# SUBJECT: SOLAR-B EIS FM AIV HANDLING PLAN

**PREPARED BY: J Lang**

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# 1. SCOPE

This document specifies the handling procedures for aspects of the Solar-B EIS FM AIV integration. It thus covers the period from the end of the structure thermal cycling until the flight-ready EIS is shipped from RAL to ISAS. In particular, the major phases of the project are covered, as follows.

(1) The time between the structure stress relief and the final structure bake out when the MLI fit check and MLI studs will be attached to the structure as well as the fitting of both the electrical and purge harnesses.
(2) The period between the final bake out and the vibration test when a plethora of tasks will be undertaken, including fitting EIS into the blue tank.
(3) The handling necessary for the off-site EMC and vibration tests.
(4) The procedure to install EIS in the STC for the thermal vacuum test.
(5) Handling activities associated with the calibration.
(6) Preparation for shipping.

The handling procedures in this document are for EIS considered as an instrument. Thus if the alignment template needs to be used or dismounted from the structure, this is covered. However, procedures such as swapping the test grating for the flight grating, changing from test CCD to flight CCD or installing the clamshell are not covered. Such work is covered by procedures written by the institute responsible for the particular activity and whose staff will lead, and be closely involved in, the activity.

The handling procedures are specified in detail both to avoid damaging EIS during handling operations and to ensure that the stringent cleanliness regime is maintained and not compromised in any way. Therefore, the procedures are consistent with both the EIS Product Assurance Plan and the Cleanliness Control Plan. They are also consistent with the SSTD Safety Plan, a copy of which is held in the STC Control Room. All RAL staff involved in this project (as specified in the circulation list) must have been on a manual-handling course which satisfies the Manual Handling Operations Regulations 1992. All staff from BU, MSSL, NAOJ and NRL involved in handling operations must also be trained. Training is available at RAL for those requiring it. In addition, the procedures described in this document involve more than one person in a lifting, so for each operation a team leader must be designated.

The procedures specified are based on those developed by CM Castelli at BU for the successful build of the MTM/TTM and described in the SOLAR-B EIS Instrument MTM/TTM Handling Document.

In this document, a transportation frame, a transport frame, a handling frame and a lifting frame may be mentioned, and these are in fact the same thing.

# 2. ABBREVIATIONS

| | |
|---|---|
| AIV | Assembly, Integration and Verification |
| AWE | Atomic Weapons Establishment |
| BU | University of Birmingham, UK |
| CCD | Charge Coupled Device |
| EIS | Extreme-ultraviolet Imaging Spectrometer |
| EMC | Electro-Magnetic Compatibility |
| ESD | Electro-Static Discharge |
| EUV | Extreme-UltraViolet |
| FM | Flight Model |
| HDL | Heavy Duty Laboratory (R25 RAL, the building housing RAL facilities) |
| I/F | Interface |
| ISAS | Institute of Space and Astronautical Science, Japan |
| ITP | Interface Test Plate |

| | |
|---|---|
| MLI | Multi-Layered Insulation |
| MSSL | Mullard Space Science Laboratory, UK |
| MTM | Mechanical Test Model |
| MTM/TTM | Combined Mechanical Test Model and Thermal Test Model |
| NAOJ | National Astronomical Observatory Japan |
| NRL | Naval Research Laboratory, USA |
| PA | Product Assurance |
| RAL | Rutherford Appleton Laboratory, UK |
| S/C | Spacecraft |
| SSTD | Space Science and Technology Department |
| STC | Space Test Chamber |
| TBC | To be confirmed |
| TBD | To be determined |
| TRR | Test Readiness Review |
| UK | United Kingdom |
| USA | United States of America |

## 3. REFERENCE DOCUMENTS

| Document Reference | Document Title | Document Source |
|---|---|---|
| | | |
| EIS-man-manplan-1.2d | EIS Management Plan | http://www.mssl.ucl.ac.uk/solar-b/docs/EIS_docs.html |
| MSSL/SLB-EIS/PA/001.03 | MSSL EIS Document List | http://www.mssl.ucl.ac.uk/solar-b/docs/EIS_docs.html |
| MSSL/SLB-EIS/PA/002.01 | EIS Product Assurance Plan | http://www.mssl.ucl.ac.uk/solar-b/docs/EIS_docs.html |
| MSSL/SLB-EIS/PA/003.01 | Cleanliness Control Plan | http://www.mssl.ucl.ac.uk/solar-b/docs/EIS_docs.html |
| MSSL | EMC Test Plan | |
| BU/SLB-EIS/PS/003.02 | Solar-B EIS Instrument MTM/TTM Handling Document | |
| | EIS Structure Final Bake Out Plan | |
| | SSTD Safety Plan | STC Control Room or RAL SSTD web site |
| BU | FM MLI Fitting Plan | |
| RAL/SLB-EIS/PL/002 | Solar-B EIS FM Vibration Test Plan | |
| RAL/SLB-EIS/PL/003 | Solar-B EIS FM Thermal Vacuum Test Plan | |
| SLBS-E-0138 Rev. A | SOLAR-B EIS Interface Test Plate Handling Manual | |

Note that the web accessible documents are not signed, but that there are signed copies at MSSL.

## 4. CLEANLINESS

Cleanliness is paramount. Failure to adhere to the EIS Product Assurance Plan and Cleanliness Control Plan will result in the failure of EIS. Effectively, contamination will cause EIS to be blind and unable to observe the Sun and thus to meet its science objectives. All staff involved in handling operations must have read and

understood the plans. They must be conversant with general clean room practices and, in particular, the additional mandatory practices as detailed in the plans.

Although the structure bake out defines the point at which the structure is declared clean, all operations carried out in the clean rooms between the final stress relief and the bake out will be carried out as if EIS were declared clean. This reduces the risk of EIS being contaminated and having to undergo extra cleaning to achieve the necessary cleanliness levels.

Anything that comes into contact with flight equipment, e.g., tools, handling equipment, needs to be cleaned and certified clean as described in the Cleanliness Control Plan. If the item cannot be cleaned to this standard it needs to be double bagged and independently inspected. It should also be noted that there are restrictions on the number of people who can be in the clean area with the flight equipment. Extreme care should be taken to ensure that any gloves used in handling (or other operation) are clean. If there is any doubt, the gloves should be changed immediately.

If a cleanliness problem arises which is not explicitly dealt with in the EIS Product Assurance Plan or Cleanliness Control Plan, advice should be sought. The proposed solution should be agreed by BJ Kent.

# 5. HANDLING OPERATIONS IN CLEAN ROOMS

**WARNING** - the structure must not be handled or lifted in the area around the baffle extension. This area is fragile and cannot support any load. This no-handling area is shown in figure 5.1. Note that if EIS is to be handled by four people, it should be double bagged.

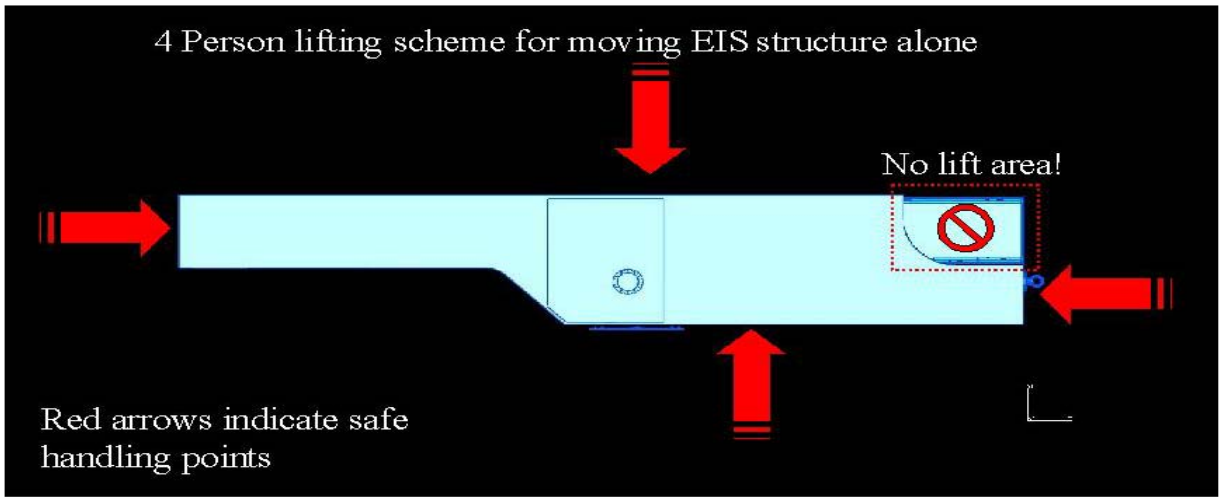


**Figure 5.1.** The lifting points for the safe handling of EIS structure are indicated. The schematic is of EIS looking down at the lid.

## 5.1 Between structure stress relief and final structure bake out

### 5.1.1 From blue tank to clean room table

The steps to be taken for this movement are detailed below.

