SEGMENT SUPPORT ASSEMBLY (SSA) MODULE ASSEMBLY ACCEPTANCE TEST PROCEDURE

TMT.OPT.TEC.12.088.REL01

Initiator/Author: Robert Bernier

September 12, 2012
## Changes Page

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Description</th>
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<th>Change Owner</th>
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<td>9/12/12</td>
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</tr>
</tbody>
</table>
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TABLE OF CONTENTS

1 PURPOSE / SCOPE ........................................................................................................................................... 6
2 TESTING OVERVIEW .................................................................................................................................... 6
3 TEST SETUP .................................................................................................................................................. 6
  3.1 DESCRIPTION ............................................................................................................................................... 6
  3.2 PURPOSE OF TEST ........................................................................................................................................ 7
  3.3 TEST SETUP / CONDITIONS .......................................................................................................................... 7
  3.4 ACCEPTANCE VERIFICATION ....................................................................................................................... 9
  3.5 MATERIALS USED: ...................................................................................................................................... 10
  3.6 ENVIRONMENT .......................................................................................................................................... 10
  3.7 CONTAMINATION CONTROL: ..................................................................................................................... 10
  3.8 DOCUMENTATION REQUIRED .................................................................................................................... 11
  3.9 SSA MODULE SAFETY: ............................................................................................................................... 11
  3.10 SSA MODULE ASSEMBLY HANDLING REQUIREMENTS: ............................................................................ 11
  3.11 SSA MODULE CONTAMINATION: ................................................................................................................ 11
  3.12 GROUND RULES DURING SSA MODULE MOTION: ..................................................................................... 11
  3.13 EQUIPMENT REQUIRED: ............................................................................................................................ 12
4 REQUIRED PERSONNEL, MATERIAL, AND EQUIPMENT ......................................................................... 12
  4.1 NUMBER OF PERSONNEL AND LEVEL OF TRAINING REQUIRED .............................................................. 12
  4.2 PERSONNEL VERIFICATION ......................................................................................................................... 13
5 TEST PROCEDURE ....................................................................................................................................... 13
  5.1 ASSEMBLE THE SSA MODULE IN THE TEST FIXTURE ................................................................................ 13
  5.2 FUNCTIONAL TESTS: ..................................................................................................................................... 14
  5.3 SECURE THE WHIFFLETREES ......................................................................................................................... 15
  5.4 METROLOGY ............................................................................................................................................. 16
  5.5 DATA REPORTING .................................................................................................................................. 17
6 CONFORMANCE VERIFICATION ............................................................................................................ 18
  6.1 PASS FAIL DOCUMENTATION .................................................................................................................... 18
  6.2 OUT OF TOLERANCE SPECIFICATIONS ...................................................................................................... 18
7 APPLICABLE/REFERENCE DOCUMENTS ............................................................................................. 18
  7.1 TMT PUBLICATIONS ............................................................................................................................... ... 18
  7.2 REFERENCE DOCUMENTS ............................................................................................................................ 18
8 SEGMENT SUPPORT ASSEMBLY ALIGNMENT CHECKLIST ...................................................................... 20
  8.1 REQUIRED PERSONNEL: ............................................................................................................................. 20
  8.2 MATERIAL USED: .................................................................................................................................. 20
8.3 PERSONAL PROTECTIVE EQUIPMENT REQUIRED: .......................................................... 20
8.4 EQUIPMENT LIST: ........................................................................................................... 20
8.5 SSA MODULE ASSEMBLY SAFETY ........................................................................... 21
8.6 GROUND RULES ....................................................................................................... 21
8.7 CHECKLIST FOR SECTION 5.0 ............................................................................. 22
8.8 PERSONNEL ............................................................................................................. 22
8.9 OPERATIONAL STEPS .......................................................................................... 22

9 INSPECTION FORM ........................................................................................................... 24

