **Progress**
2. **Kvant**
3. **Base Block**
4. **Kvant-2**
5. **Priroda**
6. **Soyuz**
7. **Kristall**
8. **Spektr**
9. **Docking Module**

1.2.2 Mir Survey and Surface Assessment

The purpose of surface assessment is to document the effects of the space environment on Station materials. Surface assessments have been grouped into three categories: (1) changes in surface condition from previous missions, (2) anomalies identified with structures observed for the first time, and (3) surface conditions where STS-79 provided improved detail over previous missions.

Changes were observed in the surface condition of the EVA / Cargo Transfer Boom. The EVA / Cargo boom shows discoloration associated with the Kapton strap which is attached along the length of the boom. An increase was expected in the amount of chipped paint on the Spektr radiator, based on STS-74 and STS-76 results. There was no change in the amount of chipped paint, however extended areas of blistered paint were identified.

Anomalies were identified on two new appendages: the CSA and the Priroda Synthetic Aperture Radar (SAR) antenna. The CSA has two solar cells which have anomalous appearances relative to the other solar cells. The Priroda SAR has three spars which have bends that indicate incomplete deployment. In addition, the $+X_B$, $-Y_B$ radiator of Priroda appears to have received a dark deposition from some source of contaminate.

The improved quality of imagery obtained on this flight provided new details on the surface condition of Mir. Three areas of potential micrometeoroid / orbital debris damage have been identified on the Base Block SP#2 array. Discoloration is identified around the base of the Base Block SP#3 array. This discoloration appears similar to discoloration seen on a similar object half-way up the array on previous missions. Photography of the RSA reveals areas of blistering paint not seen on previous missions due to poor lighting conditions.

Detailed photography of the Kvant end dome provides valuable information on surfaces which appear to be blackened from contamination, while other areas appear relatively free of contamination. Photography of the front face of the Luch antenna dish clearly illustrates the extent of discoloration on the surface, which may be caused by the same contamination which has been deposited on the Kvant end dome.

1.2.3 Docking Mechanism Assessment

An overall assessment of the docking mechanism and its visible targets is made on each docking mission. ODS centerline camera imagery during approach showed the mechanism area and latch assemblies were free of damage, but that the stand-off target cross arms had detached black laminate on two of the arms. Two frames of Nikon 35 mm film imagery taken with the 300 mm lens were acquired during station-keep at 170 feet. This imagery was sufficient to show the mechanism area and latch assemblies did not have discoloration. Orbiter Docking System (ODS) centerline and non-axial camera video showed the docking mechanism was in good condition during backaway.

1.2.4 Solar Array Motion Analysis from Video

STS-79 provided the first opportunity to observe the Cooperative Solar Array (CSA) since its deployment after STS-76. The CSA is a different design than previous Mir solar arrays and provided an opportunity to further validate loads and dynamic models. At the request of the JSC Structures and Mechanics Division, video was acquired during the docking of the Orbiter for the purpose of obtaining measurements of the CSA truss' response to applied loads. An 8 mm camcorder was bracket-mounted in window #2 of the Base Block (BB) of Mir during the soft-dock and the recorded video was used to estimate the deflection and frequency of motion of the CSA truss. A peak-to-peak deflection of approximately 2.8 inches, and a frequency of approximately 0.22 Hz was obtained for in-plane motion at the tip of the solar array. Measurement data has been provided to Structures and Mechanics personnel for further analyses.

Additionally, motion analysis of Base Block SP#2 was performed. This array exhibits irregular motion of sizable amplitude.

1.2.5 Debris During Docking Operations

Many small pieces of debris were seen during approach, docking, and backaway. The debris appeared to originate from the Orbiter and one piece was clearly shown to be originating from the ODS. Imagery obtained after soft dock showed debris moving in the

Orbiter +Z direction between PLB Camera A and the Mir Docking Module, and debris moving diagonally in a direction away from the ODS / Docking Module interface. Assuming the debris is near the Docking Module, the debris moving in the +Z direction are approximately 1.5 inches in diameter and moving approximately 5 inches per second in the +Z direction. The debris may be closer to the camera, and hence would be smaller and moving at a slower rate. One piece of debris seen just after hard dock appears to be originating directly from the ODS / Docking Module interface. Two of the small pieces of debris appear to be tumbling and irregular in shape, indicating they are a small, highly reflective, material such as ice or paint.

1.2.6 Imagery Evaluation

STS-79 image data and acquisition procedures were evaluated. Assessment of image data was performed to identify problems with procedures and equipment for subsequent rendezvous missions. Excellent video and photographic coverage of Station surfaces was obtained during the docked phase of the mission. Most of the approach was in darkness, however centerline camera imagery was adequate for docking mechanism assessment. Some glare was present. No still photography was taken during close approach or backaway. The imagery taken during backaway was marginally sufficient for docking mechanism assessment. Imagery with the Nikon 35 mm camera and 300 mm focal length lens was very good at the range of 170 feet during station-keep, which indicates that use of the 400 mm lens on future missions should provide excellent imagery. The Electronic Still Camera (ESC) imagery of the stand-off target during repairs was excellent. Fly-around coverage with the Nikon 35 mm camera and 300 mm lens provided adequate detail for assessment of the overall configuration and condition of Mir.

2. MIR CONFIGURATION

A detailed assessment of the STS-79 configuration is presented. This involved identifying and labeling features directly from the photography. Features not previously identified, as well as changes to the known configuration, are identified on the following images.

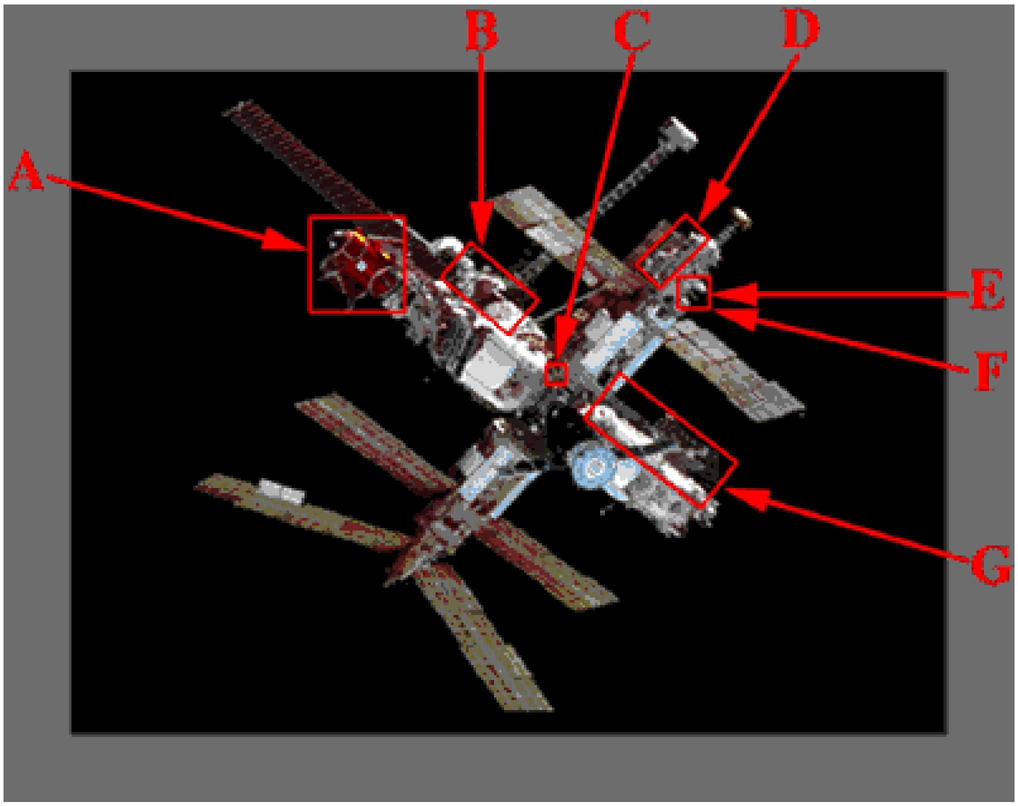

Figure 2 Mir Space Station Configuration Assessment

Figure 2 shows the Mir Space Station as it appeared during the STS-79 backaway. The boxes labeled A through G identify regions whose exteriors are described in detail in this section. The Docking Module (A) was attached to Kristall on STS-74 and is used for Shuttle/Mir dockings. Kvant (B) is an astrophysics and attitude control module. The Ljappa Arm (C) is a mechanically-driven arm which is used to move modules. Kvant-2 (D) supports extravehicular and remote sensing activities. The Particle Impact Experiment (E) and the SKK (F) are mounted on Kvant-2. Priroda (G) is an Earth remote sensing facility. Figures 2-A to 2-H show additional details of the configuration for each of the Mir regions identified in Figure 2.

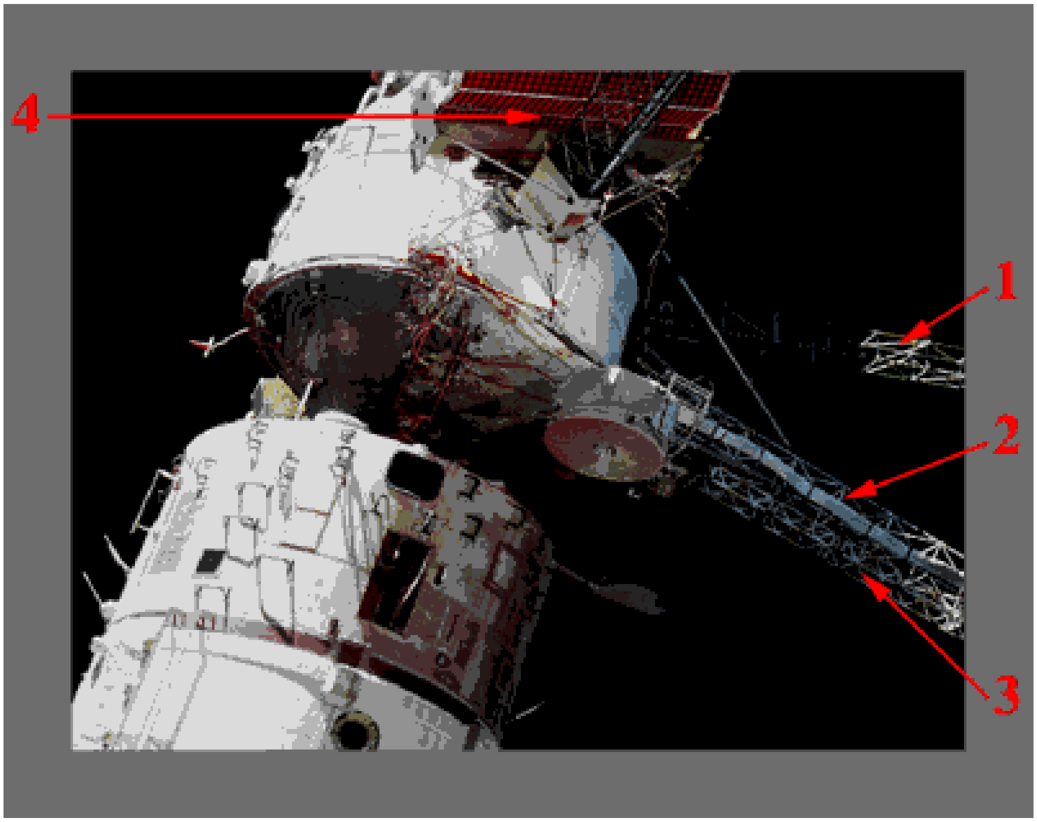

Figure 2-A Kvant

1. **“Ferma-3” Truss***
2. **“Sofora” Truss**
3. **“Rapana” Truss****
4. **Cooperative Solar Array (CSA)*****

*New feature identified during this mission.

**The “Rapana” Truss was formerly mounted at the location where the “Ferma-3” Truss is currently located.

***The CSA was deployed on Kvant -ZB axis on May 25, 1996.

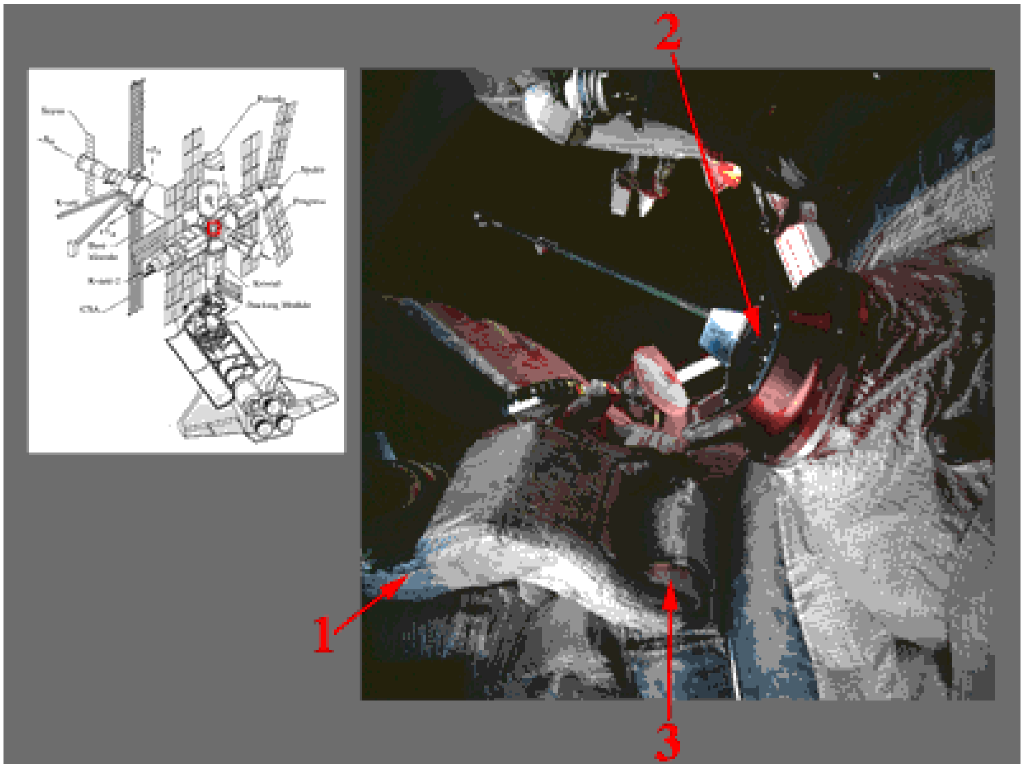

Figure 2-B Ljappa Arm

Figure 2-C is a photograph of a unique hardware item on the Mir Station. This item, the Ljappa arm, is required for construction of the Mir Station. The Ljappa arm is a mechanically-driven arm which is used to move modules from the forward (or axial) docking ports to permanent radial docking ports. The arm (1) is mated onto a socket (2) that is located on the Mir's multiple docking assembly adjacent to the -X_B end of the Base Block. Once the arm is mated, the modules main docking probe is retracted, and the arm raises the module so that it can be pivoted 90° for docking to one of the radial docking ports. The hinge of the arm is pointed out in Item 3. This STS-79 photograph is the most detailed image of the Ljappa arm obtained to date.