1. The large surface table in the Class 5 clean room tunnel will have two new layers of Llumalloy put in place.
2. Two metal batons, each about 2.5 cm by 2.5 cm cross section and length about 70 cm will have been coarse and fine cleaned, bagged in Llumalloy, inspected and then placed on the surface table. These batons have one side contoured. This contoured side will be up and the batons placed each about a metre in from the ends of EIS. The contours are designed so that the weight of EIS can be taken without damaging MLI studs, harness or heaters.
3. EIS will be lifted manually from the blue tank on to a trolley whose top has been covered in Llumalloy. It will then be manoeuvred through the door and into the clean room. It will then be lifted on to the batons, whose position may need to be altered slightly to give the correct resting position.
4. A written record is made that the structure was moved.

### 5.1.2 Moving EIS from lid-up to long side down

This movement requires the following steps to be taken.

1. At least two people take the weight of EIS and lift it up slightly.
2. Another person moves the batons to the new positions to allow the structure to be placed with the long side down. As there are only MLI studs on the long side the batons need not be used with the contour side up. However, they should be in the approximate position as in section 5.1.1 and not be touching ML studs.
3. The structure is rotated and placed gently on the batons in their correct position.
4. A written record is made that the structure was moved.

### 5.1.3 Moving EIS from long side down to lid-up

The movement is the reverse of that in the previous section with the batons moved to the positions given in section 5.1.1. The written record should be updated.

### 5.1.4 Moving EIS from the clean room to the blue tank for final bake out

This is the inverse of the procedure for moving EIS from the blue tank to the clean room. The resting position in the blue tank is as in the appropriate bake out plan (from Birmingham University). The written record should be updated.

## 5.2 Moving EIS from the blue tank after bake out and fitting to mounting frame with template in clean room

As the length of the Class 5 clean area at the end of the blue tank is less that the length of EIS it will be necessary to move the baked EIS from there to the main clean room before mounting EIS on its mounting frame. It is envisaged that the procedure has three stages, namely preparation, moving EIS from one room to another and finally the attaching of EIS and the template to the mounting frame.

### 5.2.1 Mounting frame and template preparation

1. Before the moving operation starts, both the tables in the clean room will be covered in two new layers of Llumalloy.
2. The mounting frame, which will have been baked out in accordance with the Cleanliness Control Plan will be placed on the table ready to receive EIS. It is assumed that prior to this the mounting frame will have been trial fitted to the table and the jacks placed in the correct positions to allow the rod ends to fit. Note, the jacks cannot be clamped through the Llumalloy. Bagged lead weights may be placed on the jacks to give stability if needed.
3. The template, which cannot be baked out lest its alignment cube moves, will be given both a coarse and fine clean as specified in the Cleanliness Control Plan and then double bagged in Llumalloy. These bags will need to have access in them for the mounting bolts and to allow the alignment cube optical surfaces

to be viewed without a Llumalloy cover. Obviously, particular care will need to be taken in the cleaning of the exposed parts.
4. The cleaned lifting wheels used to lift EIS should be available for use.
5. The bolts needed to fit EIS, the template and the mounting frame together should be available along with a suitable torque wrench. All these should have been cleaned to the correct specification.

### 5.2.2 From blue tank to clean room table

1. Two small trolleys whose tops have been covered in a double layer of new Llumalloy will be placed in the clean room. Each will have one of the batons, as detailed for use in the previous section 5.1.1, placed on the Llumalloy.
2. EIS will be removed from the blue tank and placed on the batons. The batons/trolleys will be positioned so that EIS can be placed as described in section 5.1.1 step 2.
3. A Llumalloy sheet will be placed over EIS.
4. EIS will then be manoeuvred from the blue tank area through the door and into the main clean room.
5. EIS will then be placed on the batons on the smaller of the two surface tables.
6. The Llumalloy cover will be removed, carefully, so that anything on it does not fall on EIS.

### 5.2.3 Fitting EIS structure to template and mounting frame

This work will involve four people, three to do the work and one on stand-by (noting the restriction on the numbers of people allowed in the clean room) to help if a major problem occurs. Note that the lifting wheels should only be used to lift EIS alone. The steps in the procedure are as follows.

1. The lifting wheels used to lift EIS at its ends will be fitted to EIS while it is on the smaller table.
2. Two people will then lift EIS over to the main table.
3. At the main table, the third person will use the bolts to attach the mounting frame through the template and spacers to EIS. The bolts screw into the feet mounting holes on EIS. The bolts will be torqued to the defined torque. The torque is 16 Nm. Note that this is smaller than given later. The later figures as supplied by the J-side agree with BU and RAL estimates. However, the bolts used have a machined thread rather than rolled thread and the 16 Nm is an estimate to allow some margin for the difference.
4. The lifting wheels should be removed.
5. The use of the EIS mounting holes should be logged.
6. The movement should be recorded.

## 5.3 Removing the template from between EIS and the mounting frame

The need is for the template to be attached and ready for use during the build of EIS. However, as the template cannot be baked out, it must be removed before EIS is put in the blue tank, prepared for EMC, vibration, thermal vacuum testing or shipping. Three people are necessary for this procedure, with one on stand-by in case a major problem occurs (noting the restriction on the numbers of people allowed in the clean room). To remove the template the following steps must be taken.

1. The lifting wheels used to lift EIS at its ends will be fitted to EIS. Remember that the lifting wheels can only be used to lift EIS alone.
2. The bolts needed to fit EIS and the mounting frame together should be available along with a suitable torque wrench. All these should have been cleaned to the correct specification.
3. Two people will be positioned to take the weight of EIS alone using the lifting wheels. At this point the weight of EIS is taken via the lifting frame.
4. The third person will undo the bolts to attaching the mounting frame through the template and spacers to EIS. During the work the weight of EIS will be taken progressively by those holding the lifting wheels.
5. When EIS is free, the third person will remove the template and spacers while the other two hold EIS to keep it clear.
6. EIS will then be lowered down and the third person will re-attach EIS to the mounting frame with the correct bolts at the torques recommended in section 5.2.3.

7. The lifting wheels should be removed.
8. The use of the EIS mounting holes should be logged.
9. The movement should be recorded.

## 5.4 Moving EIS from clean room to blue tank for EUV illumination and vice versa

It is assumed that EIS is on its mounting frame without the template. If the template needs to be removed, the procedure given in section 5.3 should be carried out. The following steps must be taken to move EIS from the clean room table to the blue tank. It is assumed that the position of the equipment in the tank has already been determined.

1. In the blue tank Class 5 area, the railway trolley which runs on the tracks in the blue tank will be placed on a table which is covered in new Llumalloy. The trolley will be positioned so that it can be put in the blue tank without being turned.
2. The EIS detector must be cooled for use in the blue tank. This achieved by cold plates which view the EIS radiators. The cold plates should be attached to the mounting frame using the purpose built fittings and the necessary connecting tubes attached. The electrical umbilicals should also be attached to EIS at this point. Note all these items will need to conform to the highest standards as in the Cleanliness Control plan as they are used in vacuum with EIS.
3. It is assumed that the alignment mirror and aperture map used for source alignment checking have been fixed to the mounting frame and the necessary alignment carried out.
4. In the main clean room EIS on its mounting frame will be draped in Llumalloy.
5. The draped EIS on frame will be placed on trolleys which have their tops covered in new Llumalloy.
6. The trolleys with EIS will be wheeled into the blue tank clean area.
7. The draped Llumalloy will be removed, carefully, so that anything on it does not fall on EIS. At this point if part of EIS is outside the clean area it the Llumalloy should remain on that part.
8. EIS will be lifted using the mounting frame and the kinematic mounts on the mounting frame matched to their corresponding mounts on the railway trolley.
9. The railway trolley can then be manoeuvred into the blue tank and locked at the correct pre-marked position.
10. The cooling radiators and electrical umbilicals should be connected.
11. Any flight equipment other than the structure will be taken from the clean area in the main clean room to the clean area at the blue tank on a trolley which is covered in fresh Llumalloy and that the equipment on the trolley will be covered in Llumalloy for the transfer.
12. Any EGSE will be placed on tables adjacent to the blue tank on the Control Room side.
13. Movements should be recorded.

The removal of EIS from the blue tank and back to the main clean room is the reverse of the above procedure.

# 6. HANDLING OPERATIONS FOR EMC TESTING

It is planned that the EMC test takes place just prior to the vibration test. Both tests will be done at facilities away from RAL. The particular facility to be used for EMC testing is TBC. However, it is hoped that EIS will go directly from the EMC test house to the vibration test house without returning to RAL and needing to go into the clean room. The EMC test house is not clean enough, so as for the vibration test, EIS will need to be double bagged to leave the RAL clean room. It will also need to be purged by nitrogen whose purity is

given in the Cleanliness Control Plan. The MTM/TTM wooden shipping container will be modified to allow purging. The major difficulty is the bagging. Llumalloy the usual bagging material because of its favourable ESD properties is thus less acceptable for EMC testing. Clean polythene can be used. However, clean polythene may not be good enough for the bagging for the vibration testing. As of the date of this plan, compromises are being investigated. For example, Llumalloy could be used for the majority of the bag and clean polythene in the radiator areas.

The handling procedures for the EMC are thus specified here as if EIS had to return to the RAL clean room for re-bagging between EMC and vibration tests. However, the specification of the bag, apart from the material, is the same for both tests. Also it is envisaged that EIS is mounted on the ITP for EMC testing just as for the MTM/TTM and the proposed FM vibration tests.