9.1 TMT SEGMENT SUPPORT ASSEMBLY (SSA) MODULE ........................................ 24
9.2 SUBCONTRACTOR ______________________________________________________________ 24
9.3 TMT SERIAL NUMBER __________________________________________________________ 24
9.4 TMT PART NUMBER ___________________________________________________________ 24
9.5 TMT REVISION NUMBER ______________________________________________________ 24

BALLOON # .......................................................................................................................... 24
CHARACTERISTICS ........................................................................................................... 24
PRINT REQUIREMENTS .................................................................................................... 24

ACTUAL 24

PASS/FAIL ......................................................................................................................... 24

INSPECTED BY ______ DATE: ______ APPROVED ______ DATE: ___________________________ 24

9.6 TMT APPROVAL ______________________ DATE: _________________________________ 24
1 PURPOSE / SCOPE
This document describes Operational Procedures for the Factory Acceptance testing of the Segment Support Assembly (SSA) Module Assembly, M1S-100-01200. This procedure shall be used at the SSA vendor to verify dimensions and report data associated with each TMT SSA Module Assembly. The tests will verify the as built dimensions of the SSA Module Assembly defined on the SSA Inspection Drawing (M1S-100-1201) while it is supported by the SSA Inspection Fixture M1S-930-00200. The tests will also verify the form, fit, and function of various SSA Module Assembly Components.

2 TESTING OVERVIEW
Testing will be performed using calibrated instrument measurements while the SSA Module Assembly is supported on the test fixture. Gauges, Micrometers, pass – fail indicators, Coordinate Measuring Machines (CMM) and laser trackers may be used to verify and quantify as built features of the TMT SSA Module Assembly. Visual Inspection will determine if the SSA Module Assembly is complete, properly assembled, within dimensional tolerance, and damage free. Functional Tests include power-on testing of the 21 Warping Harness Leaf Springs using the TMT-supplied test box and plug. All 21 Warping Harness Actuators will also be power-on tested to verify that they are functional. Data will be recorded both digitally and manually in the acceptance test procedure. The vendor shall provide the data to TMT, along with a recommendation on Pass/Fail.

3 TEST SETUP
3.1 Description
When the SSA Module Assembly is free-standing (not attached to a mirror), the whiffletrees (parts of the SSA) can move freely (tip/tilt) over a range of angles. Because of this, it is not possible to make dimensional measurements when the SSA is unrestrained. In order to make the required dimensional inspections, it is first necessary to support the whiffletrees in a suitable manner. The test is performed by placing the SSA Module Assembly in the “SSA Acceptance Test Fixture” part number M1S-920-00800 to test the alignment of the SSA subassemblies and parts. The drawing that shows the SSA in test configuration is: M1S-920-01201, “SSA Acceptance Test Fixture” See Figure 1.
### 3.2 Purpose of Test

The purpose of this acceptance test is to verify that the alignment and position of the parts as well as the specific configuration of the hardware is correctly assembled and within specified tolerances. Functionality of the Warping Harness actuators and Leaf spring strain gauges will also be checked.

### 3.3 Test Setup / Conditions

The SSA Module Assembly will be assembled into the test fixture which itself is sitting inside of a large CMM envelope or equivalent metrology system such as a Faro Arm. The SSA Acceptance Test Fixture has three support columns that interface with the precision alignment features at the ends of the SSA Moving Frame arms in order to support and position the SSA Module Assembly in all six degrees of freedom during measurements. The CMM will be used to measure the resulting datum positions of the
moving frame and the other features of the SSA Module. The temperature of the metrology room measuring the SSA should be as defined in section 3.6.2.

3.3.1 SSA Locks: The SSA locks must be placed in the “Locked” position (Horizontal) prior to performing all inspections or measurements.