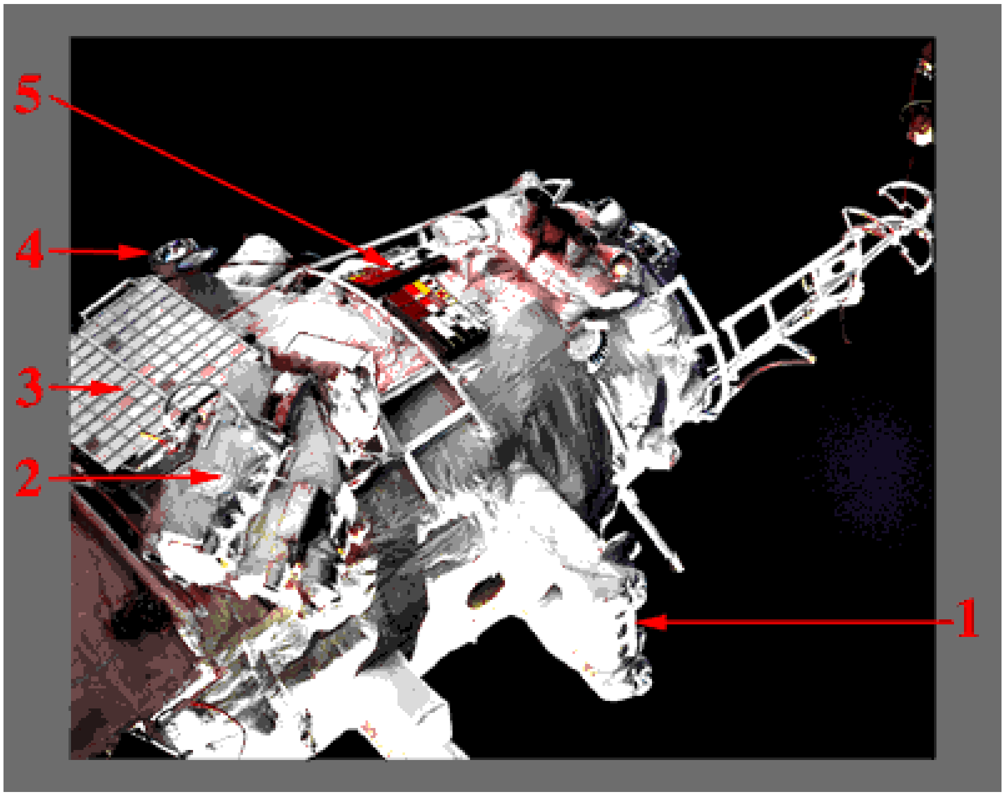

Figure 2-C Kvant-2

1. **Infrared Horizon Sensors**
2. **TV Camera on a Rotational Platform**
3. **Mir Sample Return Experiment (MSRE)***
4. **Star Orientation Sensors**
5. **“Komplast” Cassettes with Samples****

*New feature identified during this mission.

**First identification of feature.

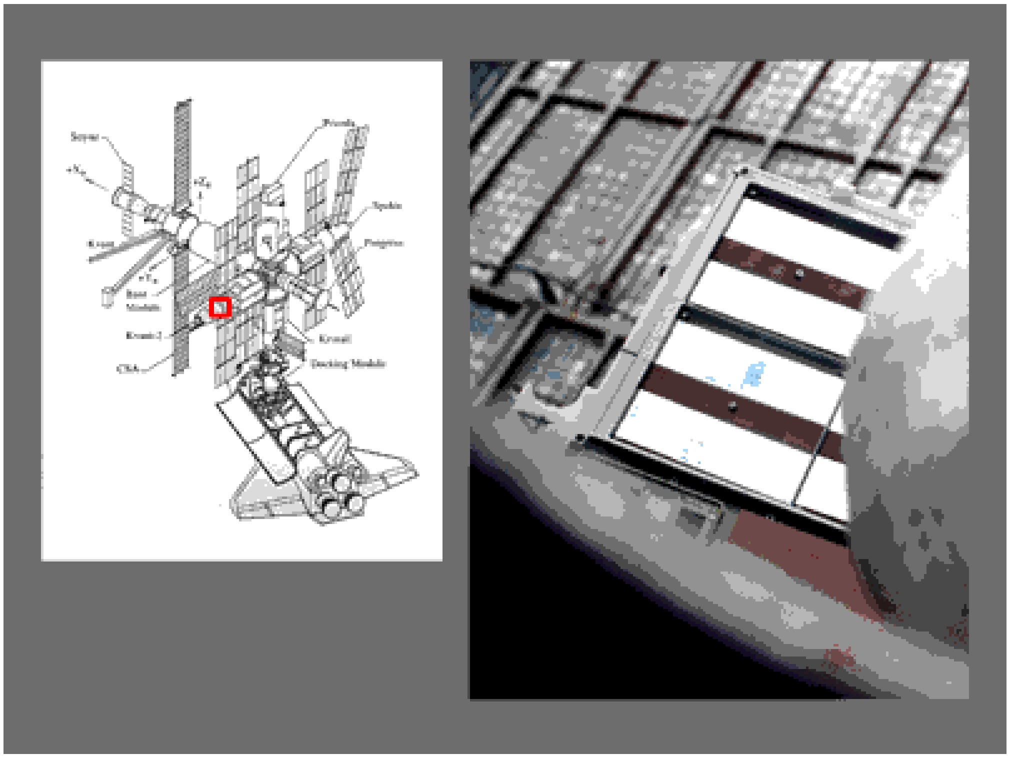

Figure 2-D Particle Impact Experiment (PIE)

Figure 2-E is a photograph taken from Kvant-2 window # 2 of the Particle Impact Experiment (PIE)* mounted on the +ZB side of Kvant-2. PIE was launched in Priroda and deployed by Russian cosmonauts on Kvant-2. PIE is scheduled to return to Earth aboard STS-84.

*New feature identified during this mission.

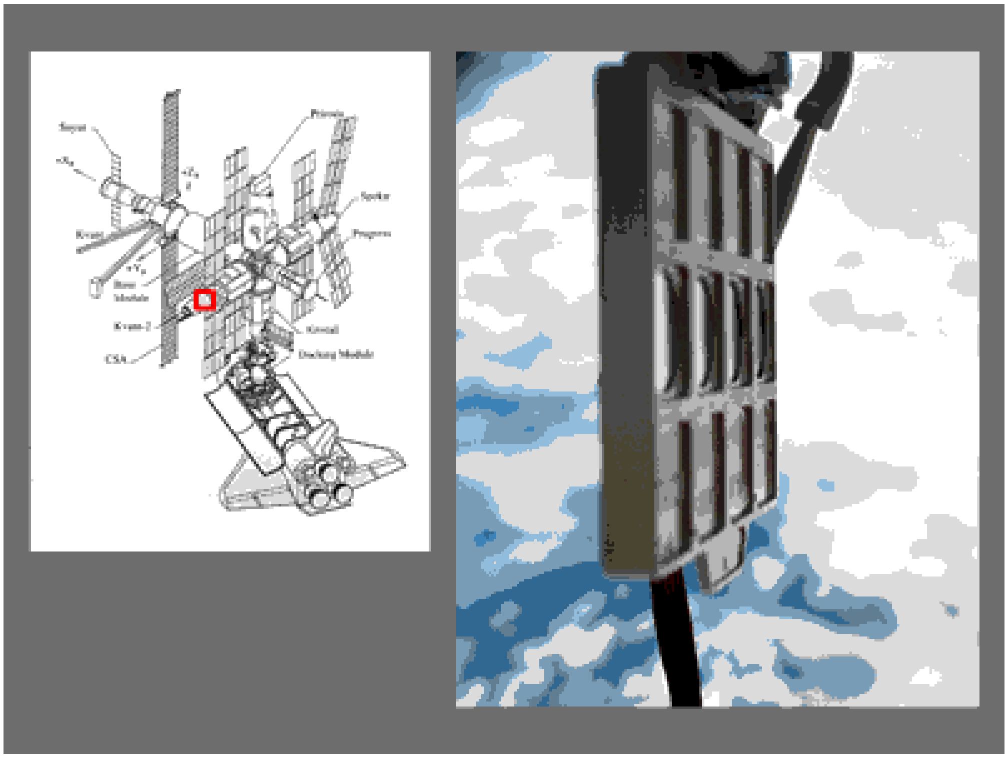

Figure 2-E SKK

Figure 2-F is a photograph of the SKK* experiment panel taken from Kvant-2 window #2. The experiment is mounted on the +ZB side of Kvant-2. The SKK is a Russian materials experiment panel. Panels similar to the SKK have also been seen mounted on the Rapana truss on the Kvant module in previous missions.

*New feature identified during this mission.

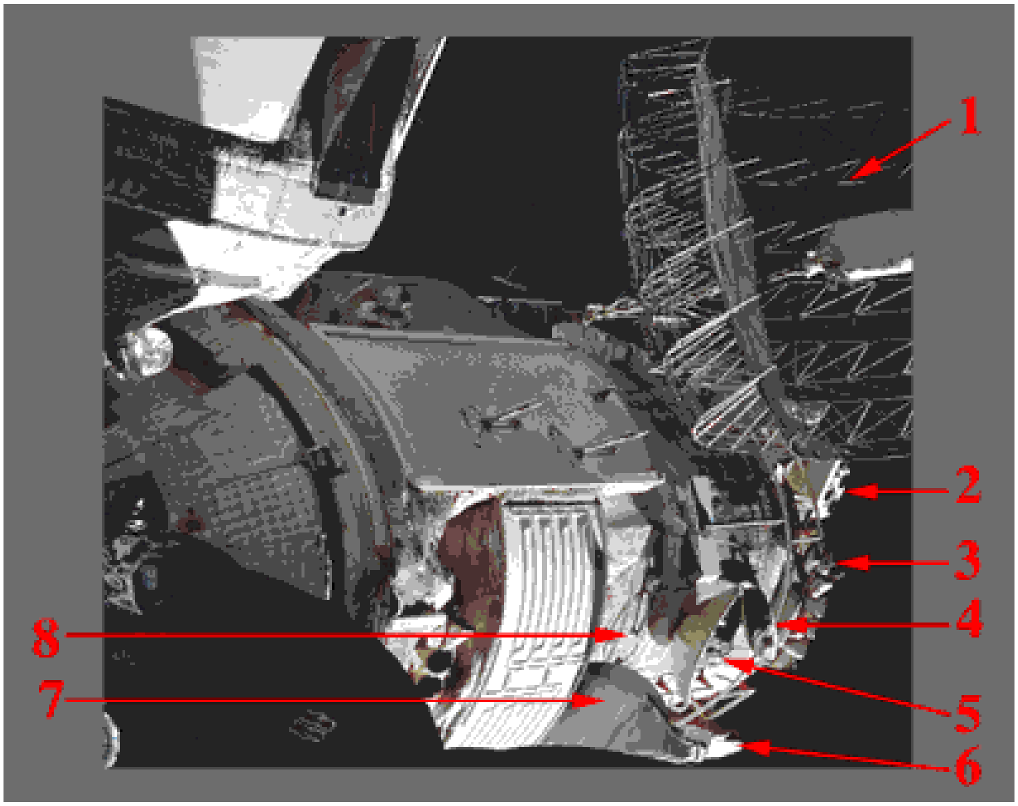

Figure 2-F Priroda

1. **"Travers" Antenna**
2. **"IOI" Unit**
3. **"BISY-PM" Antenna**
4. **"Survey" (Interior)**
5. **Radiometer R-400**
6. **Radiometer R-600**
7. **Delta-2P Radiometer**
8. **LIDAR "Alissa"**

Priroda is a new module photographed during this mission. Priroda was deployed to Mir in April 1996.

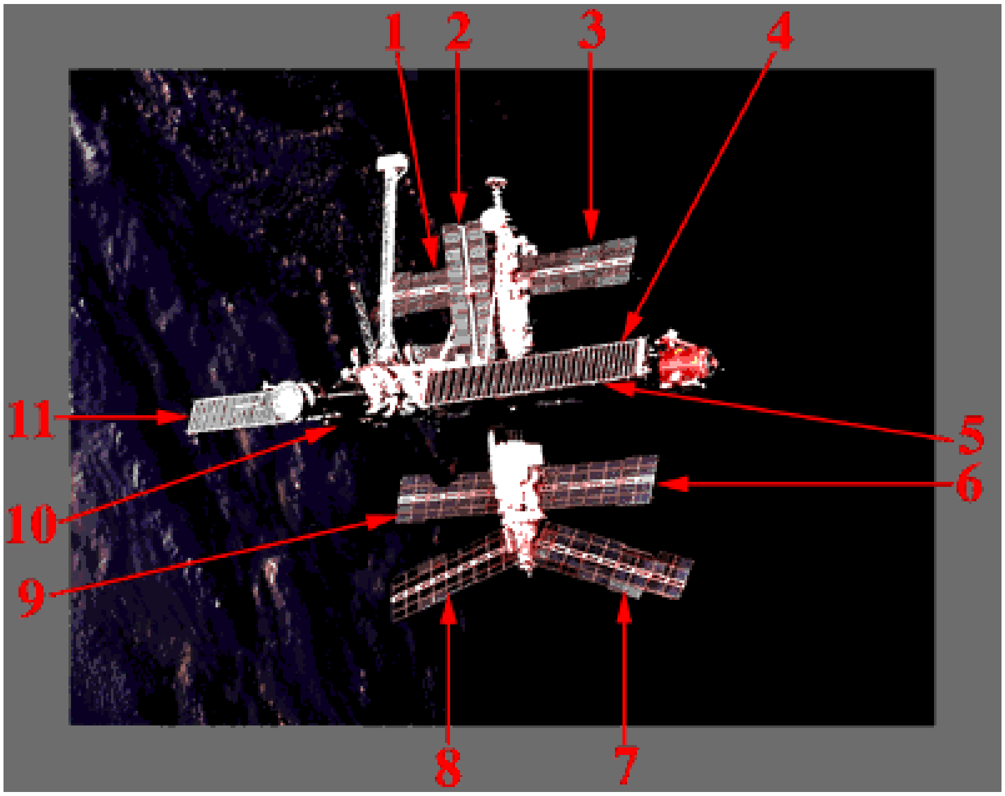

Figure 2-G Array Configuration

Figure 2-H is a photograph of all operational solar arrays on the Mir Station. There is an additional solar array, the RSA, which has not been deployed and remains stowed on the Docking Module.

1. **SP#1 Kvant-2 Solar Array**
2. **SP#3 Base Block Solar Array**
3. **SP#2 Kvant-2 Solar Array**
4. **Cooperative Solar Array (SP#2 Kvant Solar Array)**
5. **SP#2 Base Block Solar Array (behind item 4)**
6. **SP#2 Spektr Solar Array**
7. **SP#4 Spektr Solar Array**
8. **SP#3 Spektr Solar Array**
9. **SP#1 Spektr Solar Array**
10. **SP#1 Base Block Solar Array**
11. **SP#1 Kvant Solar Array (formerly mounted on Kristall)**

3. MIR SURVEY COVERAGE AND SURFACE ASSESSMENT

A survey of the visible Mir Station components was performed to identify areas of damage and discoloration. Defects, such as incomplete antenna deployment or retraction, are also identified. STS-79 imagery of areas of special interest was compared to previous mission imagery to identify and characterize changes or reinforce earlier mission findings. Appendix A lists the visible damage and discoloration found in the STS-79 survey imagery. The list serves as a cross-reference for damaged areas seen during STS-63, STS-71, STS-74, and STS-76.

Figure 3-A is an image of the back surface of the CSA which is mounted on the $-Z_B$ axis of Kvant.