If it turns out that both the EMC and vibration tests are carried out without removing the bagging, then EIS will be configured for both tests before bagging. For the EMC this is TBD and for the vibration tests, the accelerometers and associated harnesses have been cleaned, mounted on EIS on the correct locations and cabled as defined in the EIS FM Vibration Test Plan. It is also assumed that an appropriate TRR has been held before the handling operations commence and that the EIS is ready to be EMC tested. An appropriate TRR will of course be necessary prior to the vibration test.

## 6.1 Preparation for transfer to EMC test house

This work falls naturally in to the same segments as detailed in section 7.1.

### 6.1.1 Preparation of ITP
See section 7.1.1.

### 6.1.2 Preparation of wooden box
See section 7.1.2.

### 6.1.3 Preparation of EIS
See section 7.1.3. For EMC testing the bagging must allow EIS to be powered as necessary during the tests yet keep the cleanliness standards.

### 6.1.4 Mounting EIS on ITP legs
See section 7.1.4.

### 6.1.5 Removal of ITP/EIS combination from high-bay clean room and mounting on wooden box
See section 7.1.5.

### 6.1.6 Re-assembly of wooden box
See section 7.1.6.

## 6.2 Transport to/from EMC test house

See section 7.2.

## 6.3 Handling at EMC test house

See section 7.3. Note that if the vibration test takes place after the EMC test without EIS being returned to RAL, EIS will be shipped to the vibration test house. In this case, the handling is as in from section 7.3 to the end of section 7. Otherwise, the handling should be as in the remainder of this section.

## 6.4 Removal of EIS from shipping container at RAL and return to clean room.

See section 7.4.

### 6.4.1 Dismantling of the wooden box
See section 7.4.1.

### 6.4.2 Removal of ITP/EIS from base of wooden box
See section 7.4.2.

### 6.4.3 Separation of EIS from the ITP
See section 7.4.3.

### 6.4.4 Returning EIS to the clean room
See section 7.4.4.

# 7. HANDLING OPERATIONS FOR VIBRATION TESTING

It is planned to carry out the vibration testing of EIS at AWE Aldermaston, the test house used for the MTM/TTM vibration testing. The facilities at AWE are not in a clean area, far less a Class 5 clean room. Thus EIS will have to be double bagged to leave the RAL clean room and only removed from the bagging on return to the RAL clean room. The equipment will need to be purged by nitrogen whose purity is given in the Contamination Control Plan. The wooden shipping container will be modified to allow purging when in use. It is envisaged that the only time EIS will not be purged is during the test itself, i.e., when the vibrator is running.

As for the MTM/TTM vibration test the ITP will be used. EIS is mounted to the ITP via the legs and the plate mounting the legs is used as a vibration fixture.

In the following it is assumed that the accelerometers and associated harnesses have been cleaned, mounted on EIS on the correct locations and cabled as defined in the EIS FM Vibration Test Plan. It is also assumed that an appropriate TRR has been held before the handling operations commence and that the EIS is ready to be vibration tested.

## 7.1 Preparation for transfer to AWE

This work falls naturally into segments.

### 7.1.1 Preparation of ITP

The ITP must be prepared and transferred to the high-bay clean room. The operations involving I/F bolts, washers and blocks are taken from the Solar-B EIS Interface Test Plate Handling Manual. The bolts, washers and C0 block used to connect the ITP to EIS must be baked, in accordance with the EIS Cleanliness Control Plan. Thus items 1, 2 and 3 below must be done well in advance of the vibration test.

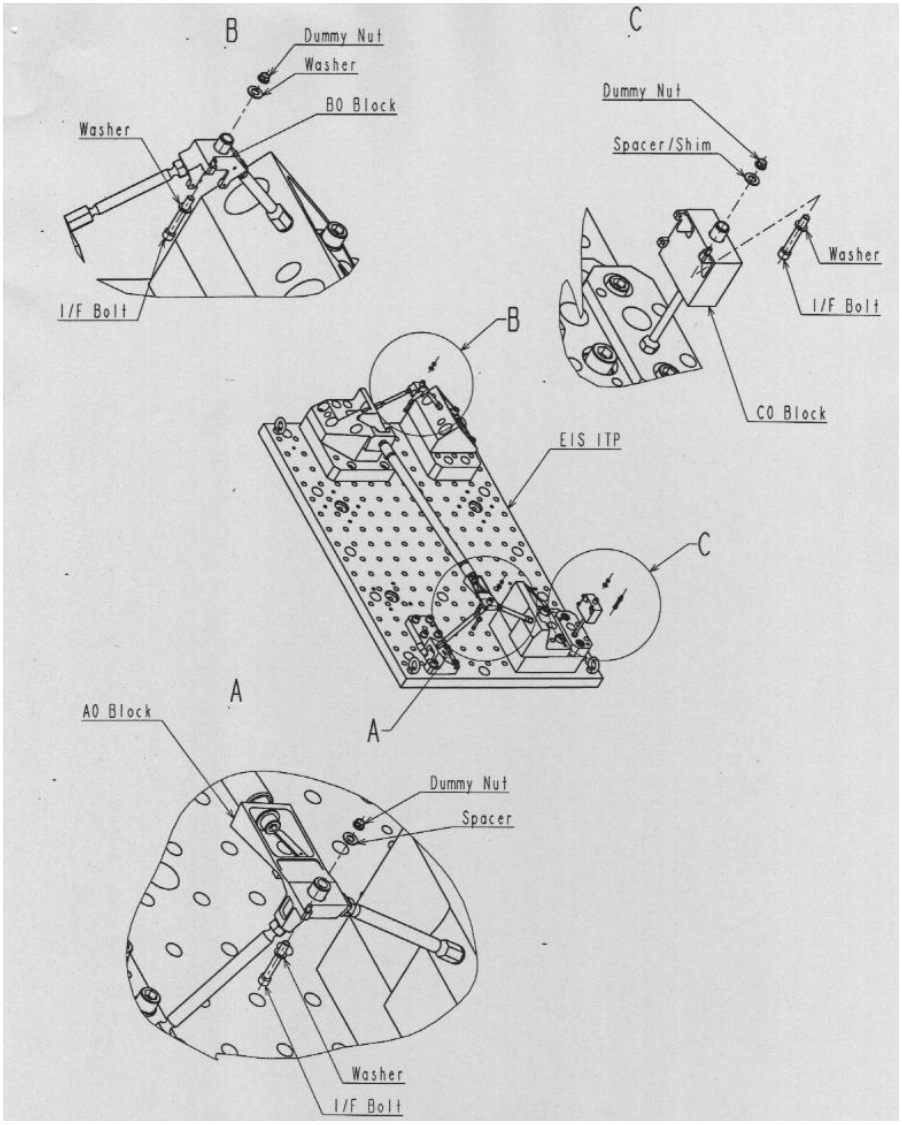


**Figure 7.1.** Definitions of A, B and C blocks.

1. Remove I/F bolts and washers from the I/F blocks (A0 Block, B0 Block and C0 Block). The interface bolts and washers are attached by dummy nuts and spacers as shown in figure 7.1.
2. Detach C0 block from the truss structure. See figure 7.2. The spacer/shims are inserted between the rod and the C0 block. Keep these spacer/shims and unscrewed nut/washer.
3. The interface bolts (or their FM replacements) and washers, C0 block and spacer/shims should be baked in accordance with the EIS Cleanliness Control Plan.
4. The ITP should be moved in its box, by forklift truck or trolley jack into the HDL outside the Visitors Centre.
5. The box should be opened and the bolts securing the ITP to the box should be removed.

6. The ITP should be lifted by crane, using the eyebolts, and deposited on the HDL floor on battens. The battens are positioned parallel to the long sides of the ITP so that a trolley jack can be used to lift it.
7. The parts of the ITP which mate to EIS will be coarse and fine cleaned, namely the A0 and B0 blocks, and inspected for cleanliness.
8. The ITP will be moved through the tunnel and into the outer (high bay) part of the clean room.
9. In the outer part of the clean room it will be rested on battens and the jack withdrawn.
10. The ITP box should be removed from the HDL back into storage.