Figure 2. Tower Locks in the Horizontal Locked Position
3.4 **Acceptance Verification**

The SSA Module Assembly needs to be verified before the assembly is accepted at the supplier. Verification of the product (subsystem or subassembly) against requirements and test parameters identified as requirements in the subsystem documentation. The SSA Module Assembly Acceptance Test shall consist of verifying the following parameters:

3.4.1 Verification of key physical and interface parameters.

3.4.2 Verification of Configuration.

3.4.3 Verification of Function.

3.4.4 Verification of Fit.

3.4.5 Verification of Form.

3.4.6 Dimensional Inspection.

3.4.7 Power-on Tests.

3.4.8 Sheet Flexure Flatness.

3.4.9 Lock Motion and Engagement.

3.4.10 Verification of quality of workmanship.

3.4.11 Verification of a complete set of as-built documentation.

3.4.12 Validation and commissioning acceptance testing plans and reports shall be reviewed and approved (and witnessed if possible) by TMT QA personnel.

3.4.13 The test shall be performed in accordance with the current version of the appropriate test procedure.

3.4.14 Instruments and gages used to determine performance characteristics must be within the range of acceptable calibration parameters, including inspection cycles and tested against known standards.

3.4.15 Tests shall be conducted in the order specified by the test procedure unless otherwise authorized by TMT.
3.4.16 Completed tests results shall be documented on authorized summary forms or test data sheets.

3.4.17 Any deviations from the test procedure or discrepancies noted during the conduct of the test shall be documented.

3.4.18 If appropriate, and to the extent practical, a post-test inspection shall be conducted of the item under test, for the purpose of identifying and recording any changes that may have occurred as a result of the test.

3.4.19 The CMM will measure the three moving frame datum positions which define the SSA coordinate system. The CMM will then measure the features of the SSA. It is important to measure the whiffletree structures while the whiffletrees are constrained parallel.

3.4.20 *Note: in this context, verification will be mainly achieved by visual inspection and review of supplier documents and data. Some items may also be required to demonstrate operational acceptance. Acceptance testing shall be performed after completion of all required operations. Acceptance testing requirements are as follows:

### 3.5 Materials Used:

3.5.1 Gloves (Neoprene)

3.5.2 Personal Protective Equipment Required:

Standard PPE (i.e. protective shoes, shop coat, gloves, safety glasses, hard hat)

### 3.6 Environment

3.6.1 Environmental requirement:

The area where the test is taking place should be clean and free from dust. The metrology fixture should be clean and wiped down with IPA before it is assembled with the SSA.

3.6.2 Thermal Environment

Ambient Temperature should be controlled to 20°C +/- 0.5°C

### 3.7 Contamination Control:

3.7.1 Change gloves after touching anything that may be contaminated
3.7.2 Use Appropriate Glove protocol in changing gloves

3.7.3 Discard used gloves in appropriate containers after changing them

3.8 **Documentation Required**

3.8.1 “SSA Module Assembly Acceptance Test Procedure” part number: TMT.OPT.TEC.12.088

3.9 **SSA Module Safety:**

The following definitions may apply to this document:

3.9.1 **Hazard**: Personal injury may occur – DO NOT DISREGARD

3.9.2 **Caution**: Equipment damage may occur, but not personal injury

3.10 **SSA Module Assembly Handling Requirements:**

3.10.1 Only Handle the SSA using approved handling equipment.

3.10.2 **Load rated rigging straps with current proof tested tag**

   Lift using approved handling interfaces shown on “SSA Module Assembly Drawing” part number: M1S-100-01200

3.11 **SSA Module Contamination:**

3.11.1 **Segment contamination:**

   The area of the test should have no visible oil and dirt or dust which would contaminate the SSA Module Assembly or the SSA Acceptance Test fixture.

3.12 **Ground Rules during SSA Module Motion:**

3.12.1 **Crane Movements**

   - **Hazard** objects on Crane may fall on operator
   - Keep all operators clear of moving hardware
   - Communication between operator on crane and operator holding SSA is critical and during the procedure Safety officer will keep other people away from the operation team.
   - Operators will have a current Crane license.
3.13 Equipment required:

3.13.1 Crane

Fitted with a drip catching umbrella

3.13.2 Rigging Hardware

Rigging Hardware will be load rated and have current tags.