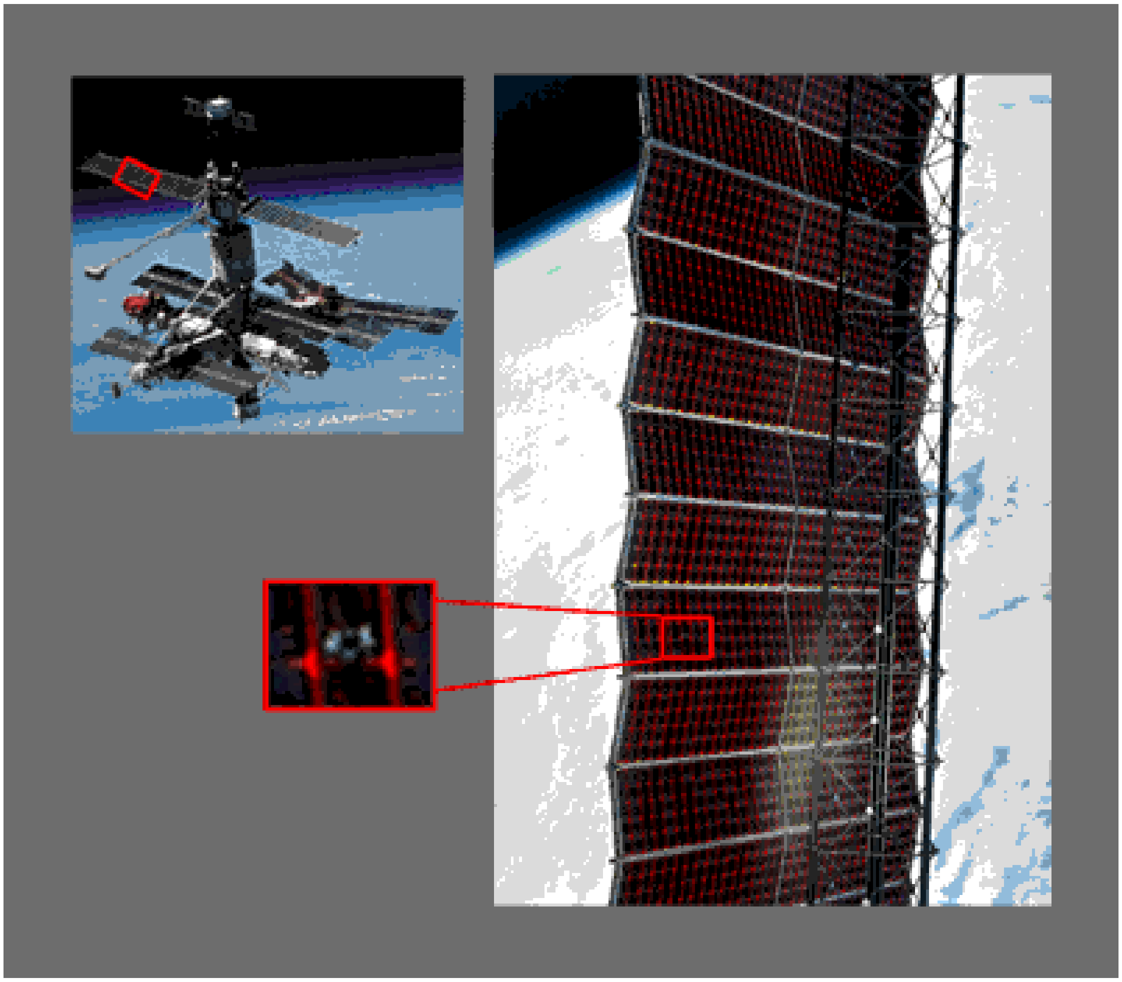

Figure 3-A Cooperative Solar Array

The enlarged area shows a region of a solar cell which is lighter in color than the rest of the cell. This anomaly covers the lower quarter of a single solar cell and may be caused by a micrometeoroid / orbital debris strike. However, a comparison of the histograms from the region in question with a region of the surface of the Earth does not suggest that there is a hole through the array.

Figure 3-B is an image of the front surface of the CSA which is mounted on the $-Z_B$ axis of Kvant.

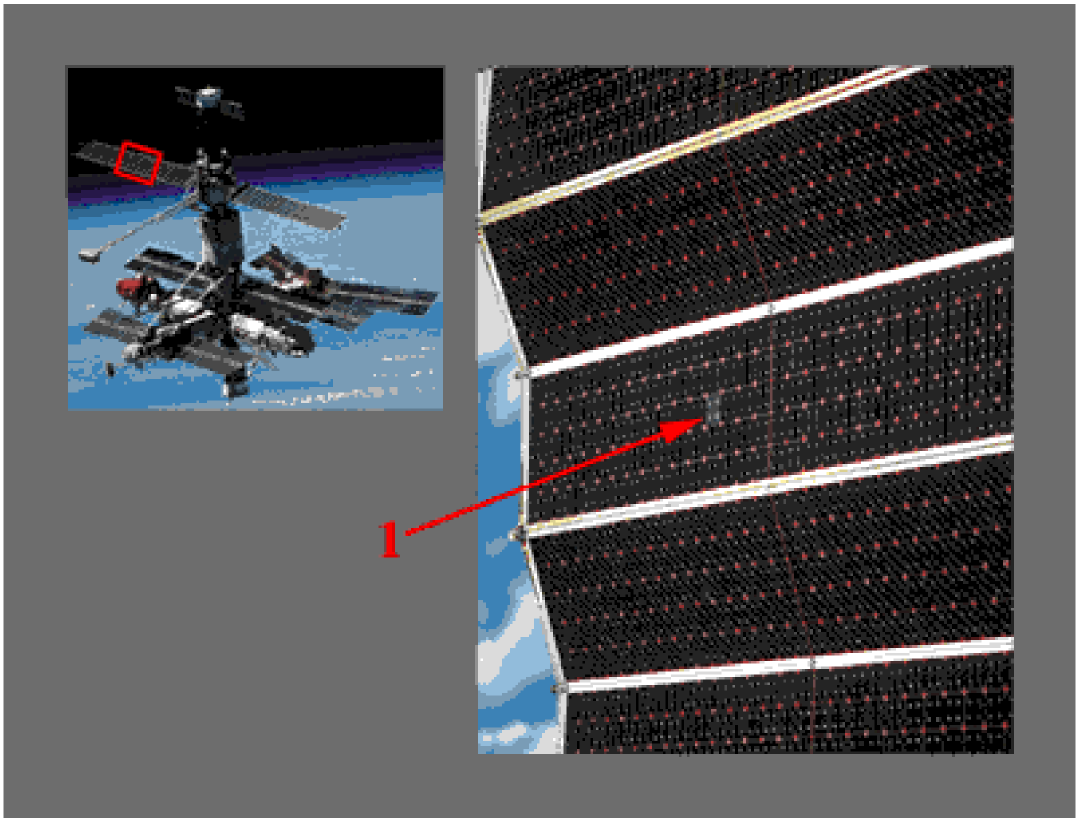

Figure 3-B Cooperative Solar Array

Item 1 points to a square region of the array that is lighter in color than the rest of the array. This area makes up one solar cell and the cause of the color difference in this cell is unknown.

Figure 3-C offers the most detailed view acquired to date of the end dome of Kvant adjacent to the Base Block.

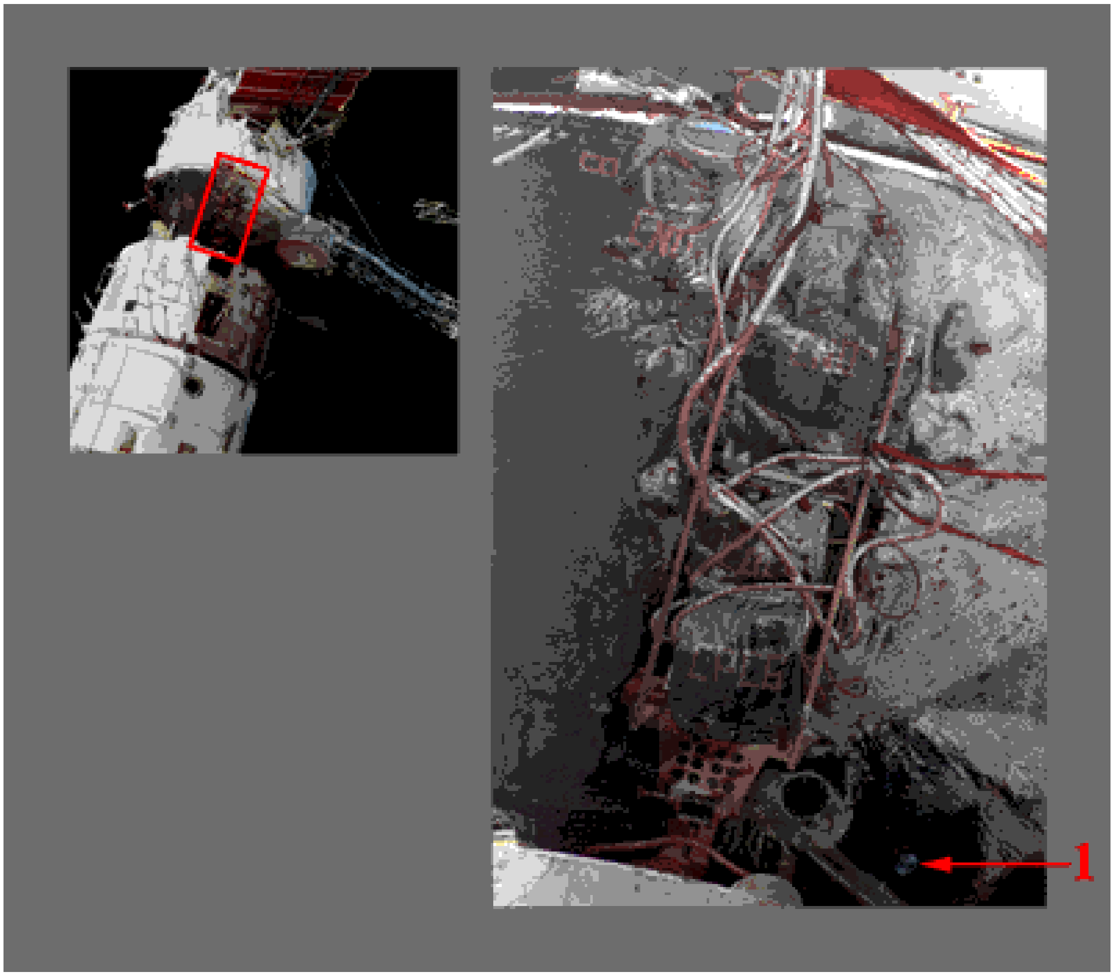

Figure 3-C Kvant End Dome

Discoloration has been observed around the end dome of Kvant since STS-63. However, this photograph, taken with a 300 mm lens on the Nikon, reveals detail around the end dome which has not been seen previously. The image provides valuable information about the contamination which has darkened one area of the end dome while leaving other areas almost unaffected. Regions of the thermal blanket which are in line with the source of the contaminate and adjacent to features protruding from the surface of the module appear to be protected. The purge port which may be ejecting the contaminate is seen in Item 1. In addition, the various cables which run from the end dome of Kvant to the Sofora Thruster package at the end of the Sofora Truss are seen in the center of this image.

Figure 3-D represents the most detailed image of the Luch antenna dish obtained to date. The antenna is located on the end of the Base Block at the interface with Kvant.

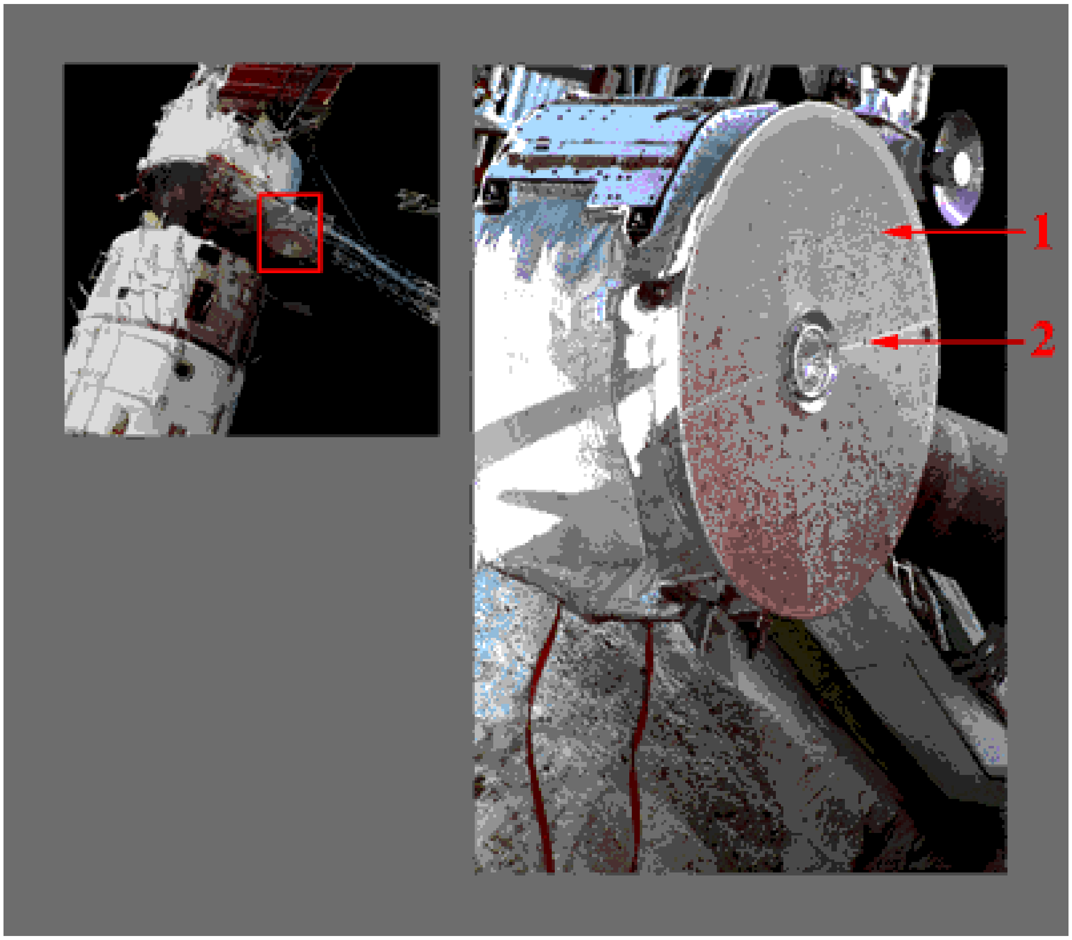

Figure 3-D Luch Antenna Dish

Figure 3-D shows the front face of the Luch antenna dish and clearly illustrates the extent of spotty discoloration on the surface. In the STS-76 mission report (JSC-27525), images of the dish from STS-63 and STS-76 were compared. A detailed examination indicated that the pattern of discoloration was very similar between the two missions. A comparison between those images and the detailed image from STS-79 reveal that the pattern of discoloration appears very similar across all three missions. This indicates that the phenomena which caused most of the visible discoloration occurred prior to STS-63 and that no significant changes have occurred since. The high degree of detail in the STS-79 image reveals two almost circular rings of dots which appear to actually be a component of the dish itself. These rings are pointed out as Items 1 and 2 in the figure.

Figure 3-E is an image of the SP#2 Base Block array showing three areas of potential micrometeoroid/orbital debris damage.

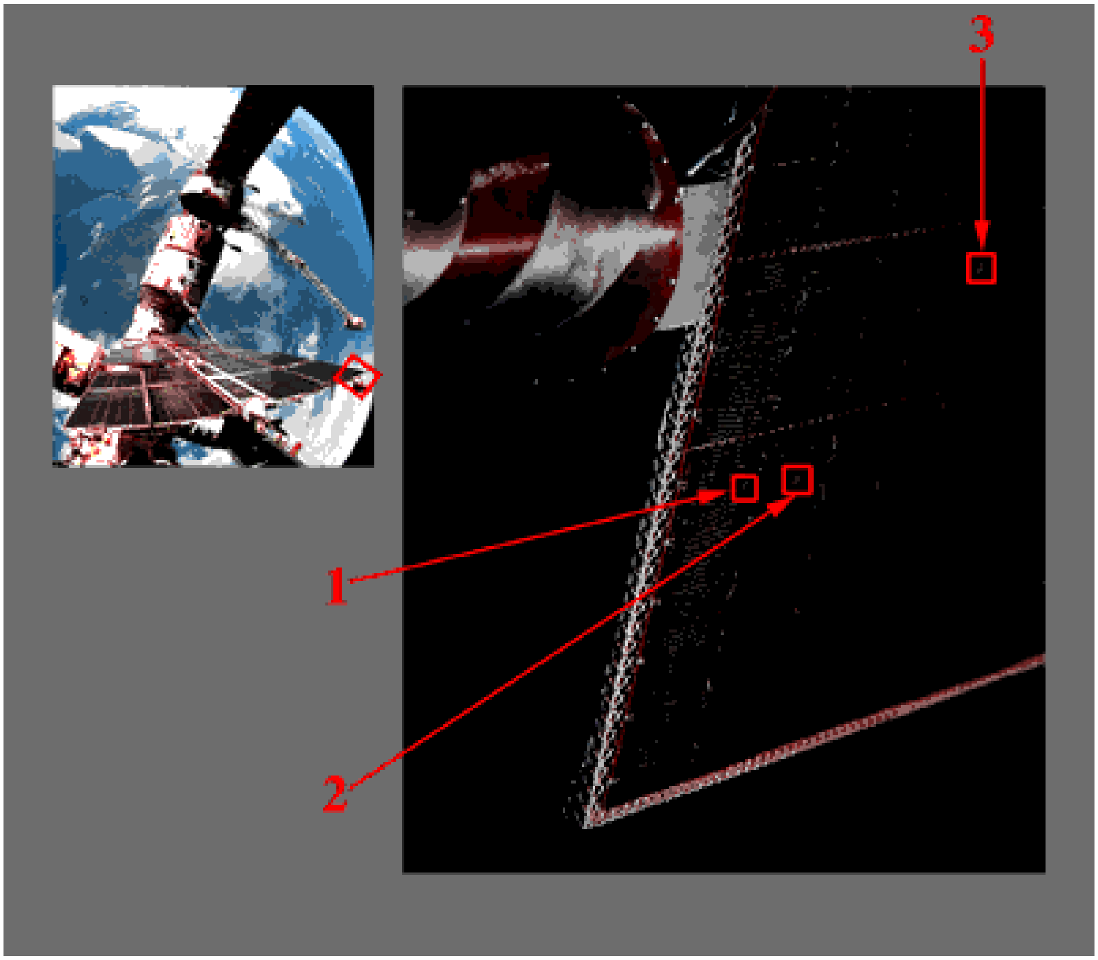

Figure 3-E SP#2 Base Block Array

Areas 1 and 2 were estimated to be approximately 4 mm to 5 mm in diameter, while area 3 was approximately 6 mm to 7 mm in diameter. Orbital debris experts from the JSC Space Science Branch (SN3) concurred that these areas could be potential micrometeoroid/orbital debris damage. In order to estimate the sizes of the damage, data from an engineering drawing was used to scale the image. An intermediate image of the entire array was used to translate dimensions from the drawing to the detailed image shown here.