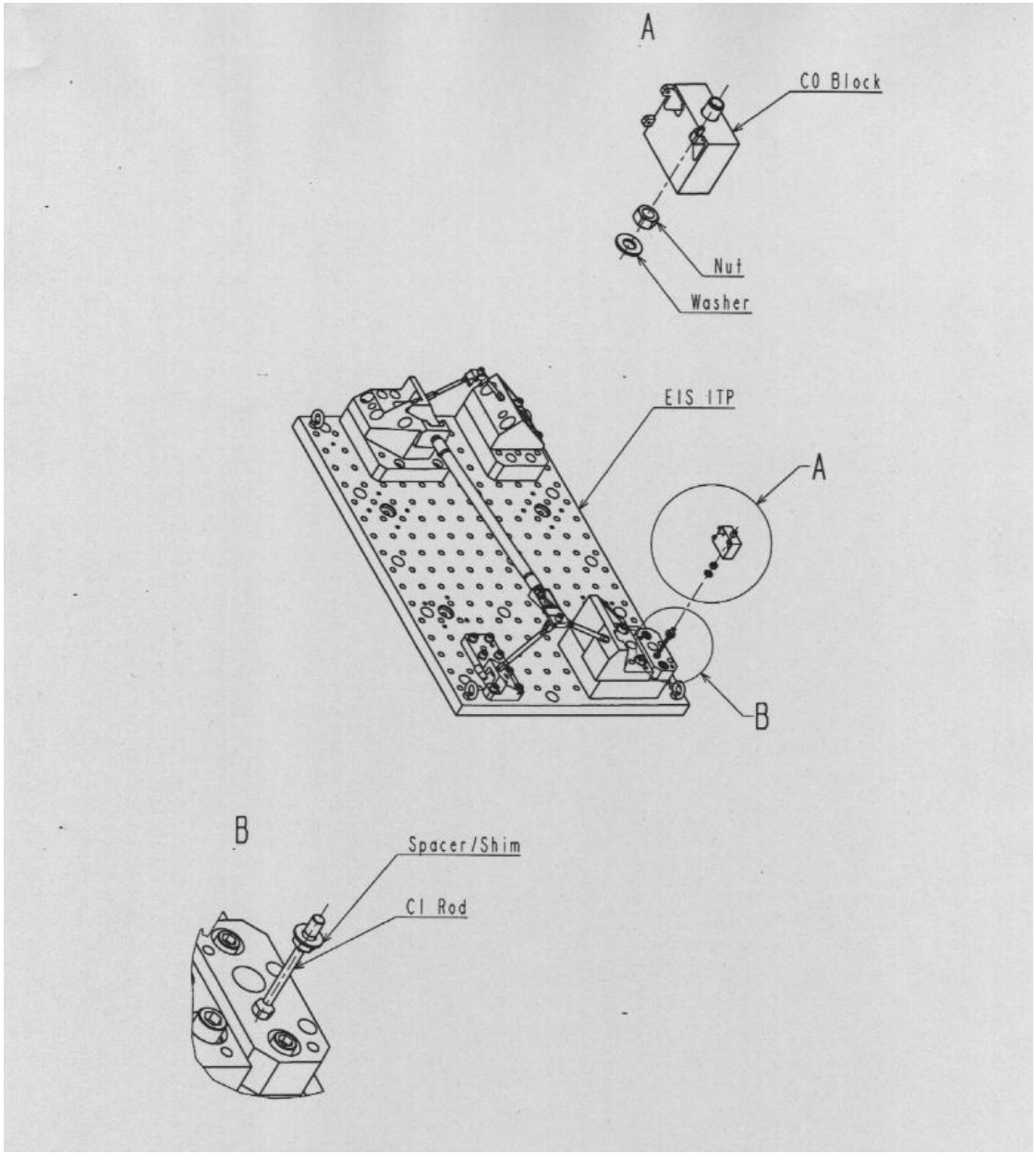


**Figure 7.2.** C0 block detachment.

### 7.1.2 Preparation of wooden box

The wooden box must be dismantled after the ITP is in the clean room. This should be done by at least three people and should be done as follows:

1. The wooden box should be moved into the HDL outside the STC.

2. Remove the lid by firstly releasing the latches on the side of the box allowing the lid to be lifted off.
3. As EIS is not in the box, the H bar will be loose in the box. Remove the H bar and it supports.
4. Remove the sides of the wooden transport box starting with the long side panels. Crosshead screws whose locations are indicated by red marks along the sides of the box hold the box sides together.
5. The mounting plate is attached to the transport box base by four large M14.5 bolts. Remove these with suitable spanners (19 mm).
6. Remove the mounting plate.

### 7.1.3 Preparation of EIS

EIS must be double bagged using Llumalloy to allow it to be removed from the clean room. This is not the place to specify the double bagging but it must meet the following requirements:

1. Allow the ITP legs to be mounted to the EIS mounting feet.
2. Allow the purge harness to be connected.
3. Allow the purge to work.
4. Allow access to TBD connector panels to permit testing with adequate flow of purge gas.
5. Allow any accelerometers to be fitted.
6. Allow the harnesses associated with, e.g., the accelerometers, to be kept clean yet usable.
7. Allow the lifting wheels to be attached and removed from EIS.
8. Once the double bag is in place, the lifting wheels should be attached to EIS while it is mounted in its handling frame.

Note that the purge should be on whenever possible.

### 7.1.4 Mounting EIS on ITP legs

With EIS double bagged in the clean room and the ITP on battens in the high-bay clean room, eight people are needed for this operation. The four who will be involved in removing EIS from its mounting frame (as described in an earlier section) will be in full clean room clothing. The others who will not touch the mounting frame can be in ordinary clean room clothing and remain in the high-bay area. The following steps should be taken to mount EIS on the ITP:

1. The double bagged EIS should be detached from its mounting frame, carried by four people using the lifting wheels, as in figure 5.1, and passed from the Class 5 area to the area where the ITP has been placed on battens. The orientation of EIS should be so that when EIS is above the ITP the pattern of its mounting holes matches that of the ITP legs.
2. Once EIS is in the high-bay area, those in the main Class 5 area should, quickly, go back to the changing room, change, exit the clean room and then enter the high-bay area correctly clothed, via the tunnel.
3. With four people holding EIS in the correct locations two others person will attach the legs to EIS. Two more people are on stand-by in case of problems.
4. The first step in attaching the legs is to fit the C0 block to EIS by tightening the I/F bolt with washer. See figure 7.3. The torque is 18.9 – 21.7 Nm.
5. Insert the spacers/shims at the C1 rod. The spacers/shims should be those detached in step 2 in section 7.1.1. See figure 7.4.
6. Slowly lower the instrument on to the mating surfaces, checking that they are parallel, while fitting the pins (A0 and B0) and rod (C0). Remember, the ITP A and B blocks should have been coarse and fine cleaned and kept clean (see earlier section).
7. Insert the interface bolts with washers at A0 and B0 blocks and screw them into the instrument. See figure 7.5.
8. Torque the A0 and B0 interface bolts to 18.9 – 21.7 Nm. See figures 7.6 and 7.7.
9. Re-install the nut/washer detached at step 2 section 7.1.1. When screwing the nut, the C1 rod should be clamped to prevent twisting.
10. Torque the nut to 56.35 – 61.25 Nm. When torquing the nut, the C1 rod should be clamped to prevent twisting. See figure 7.8.
11. The purge should be connected.