3.13.3 CMM with a 1.5 x 1.5 m x 1 m envelope and an accuracy of 50 um

CMM shall have a current calibration

3.13.4 Gauge Tooling

3.13.4.1 “Tower Registration Bushing Go/No-go gauge” part number M1S-920-00102

4 Required Personnel, Material, and Equipment

4.1 Number of Personnel and level of training required

Two operators required: both must be trained in the SSA Module Assembly Acceptance Test Procedure. They will have demonstrated how to operate the fixture, crane, rigging, CMM and other metrology tooling gauges and hand tools. Upon completion of the training, they will be certified as a Specialist in the SSA Module Assembly Acceptance Test Procedure. A QA person will assist in verification of critical inspections. A safety officer will supervise during critical crane operations.
4.2 **Personnel Verification**

Prior to the initiation of hazardous operations, Supplier Quality Assurance shall verify that personnel safety training and qualification requirements are met. The verification shall be conducted in accordance with the suppliers ES&H System Safety Plan, which conforms to TMT ES&H System Safety Plan.

5 **Test Procedure**

5.1 **Assemble the SSA Module in the Test Fixture**

5.1.1 **Install the SSA Acceptance Test Fixture on the CMM**

The SSA Acceptance Test Fixture must be installed on the CMM and made level relative to the earth by shimming at the three support feet prior to use. Use a 1m long precision bubble level placed on the SSA Moving Frame support columns (two at a time) until the unit is level to the precision of the bubble level.

5.1.2 **Prepare to lift the SSA.**

5.1.2.1 Disconnect all attachment hardware from the SSA that would hold it down when the crane lifts it. Double check and sign off on the checklist that SSA attachment hardware has been removed.

5.1.2.2 Verify that the SSA is in the correct orientation. The + Z direction should be pointing down, as if the SSA were upside down as if it were being placed down on the mirror.

5.1.2.3 Place three 10 mm diameter x 50 mm long eye bolts and washers into the three empty holes near the tower kinematic mounts that are at 120 degrees relative to each other and the center of the SSA. Place washers and nuts on the bottom of the eye bolts and tighten up the eyebolt nuts so the eyebolts are secure. Place clevises with three 1-meter long straps (or equivalent) and attach them to the crane so the SSA Module will lift evenly.

5.1.3 **Mount the SSA Module Assembly into the Test Fixture**

5.1.3.1 Using the crane gently lift the SSA Module up and place it over the SSA Module Assembly Test Fixture

5.1.3.2 Set the SSA down aligning the three moving frame 25 mm diameter holes with the engagement pads on the “SSA Inspection Fixture” part number M1S-930-00200. Important: The SSA Module Assembly shall be rotated such that the Moving Frame Arm labeled “Y” is located on the post labeled “Y”, in order to
orient the SSA Assembly Module correctly relative to the SSA Acceptance Test Fixture.

5.1.3.3 Attach and tighten the restraints to secure the SSA Moving Frame to the SSA Acceptance Test Fixture.

5.2 **Functional Tests:**

5.2.1 **Warping Harness Test.**

This test will confirm that the Leaf Spring Strain Gauge (LSSG) and the Warping Harness Actuator are operational (alive). The testing will be performed using a Warping Harness Test Box (provided by TMT) that can command a single actuator and monitor the corresponding strain gauge.

5.2.1.1 **Test Each Warping Harness:**

Perform the following test on each of the 21 warping harness units, one at a time. Connect the test box to the LSSG and the actuator. Power-up the test box. Record the strain gauge count. Next, push the “Forward” button on the test box. This will advance the stepper motor one full revolution. The operator will visually verify that the motion has occurred (watch the knob turn approximately one revolution), or not, and record the result (pass/fail), and then record the LSSG strain value indicated on the test box. Next, push the “Reverse” button on the test box to return the actuator to the original position. Observe the motion and record the result. Record the strain gauge count. Finally, power-off the test box, remove it and test the remaining LSSGs in the same manner. To “Pass”, the forward and reverse motion of each actuator must be observed. To “Pass” the strain readings in both positions shall be between TBD, and TBD. The difference between each pair of readings shall be between TBD and TBD.