Figure 3-F is an image of the base of the SP#3 array on the Base Block. This image, acquired during approach, provides the best view of this array attach to date.

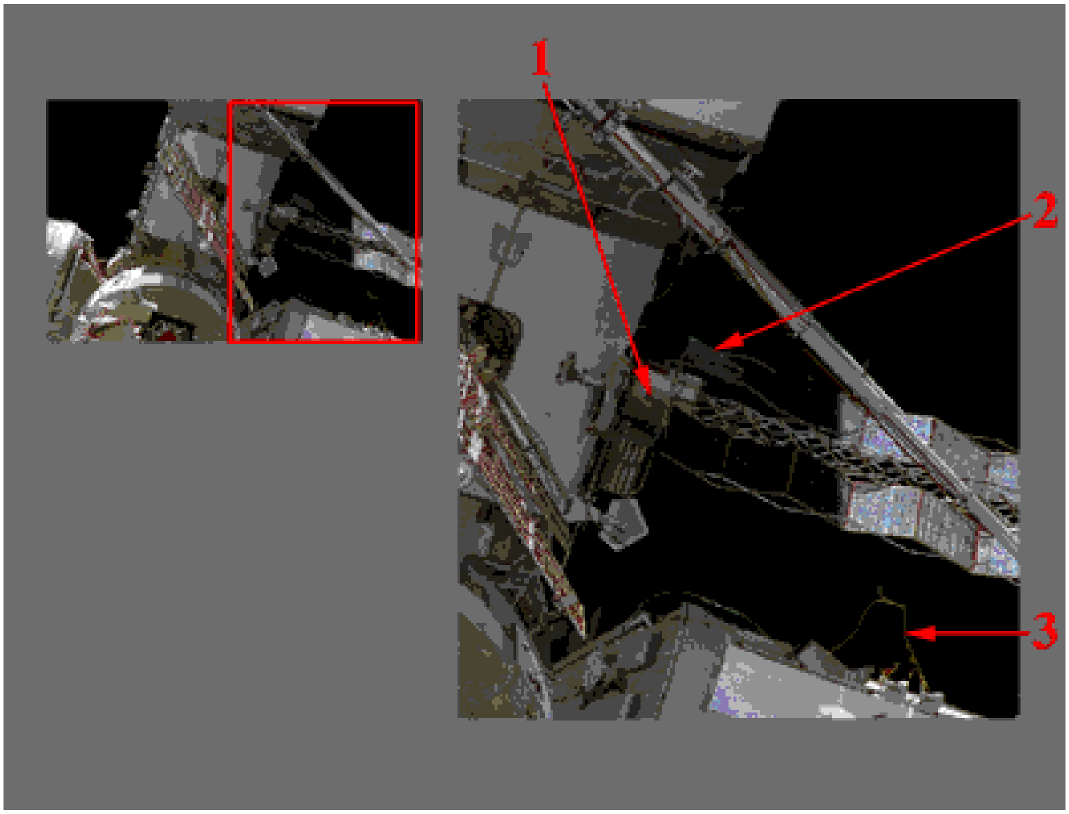

Figure 3-F SP#3 Base Block Array Attach

Item 1 points to brown discoloration around the base of the array. This appears similar in color to discoloration seen half way up the same solar array on STS-76.

Item 2 points to a region of the SP#3 array where a solar panel is missing near the array attach point on the Base Block. This missing panel was first photographed in detail on STS-74 and was measured to be approximately 60 x 75 cm.

Item 3 points to loose EVA tethers along the surface of Kvant-2.

Figure 3-G is an image of the Extravehicular Activity (EVA) / Cargo Boom connecting the Base Block and Kvant-2.

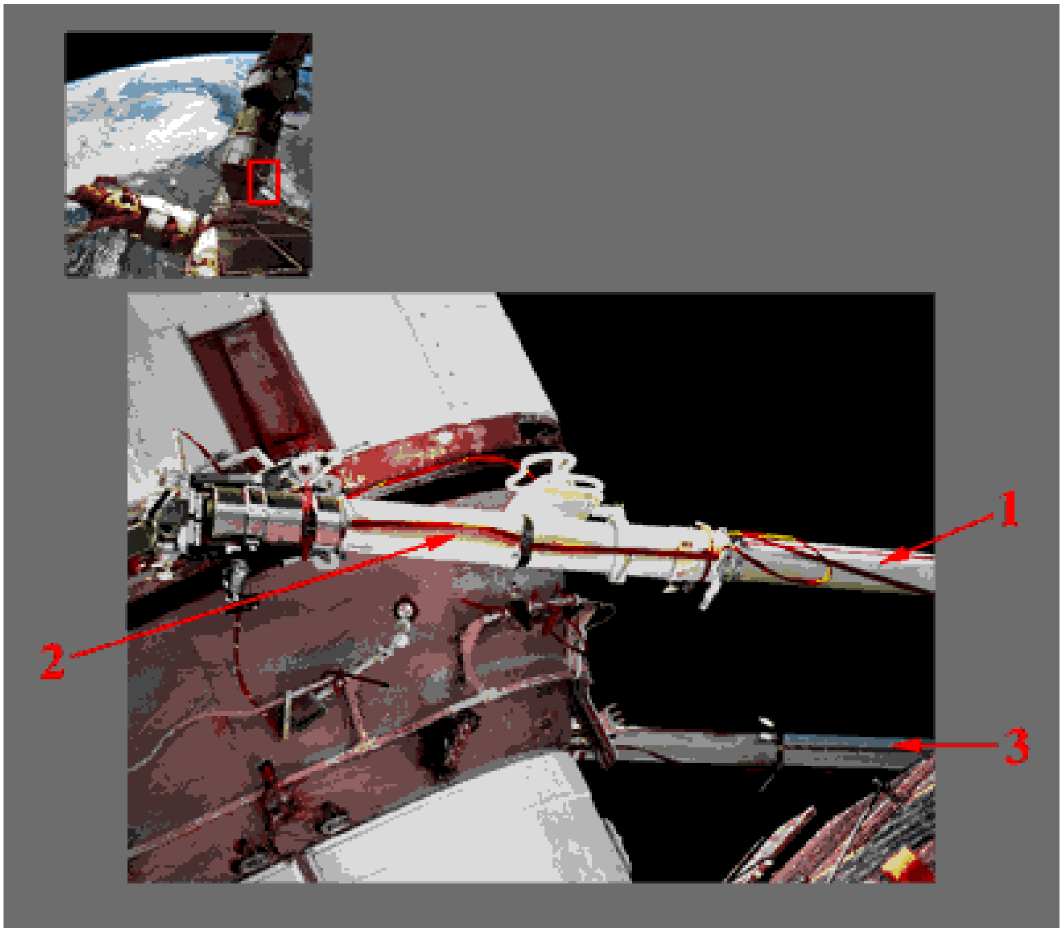

Figure 3-G EVA / Cargo Transfer Boom

Item 1 points to the EVA / Cargo Transfer Boom which was mounted to the Base Block sometime after November 1995. Investigators are interested in the brown discoloration under the straps which run along the length of the boom. Item 2 points to this discoloration which appears to be caused by outgassing from the Kapton straps.

Item 3 points to a second EVA / Cargo Transfer Boom which was mounted to the Base Block sometime prior to February 1995.

Figure 3-H shows discoloration (Item 1) on the $+X_B$, $-Y_B$ radiator of Priroda. Priroda was deployed to Mir in April 1996.

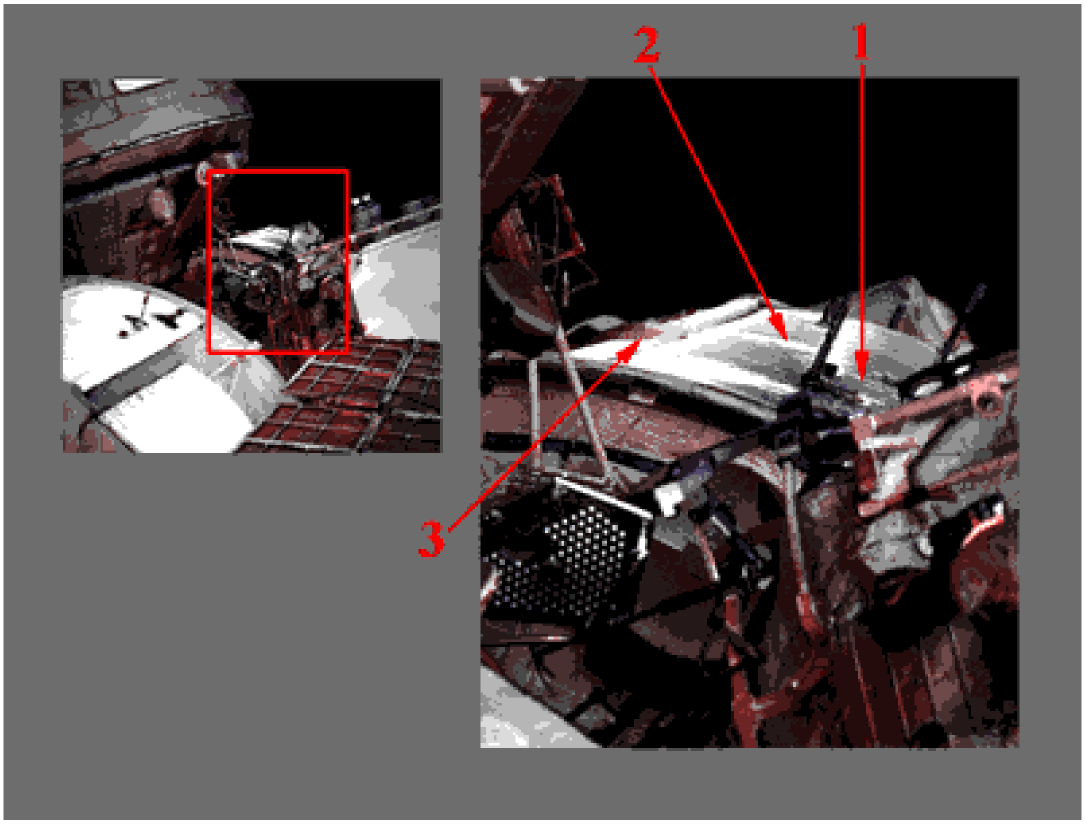

Figure 3-H Priroda Radiator Discoloration

Approximately three-quarters of the radiator surface has a dark gray deposition from an unknown source. Item 1 points to the area of darkest discoloration located on the lower $+X_B$ corner of the radiator. There is an uneven pattern to the deposition seen on the radiator. Some areas of the radiator appear to be their original whitish color, yet they are surrounded by areas of dark discoloration (Item 2).

Item 3 points to an area of brownish discoloration along the $-Y_B$ edge of the radiator.

Figure 3-I shows the Spektr radiator as recorded with a 300 mm lens on the Nikon camera during STS-79. A comparison was made of the extent of chipped paint across three missions: STS-74, STS-76 and STS-79. The Spektr radiator has been the subject of attention since the STS-74 mission imagery showed several areas of chipped and blistering paint.

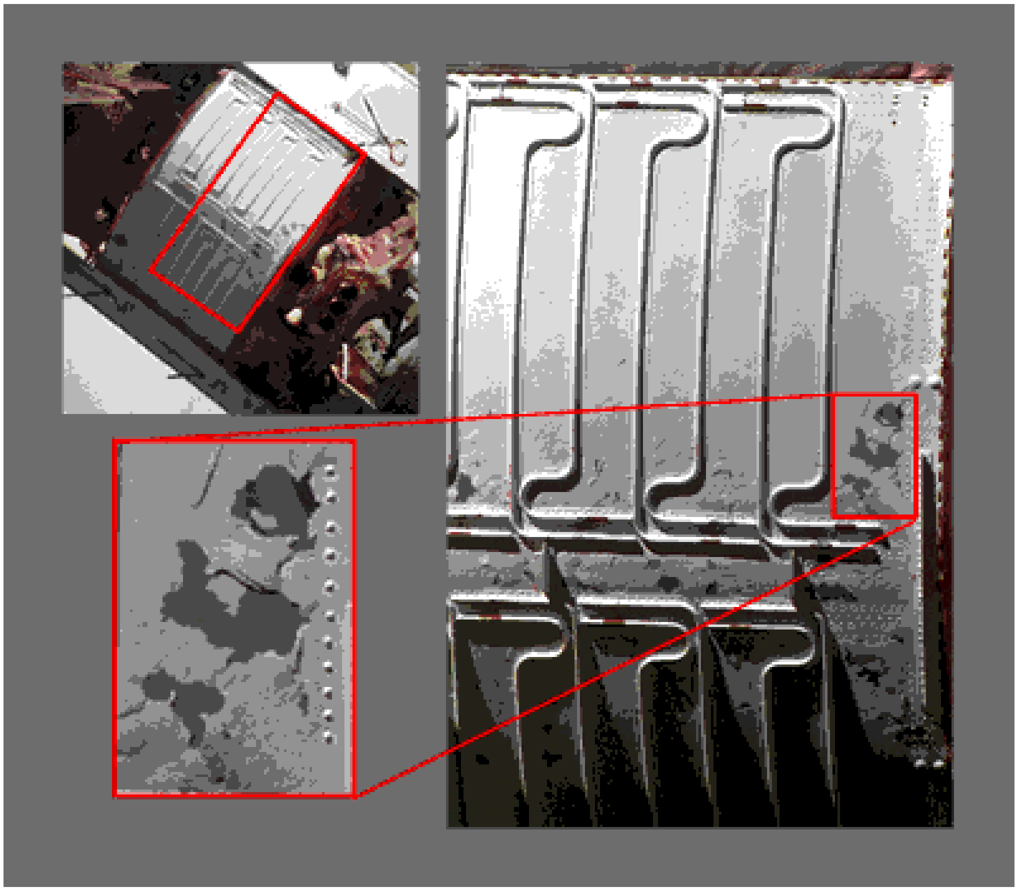

Figure 3-I Spektr Radiator

The STS-79 image identified close to 100 areas of chipped paint on the surface of the radiator. Although the amount of chipped paint increased by approximately 50% in the four months between STS-74 and STS-76, there was no significant change in the four months between STS-76 and STS-79. However, the STS-79 image revealed for the first time a large amount of blistered paint which appears ready to peel off the radiator.

An improved method was used for estimating the area of chipped paint. Results are decreased from earlier reports. In the earlier reports, the area of chipped paint was determined by thresholding the digitized image. Thresholding errors associated with lighting and shadowing variations resulted in estimates which favored larger area estimates. In the current approach, the analyst manually “blackened” the pixels observed as chipped paint before thresholding was applied. The results are 0.7% (550 cm^2) for STS-74 and 1% (800 cm^2) of the total radiator surface area for STS-76 and STS-79. The earlier estimates (JSC-27525, STS-76 Mission Report) were 1% (800 cm^2) for STS-74 and 1.7% (1300 cm^2) for STS-76.