12. The lifting wheels should be removed from EIS.
13. The movement should be logged.

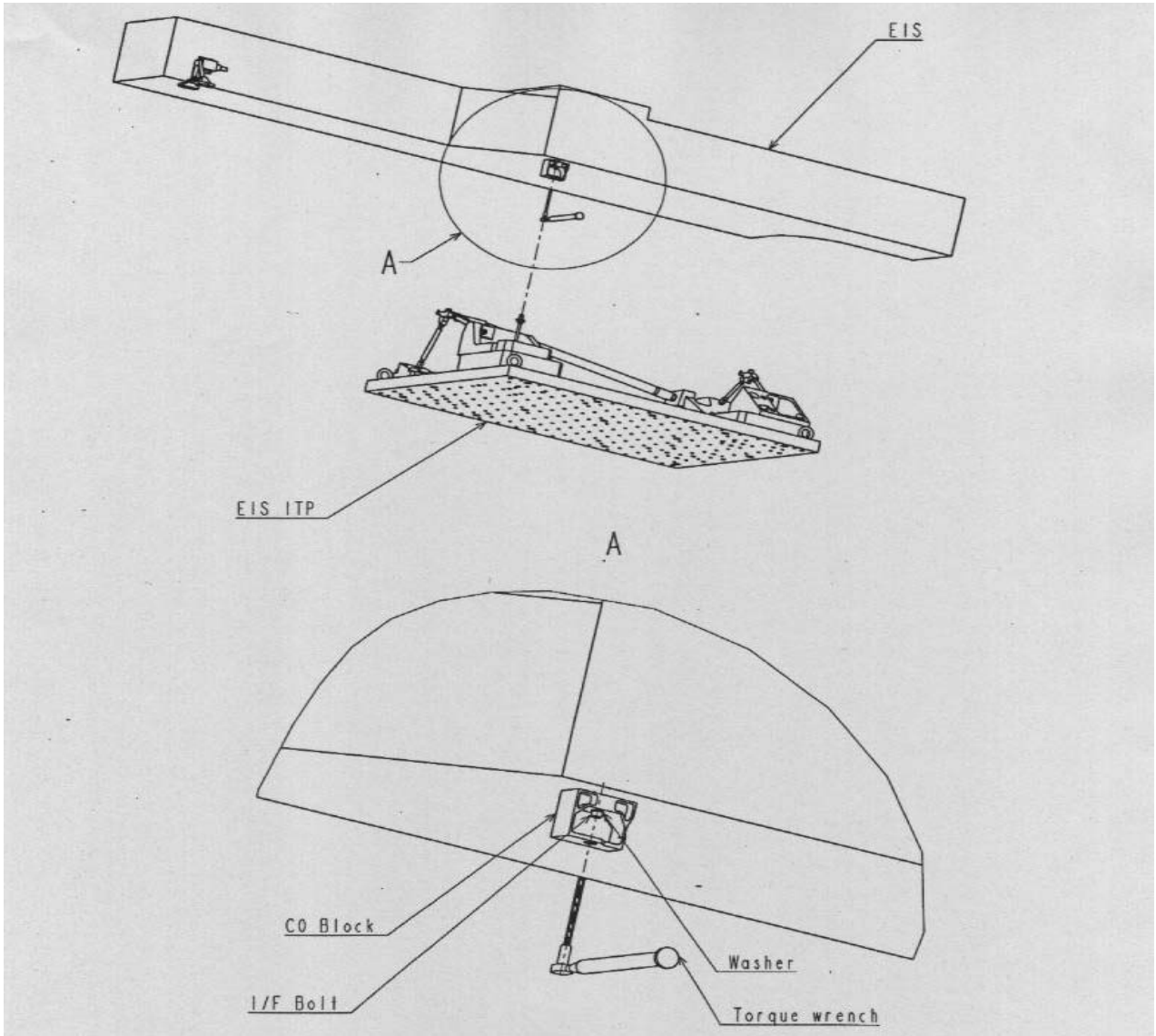


**Figure 7.3.** C0 block integration to EIS.

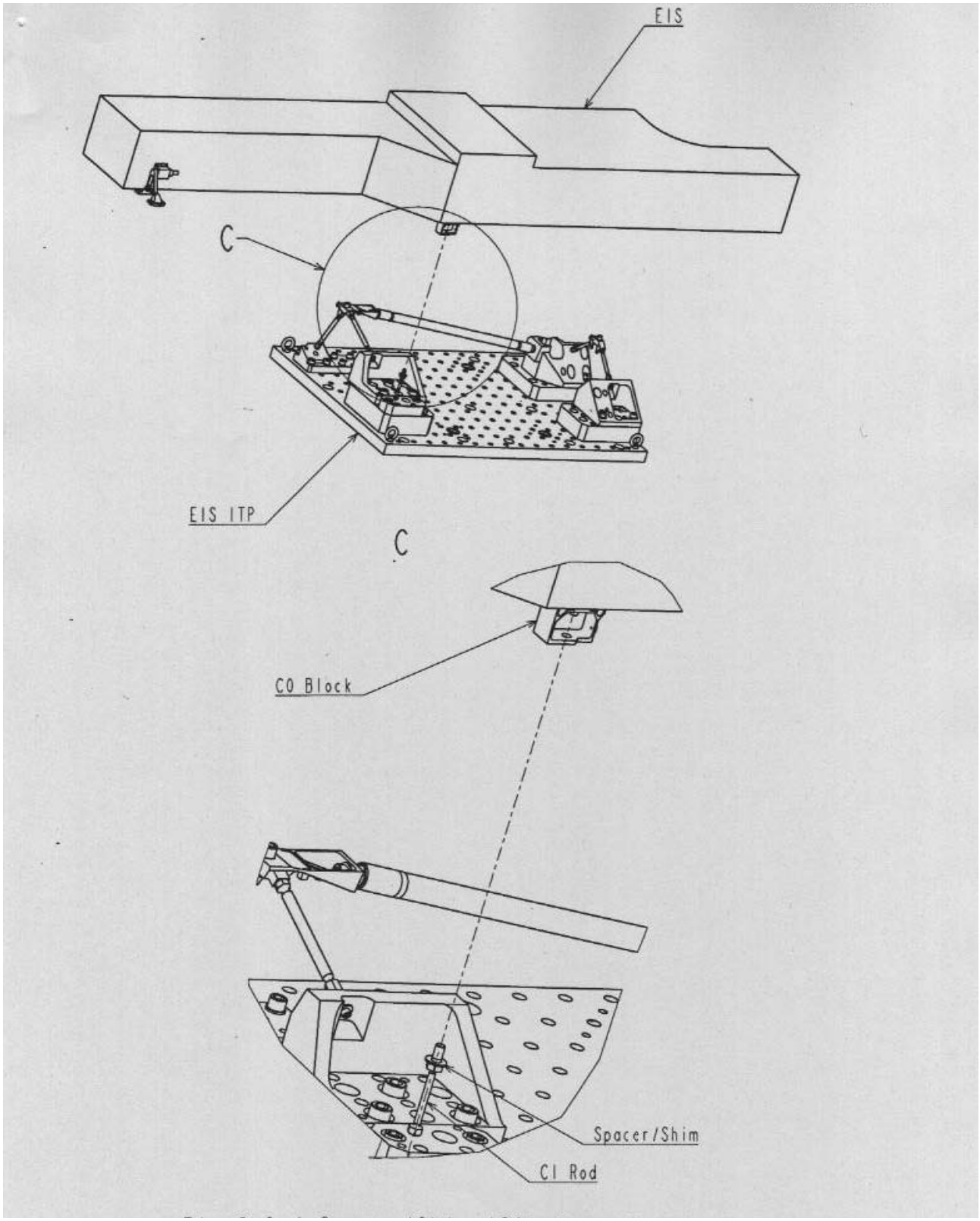


**Figure 7.4.** Spacer/shim (C0) insertion.

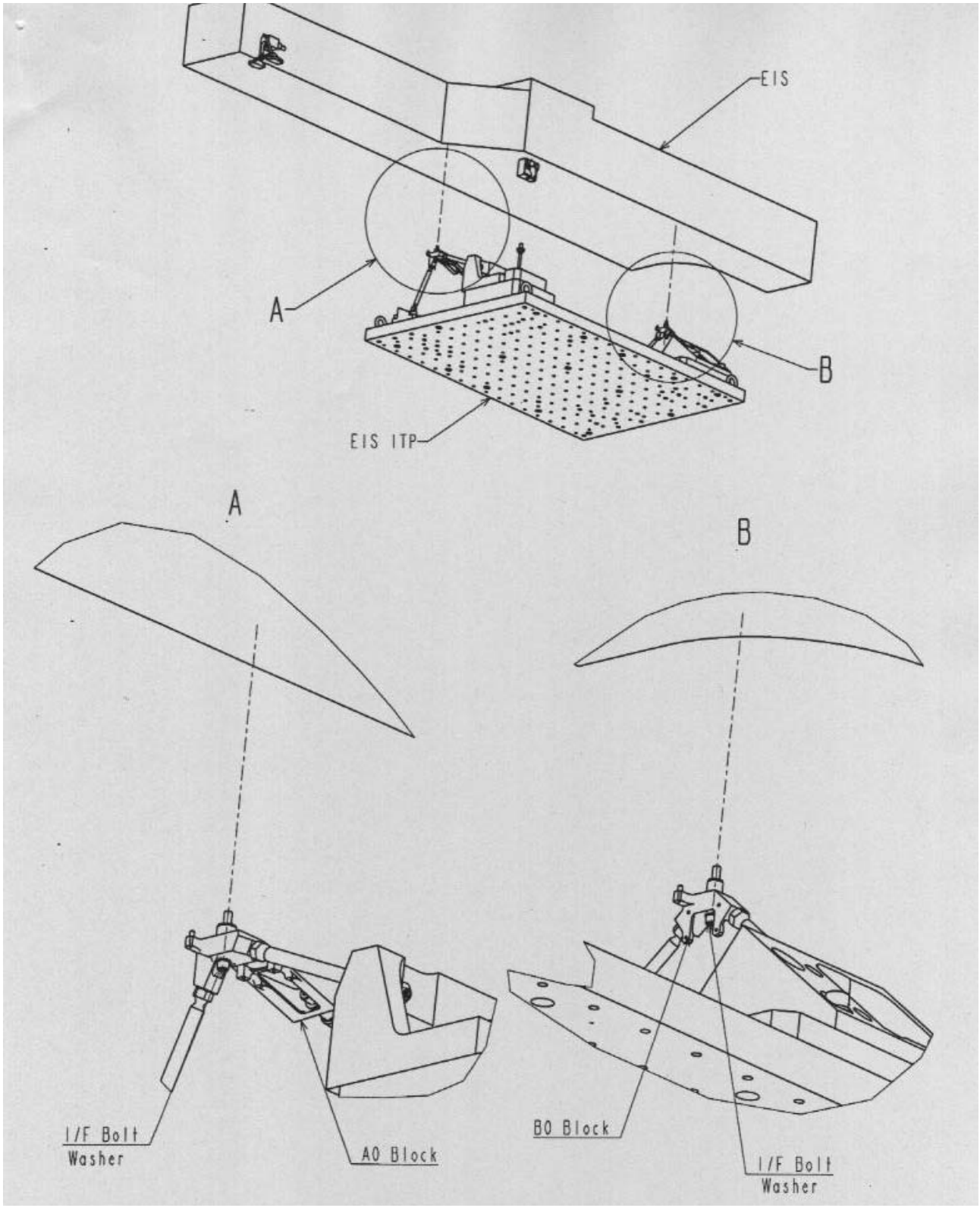


**Figure 7.5.** Interface bolt (A0, B0) insertion.

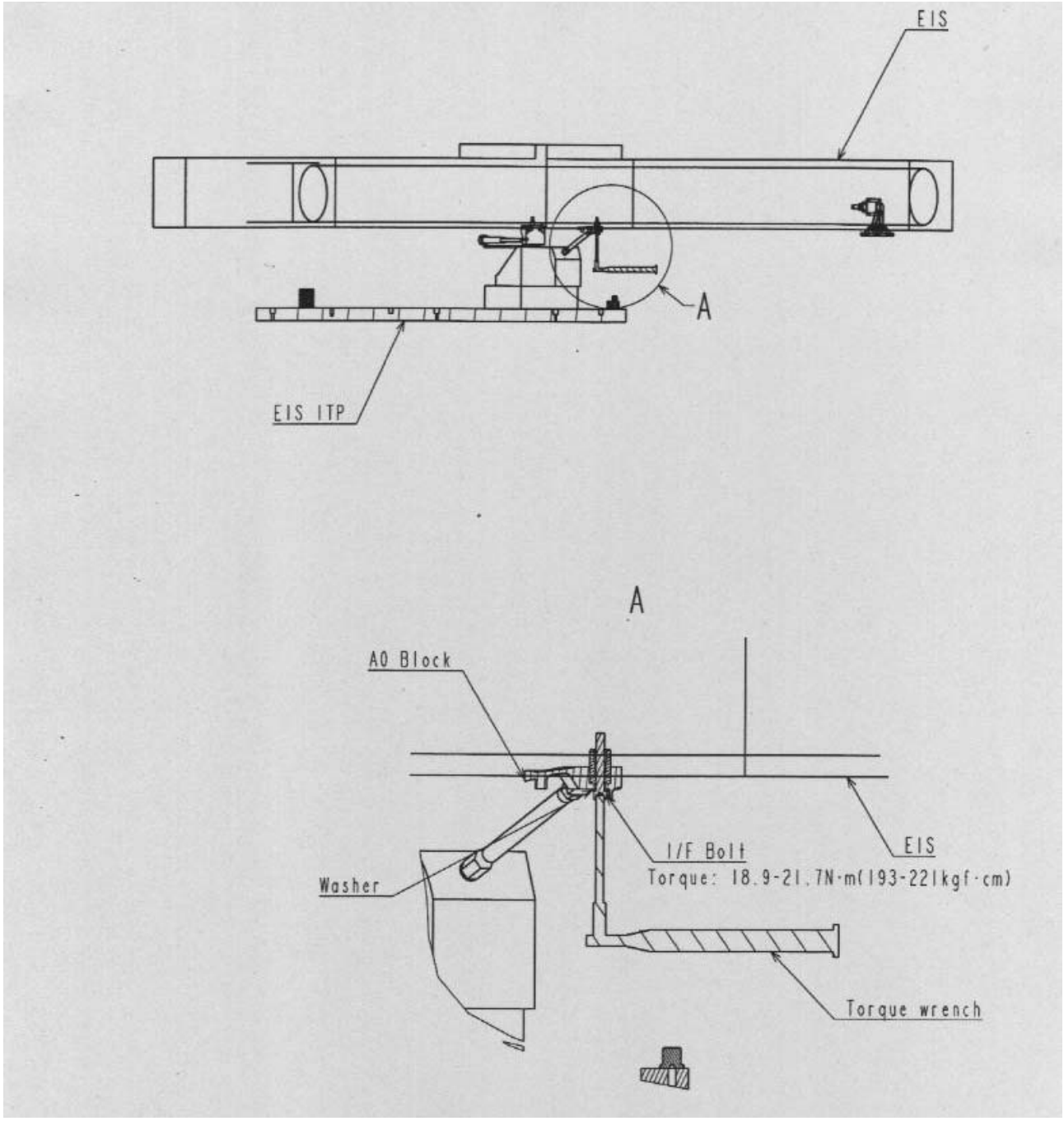


**Figure 7.6.** A0 point assembly instruction.

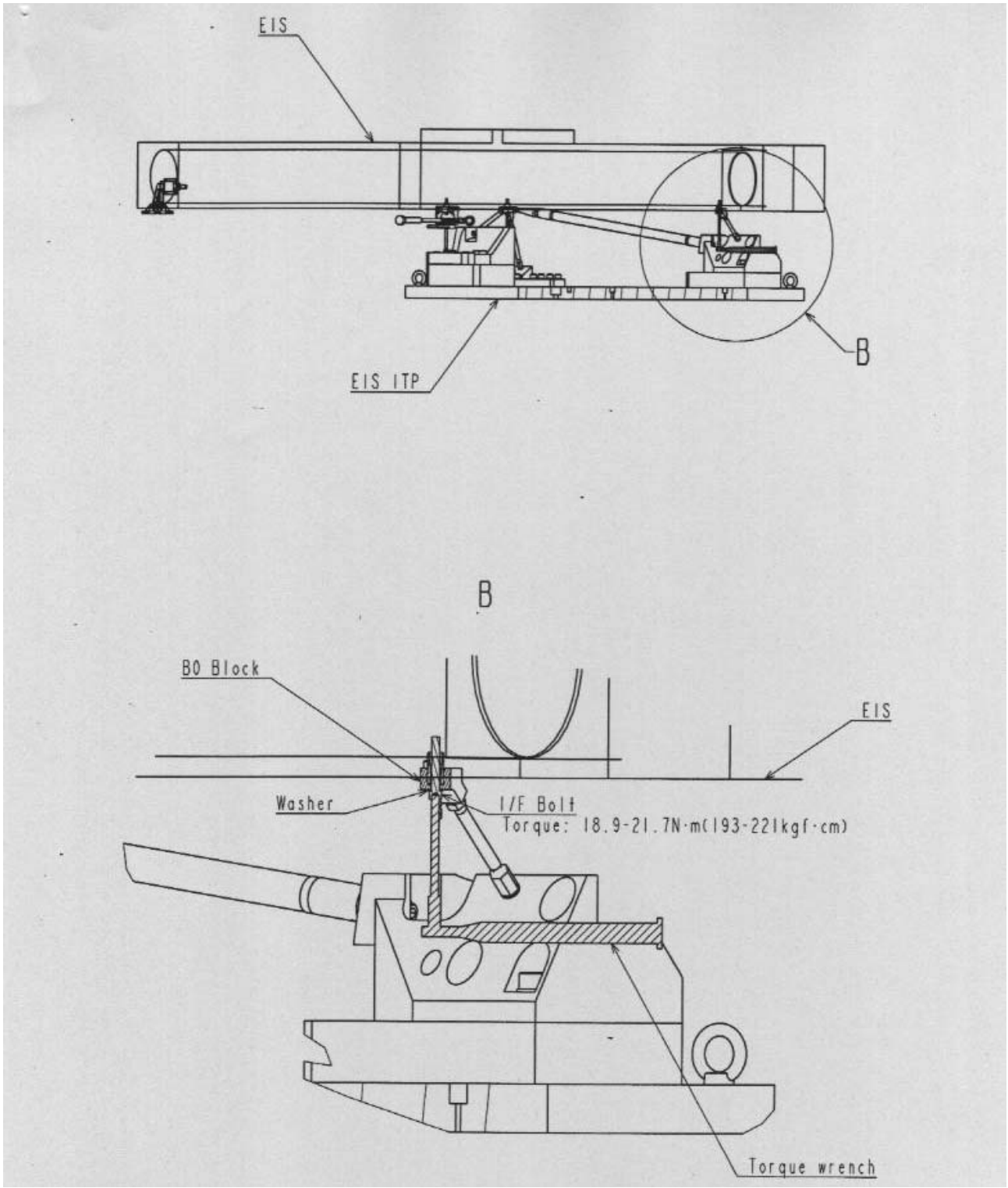


**Figure 7.7.** B0 point assembly instruction.

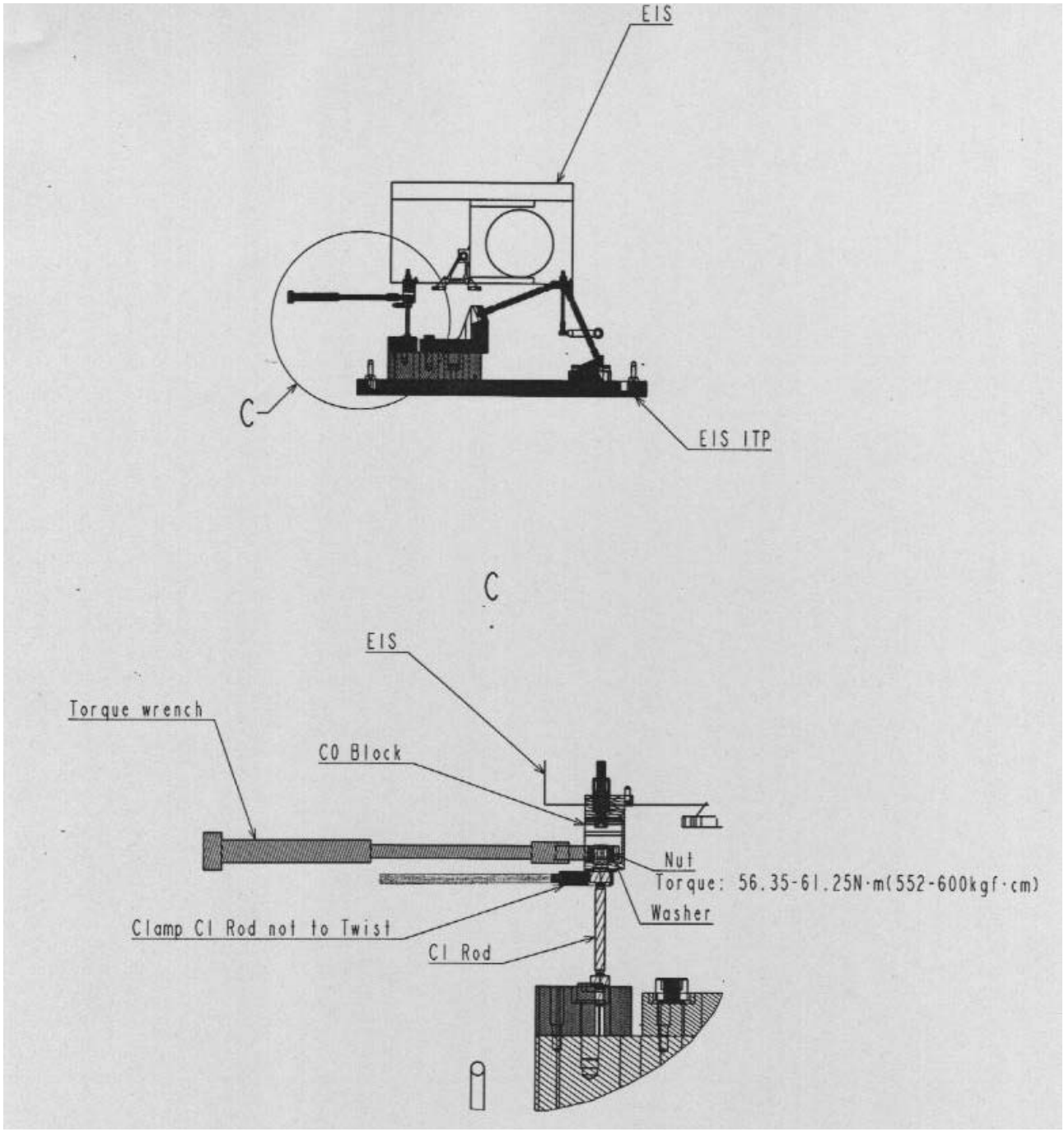


**Figure 7.8.** C0 point assembly instruction.

### 7.1.5 Removal of ITP/EIS combination from high-bay clean room and mounting on wooden box

1. The ITP/EIS combination should be moved from the high-bay room to the HDL via the tunnel using a trolley jack.
2. The ITP/EIS combination should be placed on battens and the trolley jack removed.
3. The ITP/EIS combination should be lifted using the eyebolts and the HDL crane on to the base of the wooden box. It should be positioned correctly on the base of the wooden box. The ITP does not fit

symmetrically in the wooden box. The short side adjacent to the single mounting for a leg should be mounted closer to one of the box end walls than the short side of the ITP with two leg mountings.
4. The bolts used to mount the ITP to its transport box should be used to attach the ITP/EIS combination to the wooden box.
5. Shock sensors should be attached to the ITP, their positions being TBD.
6. The handling operation should be recorded in the logbook.

### 7.1.6 Re-assembly of wooden box

Once the bagged EIS is properly mounted on the ITP and the ITP is fixed to the base of the wooden box, the wooden box can be re-assembled. This takes at least three people and has the following steps:

1. Firstly a new set of screws should be used to screw the box together.

**The box is designed to be stable with panels removed but care should be taken not to allow a panel to fall against EIS at any time.**

2. The short sides of the box should be refitted first.
3. Then the long side adjacent to the mirror side of EIS should be re-fitted.
4. The other long side should be moved into position.
5. The purge should be disconnected and the line fed through the custom-made hole in the box. The purge line should then be connected to EIS and the purging restarted.
6. This long side should be refitted.
7. The lid should be refitted and any faulty clamping clips should be replaced before the lid is secured.
8. Shock sensors should be attached to the wooden box at the marked positions (TBD).

## 7.2 Transport to/from AWE

EIS will be transported to AWE by RAL transport (TBC). The box will be loaded on to the lorry using a forklift truck. The purge will be disconnected during this operation and reconnected once the purge cart has also been loaded on the lorry. The purge will remain on until EIS is unloaded at AWE. During the unloading at AWE the purge will be off and reconnected as soon as possible after EIS is unloaded at AWE. For the return to RAL the operations will take place in the reverse order.