5.2.2 **Tower Lock Motion and Engagement**

Before the SSA has the whiffletree levels placed on it, engage and disengage each lock (90 degree motion each way). Confirm smooth motion and positive detent in each end position. Complete the test by placing each lock in the “Locked” position. The locks pass inspection if they meet all of these objectives.
5.2.2.1 Check Tower Lock Motion - Unlocked

5.2.2.2 Check Tower Lock Motion - Locked

5.2.2.3 Confirm Smooth Tower Lock Motion Each Way

5.3 Secure the Whiffletrees

5.3.1 Securing the Vertical Translation Stages

The SSA Acceptance Test Fixture has nine vertical translation stages that each have a single vertical degree of freedom. Each stage is to be clamped to one of the whiffletree small triangles as follows: raise the stage until it contacts the whiffletree triangle fully (no gap or interference with other parts), then secure it to the whiffletree triangle with the clamp provided. After all nine translation stages are clamped to the small whiffletree triangles; the large whiffletree triangles can then be leveled.

5.3.2 Leveling the Large Whiffletrees

The large whiffletree triangles are leveled, one at a time using a bubble level. Place the bubble level on the large whiffletree triangle, and level it by iteratively turning the corresponding warping harness actuator knobs. Note: there are two warping harness actuators that act between the moving frame and each large whiffletree triangle. These are the actuators to be used in this step. When complete, all twelve whiffletree triangles will be held level in the fixture.

5.3.3 Warping Harness Dead Band setting:

With the nine small triangles held level, and the large triangle leveled, iteratively adjust the remaining fifteen warping harness actuators until they are each in the dead band. When this is complete, the large triangles are level (confirm with bubble level), the small triangles are clamped level, and the 15 small whiffletree triangle warping harnesses are in their dead bands. Finally install the inner-small whiffletree triangle tooling clamp to secure it from future unrestrained motion. This completes the alignment and preparation for measurement of the SSA Module Assembly.
5.4 **Metrology**

All Measurements refer to the “SSA Module Assembly” M1S-100-01200

5.4.1 **Mechanical Measurements**

5.4.1.1 **Tower Registration Bushings**

Perform a Pass/Fail check with the “Tower Registration Bushing Go/No-go gauge” part number M1S-920-00702

5.4.1.2 **Sheet Flexures Flatness Test**

Measure the surface of the sheet flexures and determine PV and RMS deviation from a plane and the relative tip of the average. Additionally, use a straight-edge to check the flatness of each sheet flexure. The non-flatness measured across the 150mm long straight-edge shall not exceed 0.25mm.

5.4.2 **CMM Measurements**

5.4.2.1 **Define The “SSA Module Coordinate System”**

With the CMM in Manual Mode, measure the moving frame Datum Surfaces and define the SSA Module Coordinate System relative to these features. Run the program again in automatic mode.

5.4.2.2 **Measure the position of the small triangle MRF holes**

Each of the 27 Mirror Rod Flexure (MRF) cylindrical holes shall be probed to determine the location and angle of the hole centerline, and the height (Z coordinate) of the face of the whiffletree triangle containing the hole. These measurements shall be recorded and compared to the requirements specified on the “SSA Inspection fixture” drawing (M1S-930-01201).

5.4.2.3 **Balance Weight attachment hole locations**

Use CMM to measure location of the six holes that will receive the balance weights. These holes are located on the Large Whiffletree Triangle balance weight brackets. The hole positions shall conform to the dimensions and tolerances specified on the SSA Inspection Fixture M1S-930-00200
5.5 **Data Reporting**

5.5.1 **Electronic Data:**

The supplier will maintain a Database in keeping with the TMT quality plan. The Database will have a data structure for each SSA with will be populated with all of the measured parameters.

5.5.2 **CMM Data**

A procedure for operating the CMM will include a data format for the reported data.

5.5.3 **Analog Data:**

All manually measured data will be recorded in the Checklist and then delivered to QA.