Figure 3-J illustrates in detail the blistering paint and discoloration on the Reusable Solar Array (RSA) carrier mounted on the starboard side of the Docking Module.

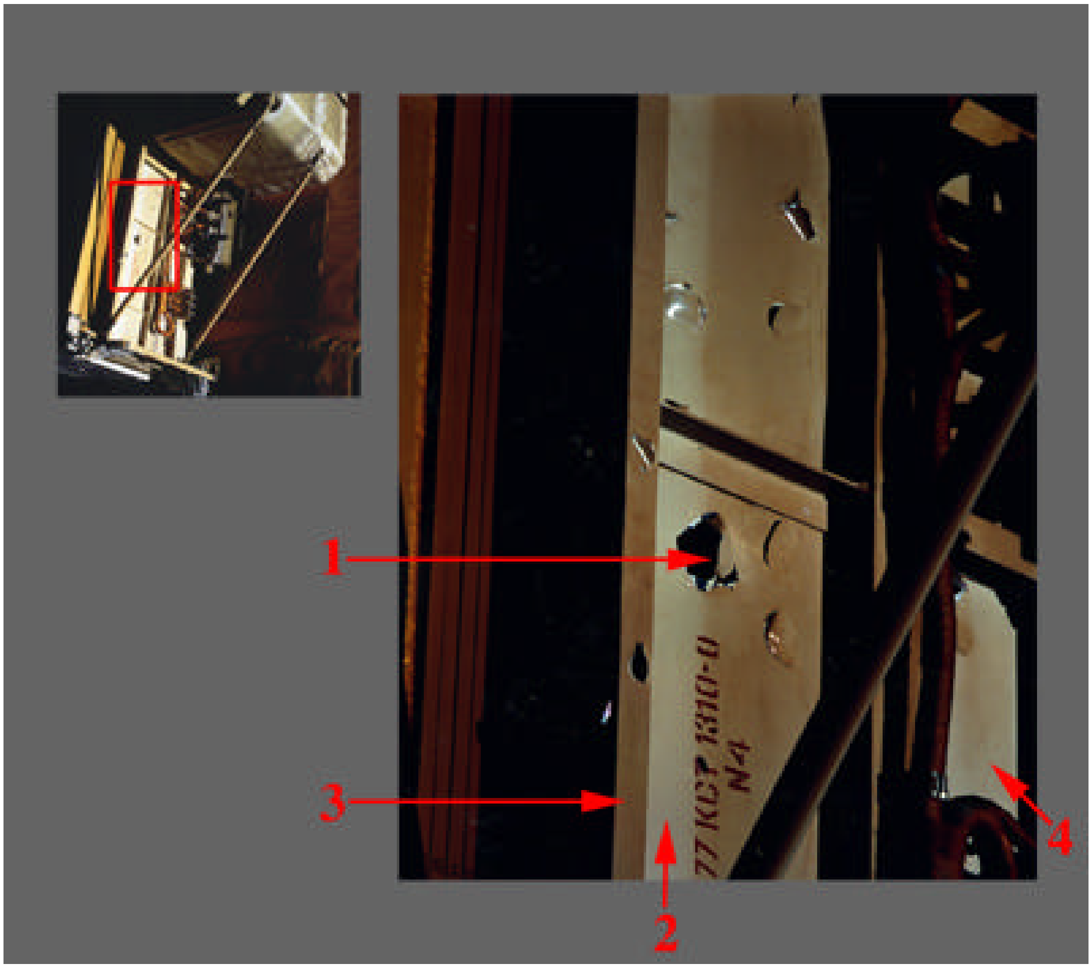

Figure 3-J Reusable Solar Array Carrier

The blistering paint and discoloration was first visible during STS-76, only 4 months after deployment of the Docking Module to Mir. The amount of damage appears to be approximately the same as that seen on STS-76. However, this image from STS-79 reveals detail not visible in STS-76 photography.

Item 1 highlights regions of chipped and blistering paint.

Items 2 & 3 show areas of discoloration attributed to contamination.

Items 4 & 5 show areas which appear to have undergone less deposition. The lip of the carrier (Item 2) may be blocking contamination from impinging on the surface (Item 4) directly to the right of it and the cable (Item 6) may be shielding the surface (Item 5) directly to the right of the cable.

Figure 3-K shows a portion of the Priroda module Synthetic Aperture Radar (SAR) antenna. STS-79 provided the first images of Priroda which was deployed to Mir in April 1996.

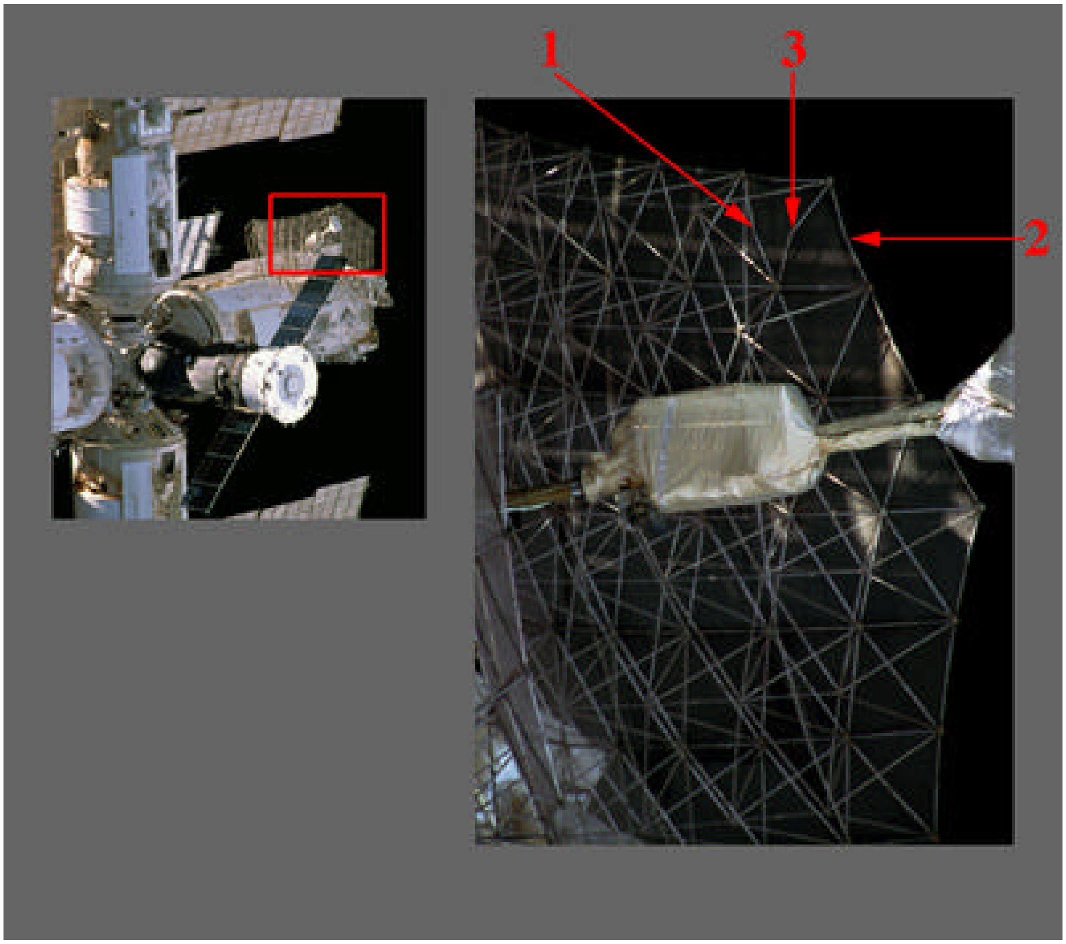

Figure 3-K Priroda SAR Antenna

The SAR antenna in the $+Y_B$ corner has a visible asymmetry. Items 1, 2, and 3 point to spars which do not appear to be fully extended. The $-Y_B$ corner appears to be fully extended. The three spars show inward bends which are estimated to be approximately 10, 20, and 30 degrees.

4. DOCKING MECHANISM ASSESSMENT

Imagery surveys of the docking mechanism were performed to verify its condition. In addition, a target viewing assessment was conducted to evaluate the performance of video cameras used during the approach. Analyses of these views help in determination of camera usage for ISS proximity operations. The STS-79 crew discovered that the black laminate was partially detached on two of the stand-off target cross arms. During their stay at Mir, the crew repaired the stand-off target by taping the black laminate into its original position.

During the Orbiter station-keep at 170 feet, two frames were taken of the Mir docking mechanism using the 35 mm camera with the 300 mm lens. Each frame was taken with bracketing exposures under good illumination conditions. The images were face-on views and show the docking mechanism to be in good condition and without discoloration as shown in Figure 4-A.

Between 170 feet and 15 feet, during approach, the Mir was in darkness. Although there are significant amounts of glare and other reflections, the ODS centerline camera shows the docking mechanism to be in good condition. The camera also reveals that the black laminate is partially detached on two of the stand-off target cross arms (see Figure 4-B). Non-axial video camera imagery taken just at the beginning of sunrise also shows the docking mechanism in good condition, however this image is less detailed than the 35 mm image.

As in the previous mission, no film or ESC camera imagery of the Mir docking mechanism was acquired during close approach. Orbiter payload bay lights provided the only illumination until the Docking Module was within approximately 15 feet. Darkness and limited overhead window access time hampered data acquisition during close approach.

Recorded views of the docking mechanism during backaway were marginal for docking mechanism assessment. Centerline camera video shows the docking target and the repaired stand-off target to be in good condition. The ODS non-axial camera video provides the only full views of the Mir docking interface area during the backaway sequence. The views are oblique and the image resolution is marginal for detailed assessment. However, base on these views, it was concluded that the docking ring and latches remained free of any obvious damage or discoloration. No still photography was taken of the docking mechanism area during backaway.

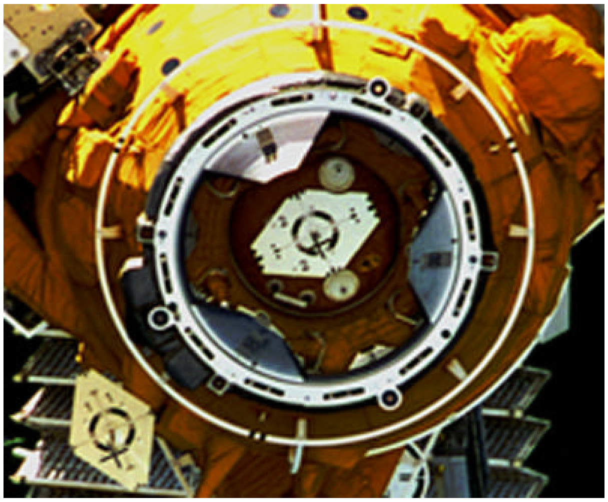

Figure 4-A Docking Mechanism View from Station-keep (Nikon with 300 mm Lens)

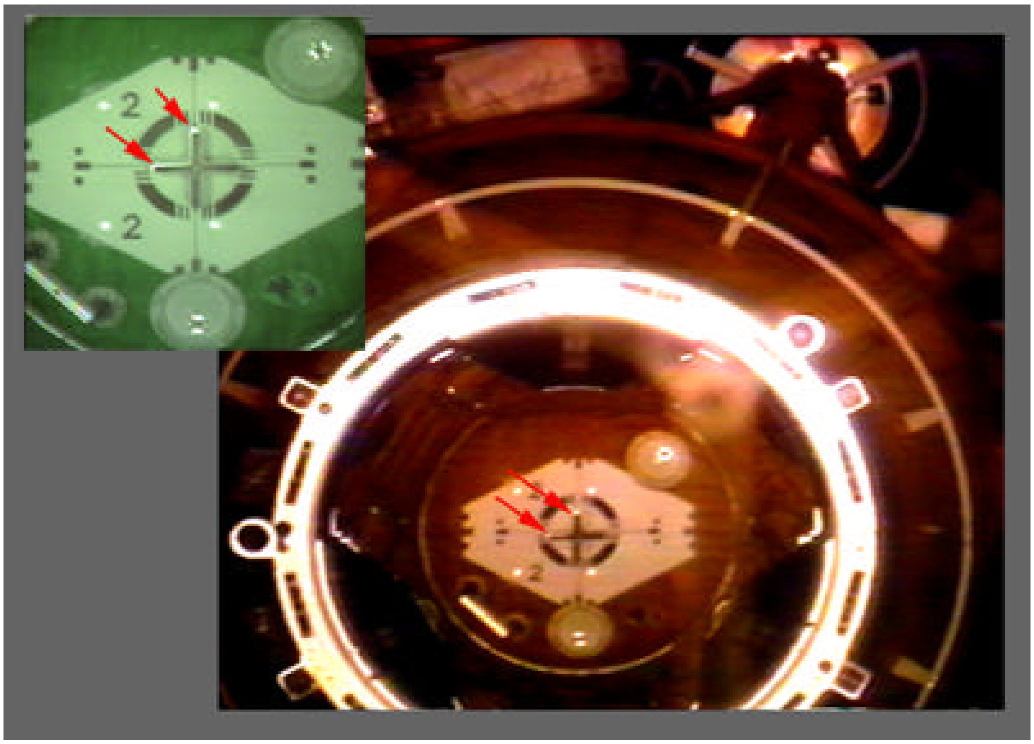

Figure 4-B Centerline Image of Docking Mechanism Showing Detached Laminate (Docking)

5. SOLAR ARRAY MOTION ANALYSIS FROM VIDEO

5.1 Motion Analysis of Cooperative Solar Array

The Mir Cooperative Solar Array (CSA) was transported by the Orbiter to Mir during STS-74. On May 25, 1996, after STS-76 and prior to STS-79, the CSA was attached to the $-Z_B$ side of the Kvant module. The CSA is a new solar array with a different structural design from previous Mir arrays. The CSA provided an opportunity to obtain new data for validation of loads and dynamics models. The JSC Structures and Mechanics Division requested that measurements be obtained of the CSA truss' response to applied loads. The data to be acquired was video of the motion of the CSA to loads induced by docking and separation of the Orbiter. Acquisition of CSA motion during docking was the primary objective while CSA motion during separation was a secondary objective. Figure 5-A shows a typical digitized frame of the CSA taken just before the Orbiter docked to Mir. Data taken from 8 mm video recorded from window #2 of the Base Block (BB) of Mir during the soft-dock was used to estimate the deflection and frequency of motion of the CSA truss. Video data was not acquired during the separation.

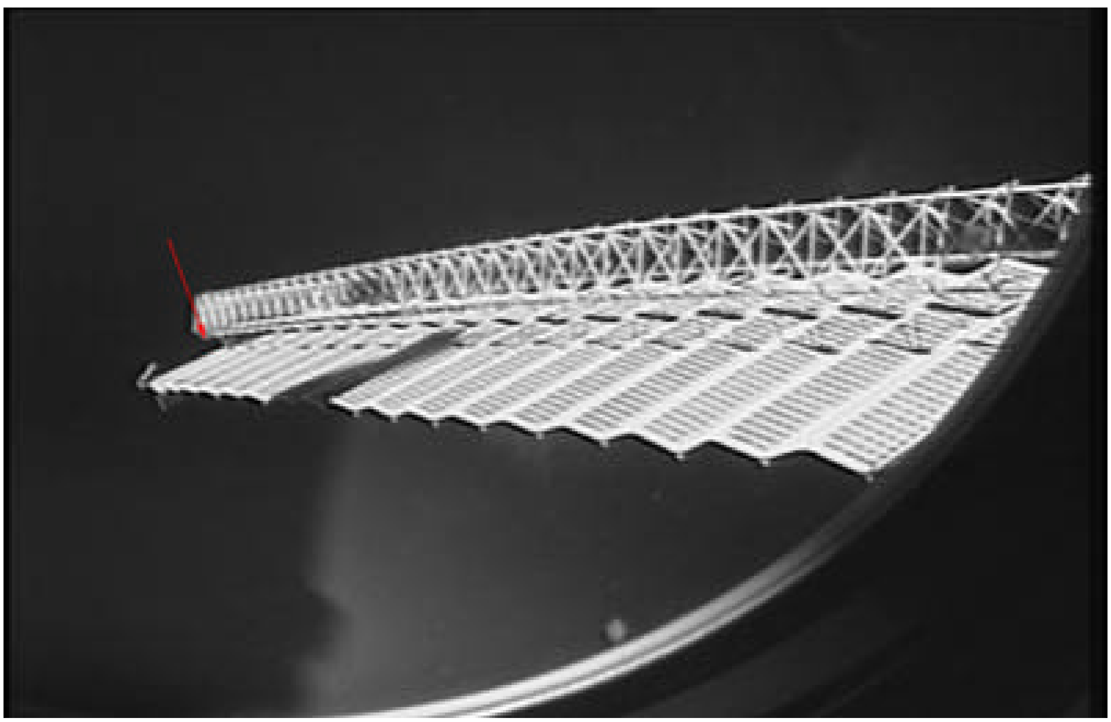

Figure 5-A Typical Digitized Frame of the Cooperative Solar Array

5.1.1 Data Acquisition

Prior to the mission, it was determined that two simultaneous video camera views of the CSA should be acquired in order to perform three-dimensional analysis of CSA motion. The first would use an 8 mm video camcorder bracket-mounted in window #2 of the Base Block. As the view from BB window #2 was oblique, payload bay video camera B was selected for the second, orthogonal, view. These two views provided the most unobstructed coverage of the CSA. These cameras were selected based on available engineering drawings, simulated views supplied by the JSC Graphics Research and Analysis Facility (GRAF) lab, and videos and photos from previous missions.