## 7.3 Handling at AWE

Following unloading from the lorry, EIS will need to be removed from the wooden box. During this work the purge should only be off for a minimum amount of time. The procedure to dismantle the box is as follows and needs three people at least.
1. Check and log the condition of the shock sensors.
2. Remove the lid by firstly releasing the latches on the side of the box allowing the lid to be lifted off.
3. Remove the sides of the wooden transport box starting with the long side panels.

**The box is designed to be stable with panels removed but care should be taken not to allow a panel to fall against EIS at any time.**

4. The first panel to be removed is marked with the words ‘remove this panel’.
5. Crosshead screws whose locations are indicated by red marks along the sides of the box hold the box sides together.
6. Once the box is dismantled, the EIS/ITP unit can be freed from the box by undoing the attachment bolts.

7. EIS can then be lifted to the vibrator using the ITP eyebolts.

After the vibration, EIS/ITP can be re-packed into the box and the box re-assembled as follows. This takes at least three people.
1. The EIS/ITP unit will be lifted back on to the wooden base unit and attached using the mounting bolts.
2. A new set of screws should be used to screw the box together.

**The box is designed to be stable with panels removed but care should be taken not to allow a panel to fall against EIS at any time.**

3. The short sides of the box should be refitted first.
4. Then the long side adjacent to the mirror side of EIS should be re-fitted.
5. The other long side should be moved into position.
6. The purge should be disconnected and the line fed through the custom-made hole in the box. The purge line should then be connected to EIS and the purging restarted.
7. This long side should be refitted.
8. The lid should be refitted and any faulty clamping clips should be replaced before the lid is secured.
9. Any 'activitated' shock sensors should be replaced, and the replacement logged.

After this the wooden box and purge can be returned to RAL (see section 7.2).

## 7.4 Removal of EIS from shipping container at RAL and return to clean room

When the wooden box has been returned to RAL and moved from the lorry to the HDL near the visitors centre, the wooden box can be unpacked, ITP/EIS disconnected from the base of the wooden box and then moved back into the clean room. Thus the handling falls into three stages.

### 7.4.1 Dismantling of the wooden box

The dismantling of the wooden box should be done by at least three people and should be done as listed below. During this work the purge should only be off for a minimum amount of time.
1. Check and log the condition of the shock sensors.
2. Remove the lid by firstly releasing the latches on the side of the box allowing the lid to be lifted off.
3. Remove the sides of the wooden transport box starting with the long side panels.

**The box is designed to be stable with panels removed but care should be taken not to allow a panel to fall against EIS at any time.**

4. The first panel to be removed is marked with the words 'remove this panel'.
5. Crosshead screws whose locations are indicated by red marks along the sides of the box hold the box sides together.

### 7.4.2 Removal of ITP/EIS from base of wooden box

This is the reverse of the work in section 7.1.5.