Supplier QA will add measurement data to the individual SSA Module End Item Data Package (EIDP). The name and serial number of the SSA will be used to capture the data.
6 CONFORMANCE VERIFICATION

6.1 Pass Fail Documentation

6.1.1 All Parameters of the SSA Module as defined in Section 4.4 Performance Verification shall be checked and verified

6.1.2 When all of the tests in section 5 are recorded the Test Engineer shall update the Check List with a Pass/Fail criterion

6.1.3 If all tests pass the requirements then the SSA Module can be accepted

6.2 Out of Tolerance specifications

6.2.1 Report Out of Tolerance Hardware:

   If a measurement is out of tolerance it is non conforming. The QA must report it to TMT. A disposition will be directed from TMT as to the resolution of the nonconforming measurement.

6.2.2 Disposition of out of Tolerance Hardware

   TMT may decide one of the following based on the direction from the TMT quality plan:

   1) Re-measure

   2) Use “as is” and issue a waiver for the non-conforming measurement

   3) Rework the hardware and measure again

7 APPLICABLE/REFERENCE DOCUMENTS

7.1 TMT Publications

   TMT Quality Control Plan and Procedures
   TMT Configuration Control Plan, TMT.SEN.SPE.05.004.REL14
   TMT Environmental, Safety and Health (ES&H) Plan,
   TMT.PMO.MGT.10.004.DRF01

7.2 Reference Documents

   TMT Project Supplier Quality Requirements, TMT.OPS.MGT.10.009.DRF02
8 SEGMENT SUPPORT ASSEMBLY ALIGNMENT CHECKLIST

8.1 Required Personnel:
Two Operators required: both must be trained to a Specialist Level. Record this on the checklist. Training Levels will be defined in the Subcontractors Training Program Documentation.

Trained personnel must work through a procedure, tracking progress with this checklist

8.2 Material Used:
(See Section 4.6)

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<tr>
<td>Approved Wipes</td>
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<td>As Required</td>
</tr>
<tr>
<td>Gloves (Type)</td>
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<td>As Required</td>
</tr>
<tr>
<td>Approved Cotton Swabs</td>
<td>NA</td>
<td>As Required</td>
</tr>
</tbody>
</table>

8.3 Personal protective equipment required:
(See Section 4.6)
Standard PPE (i.e. protective shoes, shop coat, gloves, Safety Glasses)

8.4 Equipment List:

<table>
<thead>
<tr>
<th>Equipment list</th>
<th>Equipment Serial number or Cal number (tracking) if applicable</th>
<th>Cal due date, if applicable</th>
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<tr>
<td>SSA Module Assembly</td>
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<td>NA</td>
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<tr>
<td>SSA Acceptance Test Fixture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tower Registration Bushing Go / No Gauge</td>
<td>M1S-920-00702</td>
<td></td>
</tr>
<tr>
<td>150 mm straight-edge</td>
<td></td>
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</tbody>
</table>
8.5 SSA MODULE ASSEMBLY SAFETY

Ensure work area is free of hazards, obstructions, and equipment not required for the procedure.
DO NOT CONTACT Whiffletrees
Do not drop, bump, torque, wet, or otherwise disturb the extremely sensitive equipment

8.6 Ground Rules

Prior to executing these procedures a pre-task briefing shall be held to identify task assignments, procedure readiness, ground rules, sequence of events, hazard identification and recovery.

Ground Rules:

Minimize distractions

Cell phones shall be turned off or removed from pockets.

All items should be out of your upper pockets.

Remove anything that might inadvertently contact the SSA Module Assembly.

i.e. Rings, Watches, Necklaces

Check Hands, Hair, Lapels and each other to make sure you are ready.

Operators shall change gloves after touching anything that may have contacted the floor before touching a SSA Module Assembly

If operations are expected to continue across a shift change, plan accordingly to ensure continuous safe operation with trained operators on upcoming shifts. Shift changes are not allowed if a section is in process. Operators shall fill out the name and training level section prior to performing task, signifying they will remain present until section is completed.