For approach and docking, the CSA was feathered such that the array blanket was oriented at an angle which placed it “edge-on” with respect to the nose of the Orbiter. This minimized plume impingement loads due to the Shuttle nose jets. However, it made in-plane motion of the CSA difficult to analyze because the observed motion was toward and away from the cameras, effectively reducing the image size of the deflection. It was also determined that the imagery from payload bay camera B was unacceptable for the extraction of motion data. The camera B field of view was not narrow enough to observe any motion, and the array was rotated such that the truss was not visible. It was further determined that out-of-plane motion from Base Block window #2, given the wide field of view, was too small to measure from the available data. As a result, only in-plane motion taken from the 8 mm video was measurable.

5.1.2 Data Analysis

In the video, motion of the array blanket is evident and is correlated to the firings of the PRCS. However, discernible motion of the truss does not occur until the time of soft dock. As the farthest point from the camera, the tip of the truss displayed the lowest resolution on the CSA. The red arrow in figure 5-A denotes the location of the point that was tracked. One thousand frames of the 8 mm video were digitized, and alternate frames were selected for analysis. A point on the tip of the truss was selected at the intersection of two linear structural elements and it was then tracked from frame-to-frame. Selection of the same point in different frames was difficult because of low image resolution. The uncertainty in selecting the same position on the CSA for each frame analyzed was estimated to be +/- one pixel.

Timing was not available from the video. However, Primary Reaction Control System (PRCS) firings were visible in the video. From the digital tape master, the times of thruster plumes were noted and the interval between them was computed. The intervals were then compared to the times of Shuttle PRCS jet firings. It was determined that plumes from thruster F1F were visible in the video. Greenwich Mean Time (GMT) was determined for the firings and correlated to the imagery. Soft dock was estimated from the video to occur at 263:03:13:17 GMT. Soft-dock time was corroborated from other, time-coded, STS-79 docking video. The extrapolation of GMT to the 8 mm video was important to verify that the event leading to the truss motion was indeed soft-dock as opposed to hard-dock or thruster firings.

In order to smooth the noise due to fluctuations in placement of data points, a moving average of the deflection data was calculated over 15 frames (1 second). This result is shown in Figure 5-B. An upward trend was seen in the data that may be attributed to a gradual one pixel shift in the placement of the tracking point over the time analyzed. This trend has been removed to generate the curve shown in Figure 5-B.

Approximately 1.5 cycles of motion were detected in the data. The peak-to-peak deflection was approximated from this smoothed curve as 2.8 inches. The lengths of the two cycles were averaged, and the reciprocal of that average provided an estimate of the in-plane oscillation frequency of the tip of the truss. This was calculated to be 0.22 Hz. A natural frequency of 0.28 Hz for the first in-plane mode was derived from the structural model provided by RSC-Energia.

The raw data (position correlated to time for each frame) was provided to the Structures and Mechanics Division for loads and dynamics analysis.

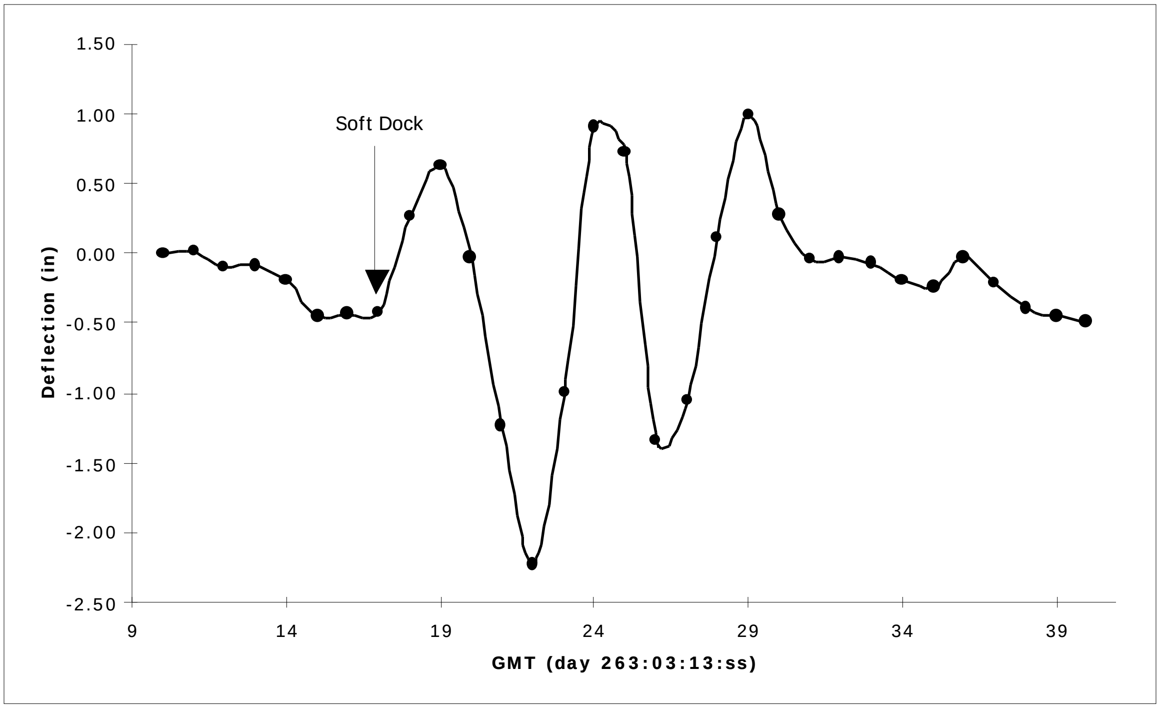

Figure 5-B CSA Truss Deflection vs GMT During Shuttle Docking Sequence

5.2 Motion Analysis of Base Block Solar Panel #2 (BB SP#2)

During the video survey while the Orbiter was docked to Mir, BB SP#2 was seen oscillating due to an undetermined cause on two separate occasions. Video was acquired of the events, and one event was selected for analysis. Figure 5-C shows a typical digitized video image of BB SP#2 taken with payload bay camera A while the Orbiter and Mir were docked.

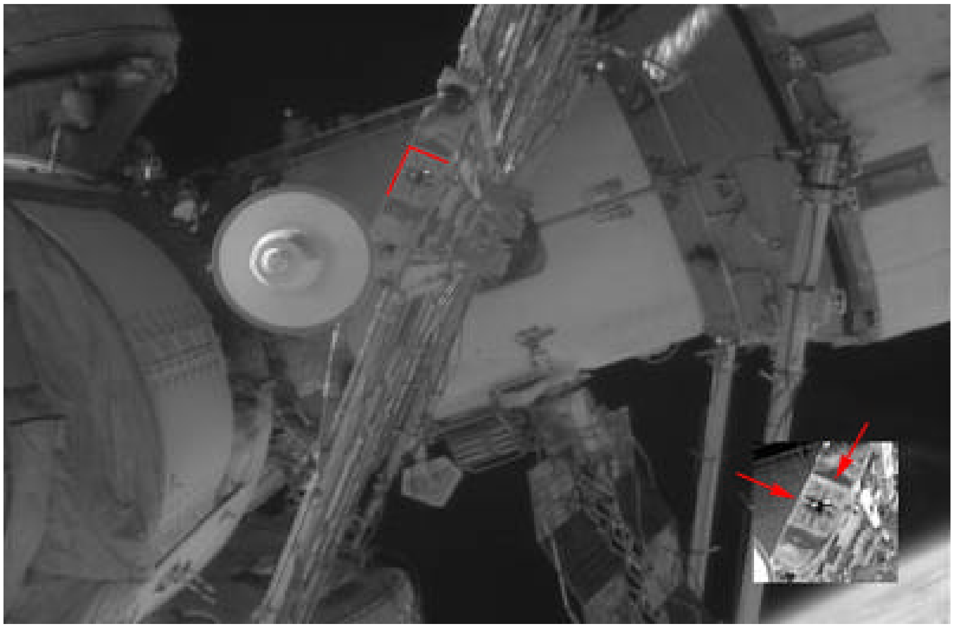

Figure 5-C Base Block Solar Panel #2

All four payload bay cameras were used to acquire imagery of the Mir solar arrays during the INCO survey. Camera A was unique in that it provided a view of BB SP#2 from an "edge-on" perspective. During the survey, two sections of video of 1.5 and 2 minute lengths were recorded that display the solar array motion. The primary difference in these two views was the field-of-view. The second recording was selected as the section from which video would be analyzed as it had higher resolution and would provide greater accuracy in determining the solar array motion. Approximately 20 seconds of video was extracted for analysis.

An automated line tracking software package was used to track the motion of the array. The red lines in Figure 5-C denote the approximate location of the lines tracked. Two perpendicular lines were tracked, and the intersection of these two lines defined the point to be analyzed. The red lines in Figure 5-C denote the approximate location of the lines tracked. The red arrows in the inset denote the structural features that define the lines. The computer data was augmented with data extracted manually. Scaling was determined using the diameter of the circular antenna on the end of the array visible in Figure 5-C. Six hundred frames of video were digitized, and every other frame was analyzed. A moving average of one second (15 data points) was used to smooth the data for this report. Figures 5-D and 5-E show the in-plane and out-of-plane motion with respect to time. The maximum in-plane deflection is approximately 4.5 inches and the maximum out-of-plane deflection is approximately 5.3 inches. No frequencies of motion were calculated for this array as there is no discernible dominant frequency visible in the data.

These results may be compared to STS-74 results which reported a maximum amplitude of lateral motion (in-plane) of 5.5 inches. Deflections measured during STS-74 occurred during a time when the array was being rotated. Array rotation was not observed during the STS-79 data acquisition.

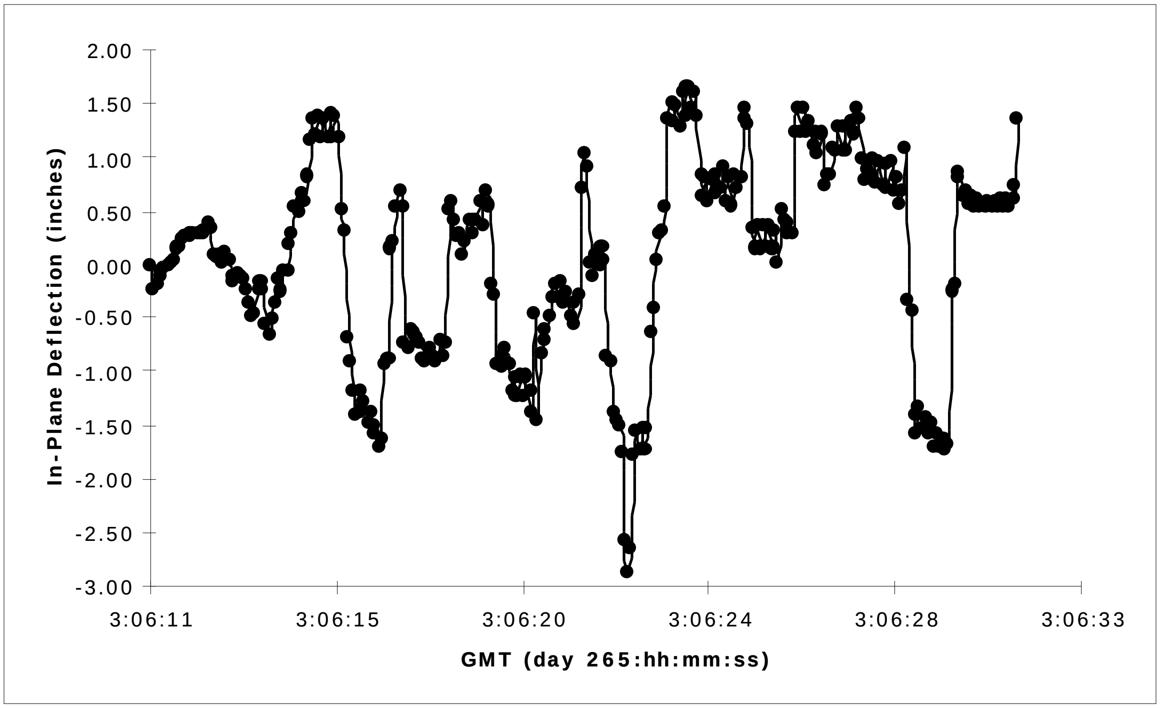

Figure 5-D In-plane Deflection of Base Block SP#2 (Shuttle Docked)

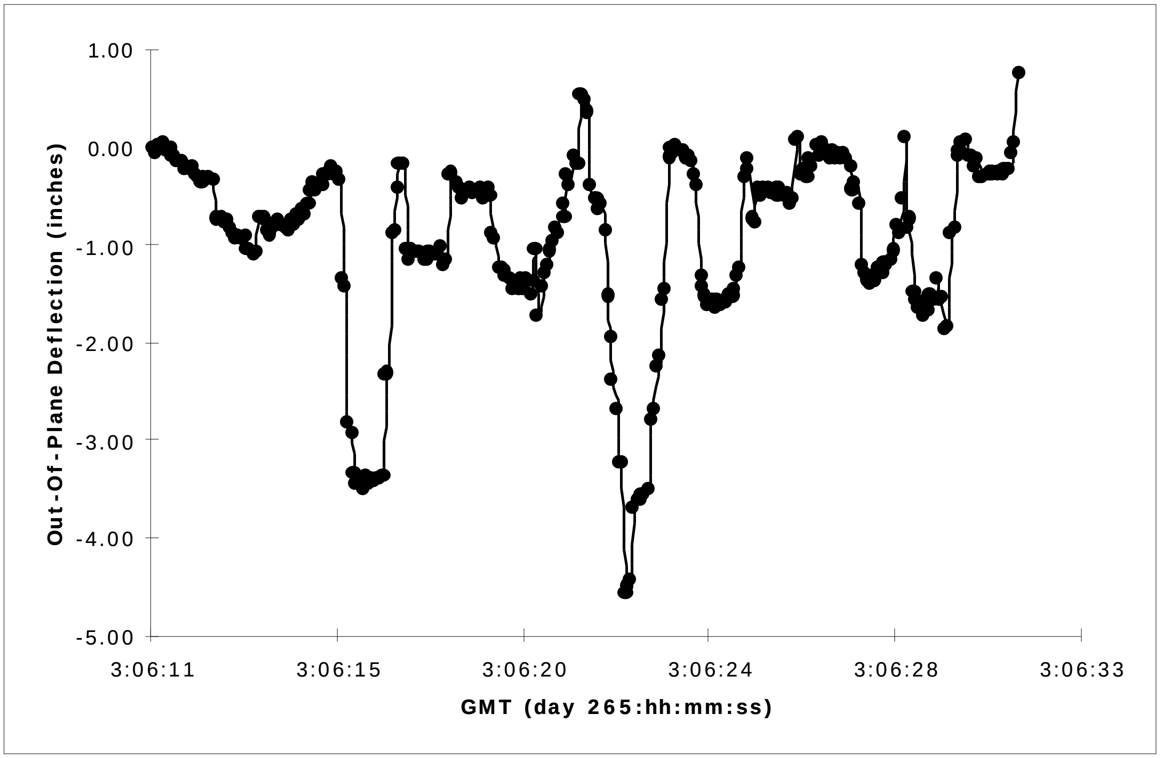

Figure 5-E Out-of-plane Deflection of Base Block SP#2 (Shuttle Docked)

6. DEBRIS SEEN DURING DOCKING OPERATIONS

Small pieces of debris are seen on orbit during most Shuttle missions. Several pieces of debris were noted near the time of docking of STS-79. None of the debris was observed to make contact with Mir or the Orbiter.