### 7.4.3 Separation of EIS from the ITP

This is the reverse of section 7.1.4.

### 7.4.4 Returning EIS to the clean room

1. Once free from the ITP, EIS can be carried through the tunnel into the clean room outer high-bay area.

2. The bagged EIS should be placed on the two battens (used previously) each laid on a trolley which has been covered in fresh Llumalloy. This manoeuvre is described within section 5.1.1
3. The bag can then be vacuumed to remove any dust.
4. The outer bag can then be removed.
5. Then EIS can be taken into the Class 5 area and attached to the handling frame as in the procedure detailed earlier.
6. Skilled staff can then remove the remaining bag.

EIS is then available for the next part of the AIV procedure.

# 8. HANDLING OPERATIONS FOR THERMAL VACUUM TESTING

It is assumed that before these handling operations are undertaken that a TRR has been held and that EIS was declared ready for thermal vacuum testing with the procedures as defined in the EIS FM Thermal Vacuum Test Plan.

The thermal vacuum test will be carried out in the STC at RAL. As only a thermal vacuum test is planned there is no need for the MLI to be fitted to EIS. However, as the STC and the clean room are not in the same clean area, EIS must be adequately protected to move from one area to the other.

For the MTM/TTM thermal balance test in the STC, the thermal blankets were in place. Consequently, the best place to mount EIS was using the mounting feet holes and EIS was mounted lid down. The handling procedure involved seven people at one point, was complex and risky. For the FM thermal vacuum test the thermal blankets will not be fitted. EIS will be mounted feet down in the STC.

For the thermal vacuum test it is planned that EIS is tested while attached to the mounting frame but without the template. The frame will be placed on a platform in the STC such that the cabling problems are minimised. The platform can easily be moved to allow this. The thermal coupling between the frame and the platform is TBD.

In the following it is assumed that the thermocouples and associated harnesses have been cleaned, mounted on EIS on the correct locations and cabled as defined in the EIS FM Thermal Vacuum Test Plan. It is also assumed that an appropriate TRR has been held before the handling operations commence and that EIS is ready for thermal vacuum testing.

It is assumed that the moving between clean rooms will be done quickly and that purging of EIS is not necessary.

## 8.1 Moving EIS from the clean room to the STC clean room

EIS and the mounting frame have both been separately baked and they both must be bagged for the transfer. The following steps must be undertaken to move EIS from the clean room to the STC. It is assumed that the door to the STC clean room is unlocked and can be opened for a minimum time to allow the equipment to enter the STC area.

1. Enough clean polythene to cover the floor and make a clean pathway for the clean room trolleys from the high-bay/tunnel door to the STC entrance should be cut from a roll and left in the tunnel.
2. EIS should be loosely bagged, independently of the mounting frame.
3. The combined EIS and mounting frame should then be loosely double bagged together.