Date / Time ________________________________ Process Lead Signature
8.7  **Checklist for Section 5.0**  
Checklist for Section 5.0 SSA Module Assembly Inspection Procedure

<table>
<thead>
<tr>
<th>S/N (SSA ID)</th>
<th>Operation Number(s)</th>
<th>Start Date</th>
<th>Start Time</th>
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</thead>
</table>

8.8  **Personnel**

Names of all operators, initial each step completed, no check marks. Must be present for entire section of procedure

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<tr>
<th>Personnel Req.</th>
<th>Training Reqs (min)</th>
<th>Actual Training Level</th>
<th>Print Name</th>
<th>Full signature</th>
<th>Initial</th>
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</thead>
<tbody>
<tr>
<td>Process Lead</td>
<td>Specialist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support Oper.</td>
<td>Specialist</td>
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8.9  **Operational Steps**

<table>
<thead>
<tr>
<th>Step</th>
<th>Summary of the Operations steps</th>
<th>Operator Initial</th>
</tr>
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<tbody>
<tr>
<td>5.1</td>
<td>Assemble the SSA Module in the Test Fixture</td>
<td></td>
</tr>
<tr>
<td>5.1.1</td>
<td>Install the SSA Acceptance Test Fixture on the CMM. Level.</td>
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<tr>
<td>5.1.2</td>
<td>Prepare to Lift the SSA, Disconnect Attachment Hardware. Install rigging hardware.</td>
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</tr>
<tr>
<td>5.1.3</td>
<td>Mount SSA into the Test Fixture. Align Y Arm and Post. Tighten Restraints.</td>
<td></td>
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<tr>
<td>5.2.1</td>
<td>Lock Motion and Engagement. Cycle each whiffletree lock. Leave Locked.</td>
<td></td>
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<tr>
<td>5.2.2</td>
<td>Warping Harness Tests: Attach Warping Harness Test Box to each of 21 warping harness units. Test Functionality. That all Warping Harnesses Pass.</td>
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</tr>
<tr>
<td>5.3.1</td>
<td>Secure the Whiffletrees with the vertical translation stages.</td>
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<tr>
<td>5.3.2</td>
<td>Level the Large Whiffletrees</td>
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<tr>
<td>5.3.3</td>
<td>Adjust the Small Triangle Warping Harnesses into the Dead Band.</td>
<td></td>
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<tr>
<td>5.4</td>
<td>Metrology</td>
<td></td>
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<tr>
<td>5.4.1.1</td>
<td>Tower Registration Bushings. Pass / Fail</td>
<td></td>
</tr>
<tr>
<td>5.4.1.2</td>
<td>Sheet Flexures Flatness Test. Pass / Fail</td>
<td></td>
</tr>
<tr>
<td>5.4.2.1</td>
<td>Start CMM SSA Program, Measure SSA Module Datum Features. Run Program.</td>
<td></td>
</tr>
<tr>
<td>5.4.2.2</td>
<td>Measure the position of the small triangle MRF holes</td>
<td></td>
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<tr>
<td>5.4.2.3</td>
<td>Measure the Position of the balance weight attachment holes.</td>
<td></td>
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</tbody>
</table>

5.5.1 Electronic Data is saved

5.5.2 CMM Data is Saved

5.5.3 Analog Data is Saved.

6.1 Conformance Verification. If all measurements Pass then SSA Module is Accepted

6.2 Out of tolerance hardware. If any measurements are out of tolerance then QA must report it to TMT and get a disposition for the Hardware.

6.2.2 Disposition of Out of Tolerance Hardware
1) Re-measure
2) Use “as is”
3) Rework

Date and Time: _____________________________________________

Process Lead signature

*File Checklist in the appropriate mirror log book.*
9 INSPECTION FORM

9.1 TMT Segment Support Assembly (SSA) Module

9.2 Subcontractor

9.3 TMT Serial Number

9.4 TMT Part Number

9.5 TMT Revision Number

<table>
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<tr>
<th>Balloon #</th>
<th>Characteristics</th>
<th>Print Requirements</th>
<th>Actual</th>
<th>Pass/Fail</th>
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Inspected By______ Date:______ Approved _____ Date:______

9.6 TMT Approval______________ Date:______________