During Mir approach, several pieces of debris were observed which appeared to originate within the ODS. In one case, this was confirmed as shown in Figure 6-A. The debris is shown within the ODS by the centerline camera. Red arrows in the figure show the direction of the debris. From approximately GMT 263:02:32:00 to 263:02:35:00, a large amount of debris, probably ice, was seen from payload bay camera C during RCS attitude jet firings. The debris was probably more prominent because it was reflecting direct sunlight. From approximately 263:02:19 to 263:02:27, a bright object was observed from PLB camera A. The object moved very slowly; in fact, the motion was only noticeable during high speed playback.

During the transition from soft dock to hard dock, many pieces of small debris were observed. Thirteen pieces of small debris, observed with camera A after the time of soft dock, were tracked as shown in Figure 6-B. These debris, probably ice, condensate, or propellant molecules, appear to have originated from three different areas. These areas are the payload bay, the ODS / Docking Module interface, and from the Orbiter thrusters. However no piece of debris was visually observed from its origin. Three pieces traversed in the line of sight between the camera and the Mir Docking Module in an Orbiter +Z direction from the Orbiter payload bay and toward the Station. Four other pieces traversed in a parallel path, but not in the line of sight, between the camera and the Docking Module. Five pieces of debris traversed paths approximately 45 degrees diagonal to the Orbiter Y-Z plane in the -Y, +Z, direction.

Video was switched from camera A to camera D just prior to hard dock. Just after hard dock, when the sun's rays reached the docking interface, five pieces of debris were observed (see Figure 6-C). One piece of debris was observed to originate from the interface of the ODS and the Docking Module. It traversed a direction perpendicular to the ODS / Docking Module axis, and in a +Y direction.

Assuming that the debris is close to the Docking Module and in the line of sight between the camera and the Docking Module, it was measured to be approximately 1.5 inches in diameter and traveling approximately five inches per second in the +Z direction. However, the debris could be smaller, closer to the camera, and hence traveling slower. The two pieces of debris which appeared to originate from the ODS / Docking Module interface area (one each from cameras A and D) appeared to be angular and tumbling.

During backaway, three pieces of small debris were observed. One was ring-shaped, fast moving, and appeared to come from the Orbiter and move in the direction of Mir.

During fly-around, between 268:01:49:56 and 268:02:22:45, many pieces of small debris were noted. None were observed to impact Mir. Between 268:01:49:56 and 268:01:50:33, several (15-25) pieces of debris were noted that are attributed to thruster firings.

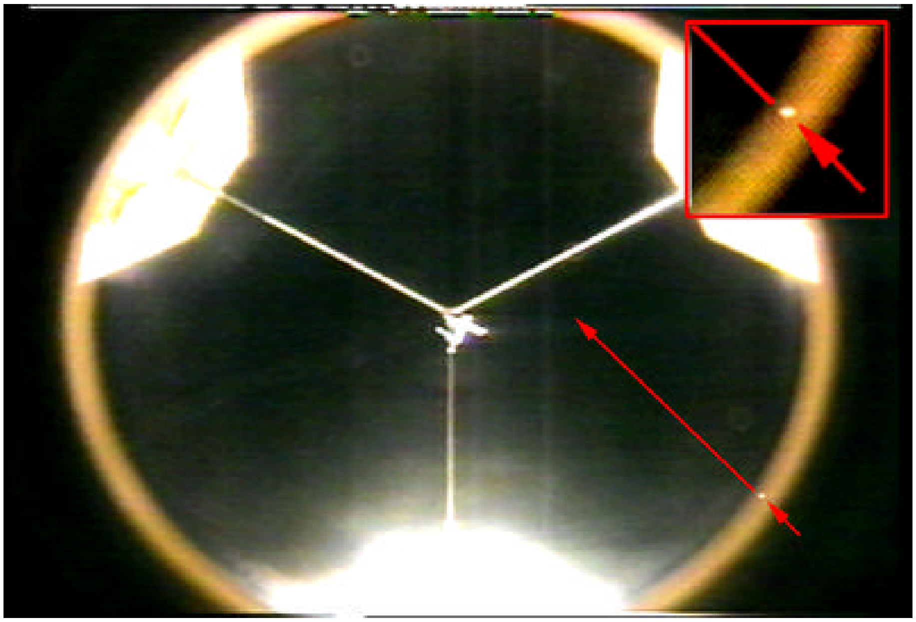

Figure 6-A Debris Originating from ODS

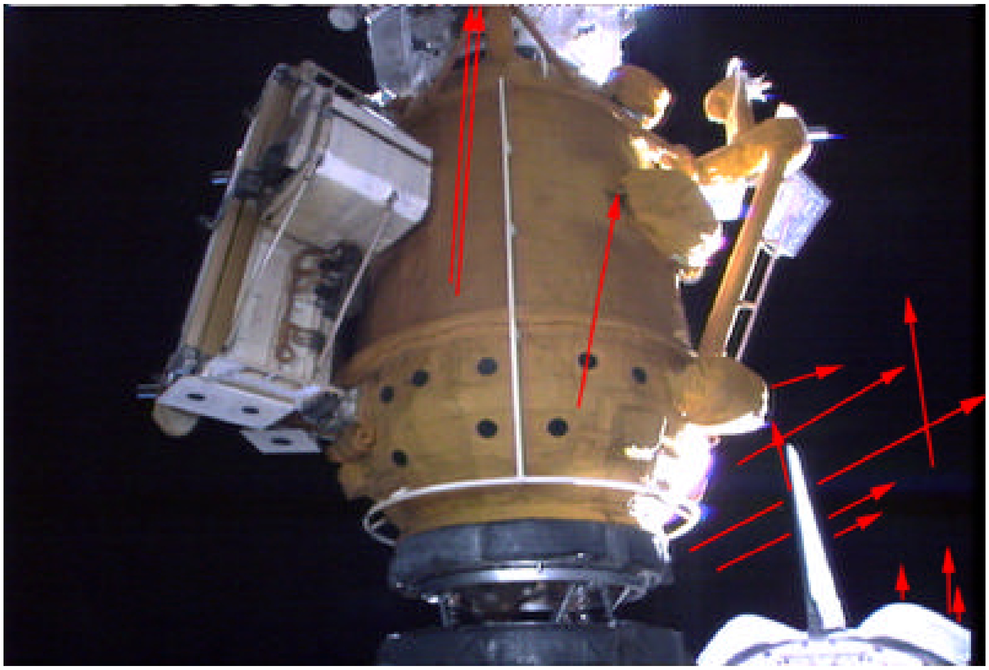

Figure 6-B Trajectories of Small Debris Observed After Soft Dock (Payload Bay Camera A)

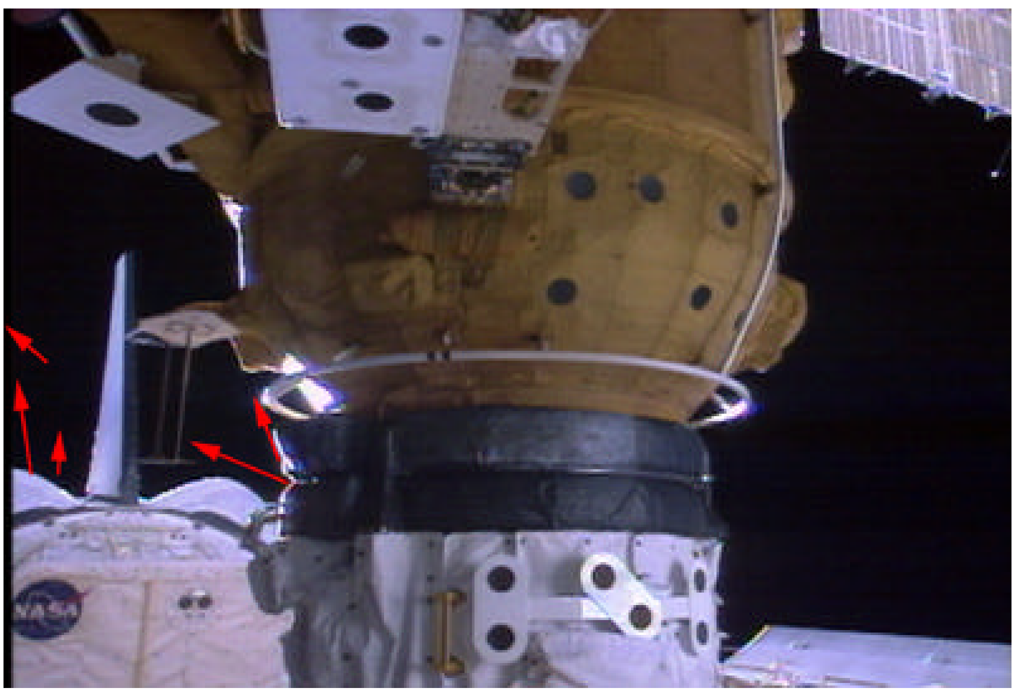

Figure 6-C Trajectories of Small Debris Observed After Hard Dock (Payload Bay Camera D)

7. MIR ENVIRONMENTAL EFFECTS PAYLOAD ANALYSIS

The Mir Environmental Effects Payload (MEEP) experiment was attached to the Mir Docking Module during STS-76. MEEP is composed of four separate experiments: the Polished Plate Micrometeoroid and Debris (PPMD) experiment, the Orbital Debris Collector (ODC), and the Passive Optical Sample Assemblies (POSA and POSA II). The MEEP experiment will study the frequency and effects of space debris striking the Mir space station. The MEEP panels also expose selected and proposed International Space Station (ISS) materials to the effects of space and orbital debris. Because ISS will be placed in approximately the same orbit as Mir, MEEP will give engineers an opportunity to test materials for the ISS in a comparable orbital environment. The ISS program has requested that imagery be obtained of the MEEP panels on each Shuttle rendezvous mission and that the imagery be analyzed for changes to the MEEP panels.

Figure 7-A is an image of the Docking Module with MEEP experiments and the Reusable Solar Array identified. The image was obtained during Station-keeping at 170 feet using the Nikon camera with 300 mm lens.

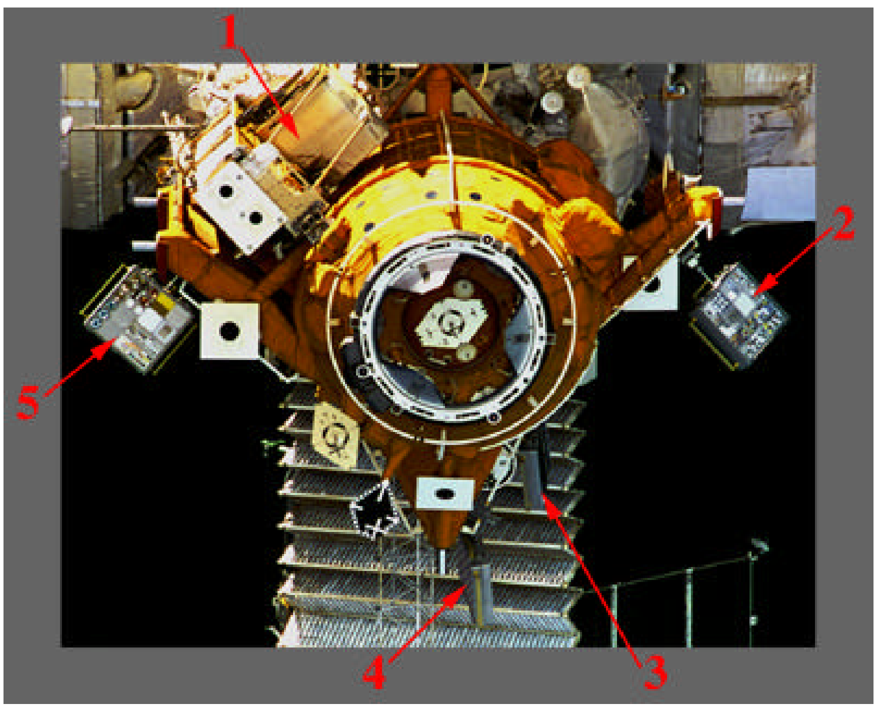

Figure 7-A Docking Module with MEEP Experiments

1. **Reusable Solar Array (RSA)**
2. **Passive Optical Sample Assembly II (POSA II)**
3. **Polish Plate Micrometeoroid & Debris (PPMD) Experiment**
4. **Orbital Debris Collector (ODC) Experiment**
5. **Passive Optical Sample Assembly (POSA)**

A video imagery survey of MEEP was performed on STS-76 to verify the initial surface condition of all visible panels and the orientation of the experiments. Only the Orbiter-facing sides of the PPMD, ODC, and POSA panels were observed on STS-76, and the views were oblique to the panels. The STS-79 imagery of POSA and POSA II panels was significantly improved over the STS-76 imagery. The STS-79 views of PPMD and ODC were oblique and effectively equivalent in quality to the views acquired on STS-76.

Imagery was acquired of MEEP from three vantage points; still photography of the Docking Module and MEEP experiments during Station-keep at 170 feet from Mir, still photography from the Shuttle aft flight deck window during the time the Shuttle was docked, and PLB video surveys using all PLB video cameras during the time Shuttle was docked.

Still photography was taken of POSA from the Shuttle aft flight deck window with the Nikon 35 mm camera and the 300 mm lens while the Shuttle was docked to Mir. This image was of high resolution and fidelity and showed no damage or discoloration of POSA.

The Nikon camera with 300 mm lens was used during the Station-keep and provided a face-on view of POSA and an oblique view (25 degrees from face-on) of POSA II. The Station-keep views of POSA and POSA II were sufficient to record color differences of several (but not all) of the sample materials. The imagery indicates no damage or discoloration to the POSA and POSA II panel surfaces but, unlike the still photograph of POSA taken with the Shuttle docked, the imagery does not have the resolution to be fully conclusive. The PPMD and ODC views were edge-on in the Docking Module image from Station-keep and were not useful for analysis of the panels.

Survey imagery taken with the PLB video cameras from the docked Shuttle captured POSA, PPMD, and ODC. POSA II views were obscured or edge-on. All views were oblique (40 - 60 degrees) and color responses were significantly less than in the still photography views. The ODC image, although oblique, is of good quality and no damage or discoloration is indicated. The imagery of PPMD also does not indicate damage or discoloration, however the polished surfaces have substantial reflections of Mir which could mask discolorations, should they exist. Additionally, the video images of POSA taken with the same camera at different times during the mission, with subtle changes in illumination, show significantly different appearances in the sample materials.

Based upon the above analyses, there are no indications of damage or discoloration to any of the MEEP panels, and there are no detected changes since the experiments were deployed on STS-76. However, the results are conclusive only for POSA where the imagery resolution and lighting conditions were adequate.

The following Figures 7-B, C, D, and E were the highest quality images of the four MEEP experiments obtained on STS-79. Figure C, D, and E images were digitally enhanced in scale, contrast, and brightness to reveal detail of the panels.