4. Handling places at the corners of the frame should be identified and additional Llumalloy strengthening should be put at these positions. This strengthening has two purposes, one to give more than doubling bagging at the vulnerable points and also to make these points easier to handle.
5. Two teams of three people are needed for transfer. One team will be in full clean room gear as defined in the cleanliness control plan. The other team will enter the outer clean room with clean room clothing, including gloves as necessary for that area.
6. In the clean room, the clean team will take the bagged EIS and mounting frame combination and place it on two clean room trolleys whose tops have been covered in fresh Llumalloy.
7. They will push the loaded trolleys from the clean room through to the outer clean room.
8. The clean team should then go via the changing room to the STC clean room to receive EIS.
9. Two people from the high-bay area should remove their clean room clothing apart from gloves. They should then roll out the clean polythene carpet from the high-bay to the STC. Then they should change their gloves.
10. The team in the outer clean room will push EIS into the tunnel. This team will remove clean room clothing in the tunnel, apart from gloves.
11. The gloved team will pass EIS from the tunnel to the STC as quickly as possible.

## 8.2 Mounting EIS in the STC

Before this manoeuvre takes place, checks should be carried out to make sure that the STC trolley to receive the equipment is in the correct place, the thermal contacts between EIS and the handling frame and the handling frame and the STC mounting plate are as agreed (and confirmed by the TRR) and that the orientation of the equipment has been agreed.

Note that that EIS and the mounting frame are still bagged, one round EIS and one round the combination of EIS and the mounting frame. This is bagging is necessary as the work needs seven people, six to do the lifting and one on stand-by, in case of any unforeseen problem(s), and the number of people exceeds that allowed round un-bagged equipment in the Cleanliness Control Plan.

The following steps are needed to get EIS into position in the STC.

1. The outer Llumalloy bag should then be carefully removed and disposed of, avoiding contaminating the remaining bagging.
2. EIS should be moved to be as close as possible to the STC and approximately aligned with its long axis parallel to the centre line of the STC.
3. Two people should enter the STC and position themselves to receive the equipment.
4. Two people should lift the equipment on to an STC trolley which is only slightly higher than the clean room trolleys. The STC trolley will have been covered in new Llumalloy.
5. Two people outside the STC will push the STC trolley into the tank to the staff inside the STC. When the equipment is in position, only two people should remain in the STC.
6. The remaining two people should take of the outer bag carefully.
7. The inner bag should be removed carefully.
8. The movement should be logged.
9. The harnessing of EIS can now take place.

## 8.3 Removing EIS from the STC

This is the inverse of mounting EIS in the STC, noting that the bagging needs to be redone.

## 8.4 Moving EIS from the STC clean area to the clean room

This is the inverse of moving EIS from the clean room to the STC.

# 9. HANDLING OPERATIONS FOR CALIBRATION

This is covered in section 5.4.

# 10. HANDLING OPERATIONS FOR PACKING EIS FOR SHIPPING TO JAPAN

Following any shipping readiness TRR and the performance of any agreed tests, EIS will be prepared for shipping. This falls into two main areas, the fitting of the MLI and the packing EIS.

## 10.1 Fitting of MLI

This is a specialist task and will be undertaken by those who made the MLI following a script developed by them. This will be done in a Class 5 clean room.

## 10.2 Packing EIS in the shipping container

The shipping container cannot enter the Class 5 clean room. It is large and at best can only enter the tunnel or be in the HDL at the STC. It is assumed that EIS will be shipped double bagged in Llumalloy. The bagging is a specialist job and is not detailed here. To pack EIS in the shipping container the following steps must be undertaken.

1. The double-bagged EIS with its MLI on will be fitted on its transport frame (see earlier). The transport frame will be then be bagged. The bagging must allow EIS to be mounted in the shipping container and secured.
2. The shipping container will be placed as close as possible to the Class 5 clean room.
3. Four people (EIS is bagged) dressed for and in the Class 5 clean room will pass the bagged EIS to four people correctly dressed for the high-bay area.
4. Those in the Class 5 area will exit the clean room as normal and then enter the tunnel with clean room gloves on.
5. Those in the high-bay area will place the bagged EIS with frame on two trolleys whose tops have been covered in new Llumalloy.
6. The trolleys will then be moved such that EIS is as close to the shipping container as possible.
7. EIS on its transport frame will be progressively moved from the trolleys and slid along the mounting rails to the correct position in the container. The correct position is TBD.
8. Once in the correct position, the equipment will be fixed to the tank. The method of doing this is TBD.
9. The tank will be sealed and kept at a pressure of TBD.
10. Shock sensors should be installed on the outside of the shipping container at TBD locations.
11. The movement should be logged

## 10.3 Packing the purge cart

The purge cart should be packed in its shipping container for shipping to Japan.

# 11. APPENDIX 1 MANUAL HANDLING RISK ASSESSMENTS

The previous sections of this document essentially detailed the steps needed to move EIS during AIV. The objectives were to move EIS without damaging it or compromising its cleanliness. However, the health and safety of the staff doing the work must be considered, particularly with reference to the Manual Handling Operations Regulations 1992. These Regulations are based on an EC Directive requiring employers to avoid manual handling tasks which may give rise to injury and, where such manual handling cannot be avoided, to make an assessment and to take appropriate measures to remove or reduce the risk of injury. The Regulations apply to the handling of EIS during AIV as the work involves manual handling. The risk of injury exists, e.g., if EIS in its mounting frame is dropped and hits someone's foot. It is not reasonably practicable to avoid moving the load and it is not reasonably practicable to automate or mechanise the operations. There are no specific requirements in the Regulations for a weight limit. The weight of EIS is estimated at 55 kg and its template at 30 kg. As these are above the guidelines, a manual handling assessment is appropriate. It should be noted that the manual handling is infrequent i.e. there could be days between lifts.

As the procedures described in the body of the plan were designed both to minimise the risk of damaging or compromising the cleanliness of EIS and to minimise any manual handling risks to the people involved, the manual handling assessments are straightforward. Indeed, the requirement to keep records is fulfilled by the requirement in the plan that each movement of EIS is recorded.

In carrying out the manual handling assessment the tasks can be divided into two classes, the first is handling operations in the clean room, for thermal vacuum testing, for calibration and for packing for shipping and the second for EMC and vibration testing operations. The assessment requires five areas to be considered, namely, the tasks, the loads, the working environment, individual capability and other factors.

In considering the tasks, it is necessary to assess if they involve the following:
1. Holding loads away from the trunk
2. Twisting
3. Stooping
4. Reaching upwards
5. Large vertical movements
6. Long carrying distances
7. Strenuous pushing or pulling
8. Positioning of the load precisely
9. Unpredictable movement of loads
10. Repetitive handling
11. Insufficient rest or recovery
12. A workrate imposed by a process.

In considering the loads, it is necessary to establish the following aspects of the load.
1. Is it heavy?
2. Is it bulky/unwieldy?
3. Is it difficult to grasp?
4. Is it unstable/unpredictable?
5. Is it intrinsically harmful (e.g. sharp, hot)?

In considering the working environment, the following question should be considered.
1. Are there constraints on posture?
2. Are there poor floors?
3. Are there variations in levels?
4. Are there hot/cold/humid conditions?

5. Are there strong air movements?
6. Are there poor lighting conditions?

In considering individual capability, the following should be considered.
1. Does the job require unusual capability?
2. Does the job hazard those with a health problem?
3. Does the job hazard those who are pregnant?
4. Does the job call for special information?

Finally, any other factors should be assessed. For example, is movement or posture hindered by clothing or personal protective equipment?

For questions where the answer is yes, firstly the level of risk, namely low, medium or high, needs to be established. Then the problems associated with such questions should be identified and remedial action suggested.

The following section gives assessment details for the two cases.

## 11.1 Manual handling assessments for operations in the clean room, thermal vacuum testing, calibration and packing for shipping

In this case, when considering the tasks, the replies to all the questions are negative. For the questions on the load, the answers again are no. Although the item is large, the use of the frame and two or more people with a defined procedure make the answer negative. It is assumed that the handling procedures are followed and the EIS lifting wheels and transport frame are used as detailed. Where the load needs to be positioned precisely, i.e., in the blue tank or shipping container, the load will be resting on rails so that its full weight is not being taken. The handling is all from bench to trolley etc. and all are at about waist height and over short distance e.g. a step or two to the side. The working environment in this case is a clean room kept at a fixed temperature and humidity. Considering the individual capability, the answers are all no. However, special information and training are required to keep the equipment at the necessary cleanliness levels and all staff involved with be cognisant with the requirements. Note that for the thermal vacuum test, as the equipment is to be placed near the floor of the STC and not suspended along the centre-line there is no large vertical movement of the load. Lastly considering other factors, those involved in the work will be dressed in clean room clothing. It is appreciated that this can be uncomfortable and hot. To obviate discomfort, the clean room temperature will be reduced. Team handing is involved in all the procedures and a team leader will be nominated for each operation.

## 11.2 Manual handling assessment for EMC and vibration testing

For these handling operations, the differences from the previous section are that operations involving a crane and/or forklift truck are involved. The operator of the crane or forklift will need to make the appropriate risk assessment for its use and log the lift if appropriate. The work will be co-ordinated by the team leader.