Figure 7-B Image of POSA taken with Nikon and 300 mm Lens from Aft Flight Deck Window (Shuttle Docked)

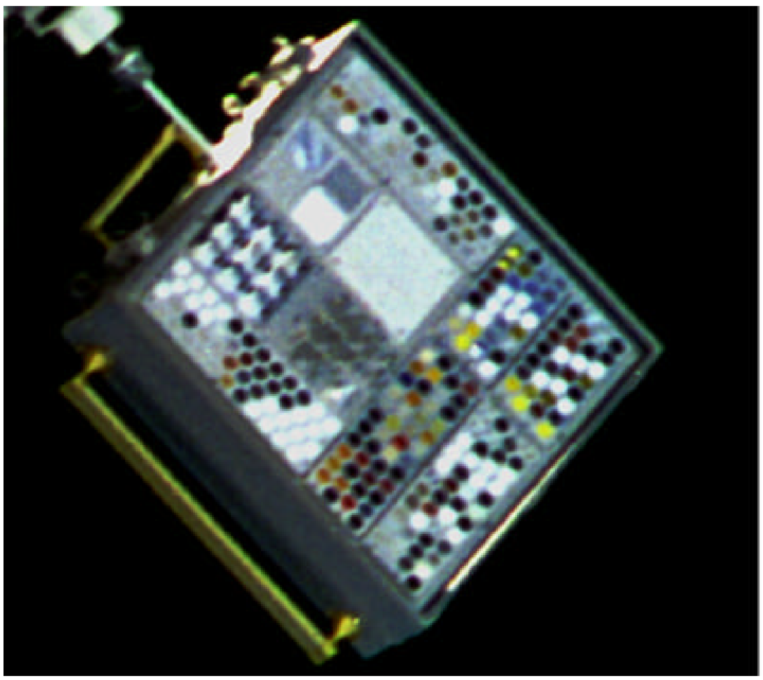

Figure 7-C Enhanced Image of POSA II taken with Nikon with 300 mm Lens during Station-Keep at 170 feet

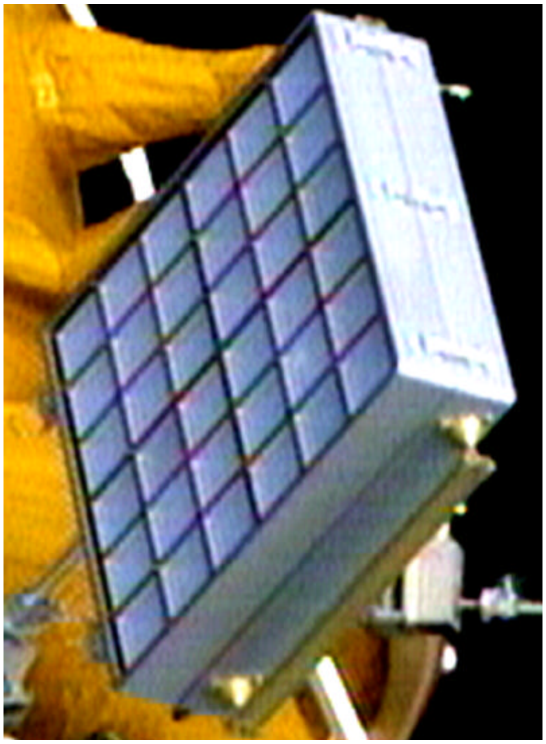

Figure 7-D Enhanced Image of ODC taken with PLB CTVC Camera (Shuttle Docked)

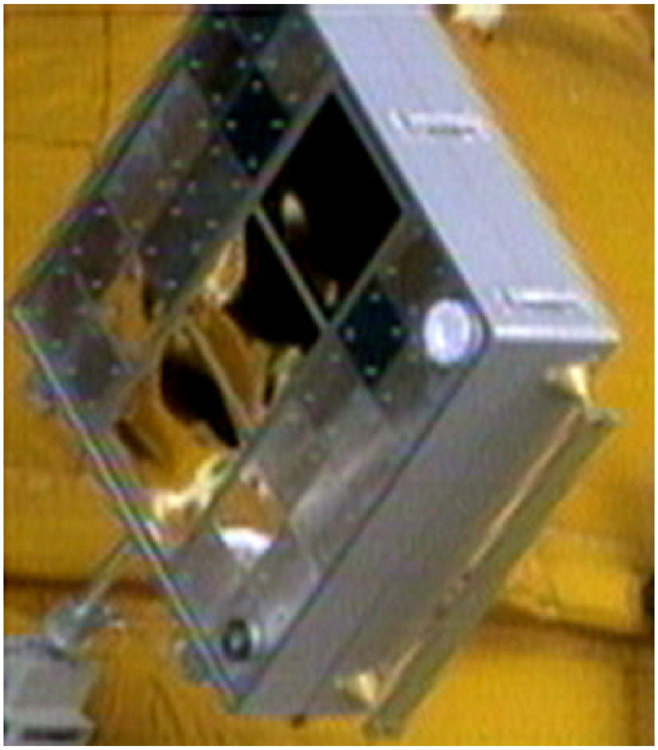

Figure 7-E Enhanced Image of PPMD taken with PLB CTVC camera (Shuttle Docked)

8. IMAGERY EVALUATION

This section discusses overall quality of the film and video data obtained during DTO-1118. The scenelist of flight films contents and an index to videotapes are included as Appendices C and D.

Imagery acquired of Mir surfaces during STS-79 consisted of the following:

- 17 hours of downlink and onboard video.
- 232 frames of 35 mm film.
- 939 frames of 70 mm film.
- 80 Electronic Still Camera (ESC) images.

8.1 Video Review

The centerline camera and payload bay camera A provided the first views of the Mir approximately two hours before docking. During the dark phase of the orbit, only the station onboard lights were visible on the available views. Views of the newly-installed Cooperative Solar Array were acquired from a camcorder bracket-mounted in one of the Mir Base Block windows. Array motion, correlated with Shuttle thruster plumes and docking loads, was visible during final approach and docking.

The centerline, ODS non-axial, and payload bay camera A provided excellent video during close approach and docking. The centerline camera clearly showed the detachment of laminate on the stand-off target cross arms in the multiplexed close-up views.

Much of the downlinked survey video was obtained via INCO ground control during three crew sleep periods of the docked phase. All four payload bay cameras were used in acquiring Mir survey imagery. This footage provided good coverage of the Orbiter-facing sides of the Spektr, Kvant-2, Base Block, Kristall, and Kvant modules. Some video data was acquired of the new Priroda module and its SAR antenna. In addition, systematic coverage of the Docking Module and the attached RSA carrier was obtained.

Detailed video coverage of the RSA (Russian Solar Array) carrier on the Docking Module was obtained. This footage revealed peeling paint on different areas of the supporting truss structure of the RSA. Coverage of the Mir Environmental Effects Payload (MEEP) panels deployed on the Docking Module was obtained from each payload bay camera. The POSA I panel was visible and mapped from PLB cameras B, C and D. The other three panels deployed were only visible from the aft cameras.

Besides the CSA motion noted during approach and docking, oscillation of the Base Block SP#2 array was noted during the mated phase.

The ODS non-axial camera provided the primary views of the Mir docking interface area during the backaway sequence. Centerline camera video was terminated before the entire docking mechanism area could be recorded.

Fly-around coverage was limited to overview imagery. Payload bay cameras A and B, as well as the centerline camera, were used to acquire data during fly-around.

8.2 Still Photography Review

The overall coverage and quality of still photography was excellent. Imagery taken during station-keep and fly-around provided a good overall documentation of configuration. Imagery taken with the Nikon and 300 mm lens during station-keep provided significant detail. Survey imagery with the Hasselblad and detailed imagery with the Hasselblad and Nikon using long focal length lenses from the docked Orbiter windows were especially valuable in examining the condition of Mir surfaces and the MEEP POSA panel. The lack of a high-resolution still image of the docking mechanism during backaway was the only significant deficiency.

One roll (37 images) of Nikon (35 mm) photography was acquired during the station-keep at 170 feet. These images, captured with a 300 mm lens, provided an overview of all Orbiter-facing sides of Mir modules during approach. Two images taken of the Mir docking mechanism under good illumination provided good detail of the docking mechanism. However, between 170 feet and 15 feet, the Mir was in darkness and views of the Mir docking mechanism were not acquired during close approach.

Survey coverage of the Orbiter-facing sides of Kvant, Spektr, Kvant-2, Kristall and Base Block modules was obtained using the Hasselblad camera from the docked Orbiter. The Nikon camera with the 300 mm lens provided detailed coverage of the end of Kvant adjacent to the Base Block, the Luch antenna & arm, experiments on the end of Kvant-2, the $-Z_B$ Spektr radiator, the $-X_B$ radiator on Priroda, and the SAR antenna on Priroda.

Overview fly-around imagery was captured with the Hasselblad. Early fly-around photography taken with the Hasselblad provided coverage of the $-X_B$ side of Kristall and the Docking Module. The Nikon camera with the 300 mm lens provided detailed coverage of the $+Z_B$ sides of all modules. Most of these surfaces were in shadow, however, some features on the top of Priroda and the damage on the $+Z_B$ Kvant array can be seen. The $-X_B$ sides of Kvant-2, Spektr, and Priroda, along with Soyuz and the docking node where they all are attached, were photographed during early fly-around.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Summary

The most significant anomalies identified from the STS-79 Mir survey were possible damage caused by micrometeoroid impacts on the Base Block SP#2 array, probable contaminant deposition on a Priroda radiator, and contaminant deposition from probable outgassing of a tether or cable material along the Cargo/EVA transfer boom located on the side facing the docked Orbiter. Three spars of the Priroda SAR antenna did not appear to be fully deployed. Two cells of the newly-deployed CSA appear to be damaged. Large areas of the RSA carrier exhibited paint peeling. Smudges and probable blemishes were found on Base Block window #2.

Overview coverage of the Mir Base Block, Kvant, Kvant-2, and Spektr module surfaces indicated no significant additional discoloration since the last rendezvous.

First-time coverage was obtained of the Cooperative Solar Array, Priroda, Ferma-3 truss, Ljappa arm, Particle Impact Experiment (PIE), SKK experiment, and Mir Sample Return Experiment (MSRE).

Imagery acquired with the 35 mm and 70 mm cameras provided adequate overview coverage of visible Mir surfaces throughout the mission. During the station-keep at 170 feet, the Nikon with 300 mm lens was used to provide improved resolution coverage of all Orbiter-facing sides of Mir modules, including a face-on view of the docking mechanism and the only good view obtained of the MEEP POSA II panel.

The crew obtained still photography of Mir using the 35 mm camera with 300 mm lens and the 70 mm camera with 250 mm lens during the time they were docked to Mir. Imagery was obtained from the Orbiter windows, the Spacehab window, and a Kvant-2 window. This imagery allowed detailed examination of Mir surfaces for discoloration and damage. A very high quality image of the MEEP POSA panel was obtained which clearly showed no damage or discoloration.

INCO-controlled acquisition from all four payload bay cameras were used in acquiring complementary Mir survey imagery during crew sleep periods. This imagery provided good coverage of the Orbiter-facing sides of the Spektr, Kvant-2, Base Block, Kristall, and Kvant modules. Some video data was acquired of the new Priroda module and its Synthetic aperture Radar (SAR) antenna. In addition, systematic coverage of the Docking Module and the attached RSA carrier was obtained.

No close-up still photographs were taken of the docking mechanism during approach or backaway. Imagery which was acquired was marginal for determining the condition of the docking mechanism. This included the 35 mm camera with 300 mm focal length lens during station-keep, and the centerline and non-axial video cameras during approach and backaway. It was only in the last few feet of docking, when the centerline camera was zoomed in on the docking target, that the damage to the stand-off target was identifiable. During backaway, the centerline camera coverage did not continue until the full docking mechanism was within the field of view. Only an oblique, non-axial camera view of the full docking mechanism area was obtained during backaway.

During docking, views of the newly-installed Cooperative Solar Array (CSA) were acquired with a camcorder bracket-mounted in one of the Mir Base Block Windows.

Analyses of the motion of the CSA has been provided to the JSC Structures and Dynamics Division for loads and dynamics analysis. In addition, oscillation of the Base Block SP#2 array was recorded by the video during the mated phase. Analyses have been performed of this solar array motion.

The combined imagery gathered on STS-63, 71, 74, 76, and 79 missions provide significant information from which an assessment can be made about effects of the space environment on an orbiting platform.

9.2 Conclusions

Based on the summary of major points made above, the following conclusions have been made:

The imagery surveys continue to provide new information on the effects of the space environment on the Mir Space Station. These effects are observed on newly-deployed structures as well as on those structures and surfaces which have been deployed for years.

The amount of high-resolution imagery is increasing over time with each additional mission. Drastic changes were not observed on STS-79, however this increase is allowing the identification of smaller features and improved definition of surface characteristics, including discoloration, micrometeoroid/orbital debris damage, and structural anomalies.

Although STS-79 imagery showed there was no additional peeled paint on the Spektr radiator, the imagery on STS-79 shows a significant amount of blistering paint which appears “ready” to peel away. Based on this observation, it may be reasonable to expect additional paint to peel away from the Spektr radiator.

The extent of observed discoloration of surfaces continues to spread. These observations are partially due to the continued collection of improved imagery. Recently deployed surfaces also show discoloration. Characterizations of the sources of these discolorations are being investigated by environmental and materials engineers.

The quality of the imagery of the CSA was significantly less than optimum with regard to resolution, view angle, and direction of motion relative to the camera. Never-the-less, data on the deflection and frequency of motion was able to be extracted and the results were consistent with the expected motion of the array. However, improved imagery with additional cameras is required to measure motion in multiple directions for the Mir solar arrays.

There were no indications of damage or discoloration to the MEEP panels, however only the imagery of POSA was of sufficient quality to provdide a conclusive result.

Conclusions relating to the acquisition of imagery are:

Docking approach during darkness and limited window accessibility severely hampered data acquisition during docking. Limited window accessibility also inhibited data acquisition during backaway. The video acquired during STS-79 was marginal in resolution for docking mechanism assessment, especially during backaway.

Use of the longer focal length lenses (Hasselblad with 250 mm lens and Nikon with 300 mm lens) provided excellent detail during the docked phase. Ground controlled surveys of

Mir with all the PLB video cameras during crew sleep periods provided excellent complementary imagery to the still camera images.

Use of longer focal length lenses during the station-keep and fly-around improved coverage of Mir surfaces not visible during the docked phase.

Equipment and time constraints precluded video acquisition of solar arrays during certain phases of the rendezvous when array motion may have otherwise been visible. In addition, conflicts with other DTOs have led to limited coverage of possible array motion events.

INCO-controlled video surveys during crew sleep periods provided the best available coverage of the MEEP panels on the Docking Module. However, there was good detail photography taken of the POSA panel which is visible from an aft flight deck window.

Use of the bracket-mounted camcorder in the Mir Base Block window provided valuable, albeit limited, data on CSA motion.

9.3 Recommendations

Based on the summary above, crew comments during training, and evaluation of the STS-79 and prior mission imagery, the following recommendations can be made for upcoming missions:

- Centerline video camera views should be the primary source for determining the condition of the docking target. However, for lighting and vehicle orientations similar to STS-79, the centerline, non-axial, and payload bay cameras should not be the only sources of imagery, especially during backaway. If imagery of the docking ring and latches is important, alternatives for imagery acquisition should be considered. These alternatives include: improved lighting and vehicle orientation, changing the timelines for docking and backaway, providing for crew time for still photography, improved imagery equipment and station-keeping at close range after backaway.
- The Nikon should be used as the primary camera during approach, backaway, and fly-around instead of the Hasselblad. This recommendation is based on crew comments that bracketing with the Nikon would be easier during these events and also because it would allow use of the 400 mm lens during the fly-around.
- The Hasselblad with the 250 mm lens should be used as the primary camera/lens combination to identify possible orbital debris impacts on module surfaces. The wider format film provides more contextual information and the longer lens provides more detail.
- Generate an updated mission-specific target priority list for the crew at the last training session. Configuration modifications and varying image acquisition requirements justify the need for an updated list.
- Continue to use INCO-controlled payload bay video cameras to perform Mir surveys during crew sleep periods. This has been the most effective way to obtain survey video coverage and also allows real-time decisions to be made on target acquisition.
- Re-evaluate the priority of acquiring unanticipated solar array motion from payload bay video cameras during approach and backaway on a mission by mission basis.
- Continue to emphasize the need for bracketing exposures when acquiring imagery.

- Request the crew to be aware of lighting conditions that highlight surface features. Lighting angles oblique to Mir surfaces convey textural information that would otherwise remain hidden.
- Fill at least one video camera field-of-view with the Mir during fly-around. Unanticipated array motion would be easier to detect with this configuration.

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