Automated X-ray Inspection
Design Considerations for PC Board
Carriers for use in the Agilent 5DX

Scope of document

This document will discuss reasons for using board carriers in the 5DX, describe various types of board carriers, and describe best practices and the reasoning behind the best practices. It is not intended to be a step-by-step design process for carriers. This is left to the expertise of the user's production tooling and fixturing provider. The Agilent Expert Center and Agilent's customer support partners can offer additional design ideas and advice regarding carrier design based on their expertise and experience.

Description of a carrier:

A carrier for use in the 5DX is a fixture designed to firmly and repeatably hold one or more assembled PC boards or panels, allowing them to be conveyed through and tested by the Agilent 5DX.

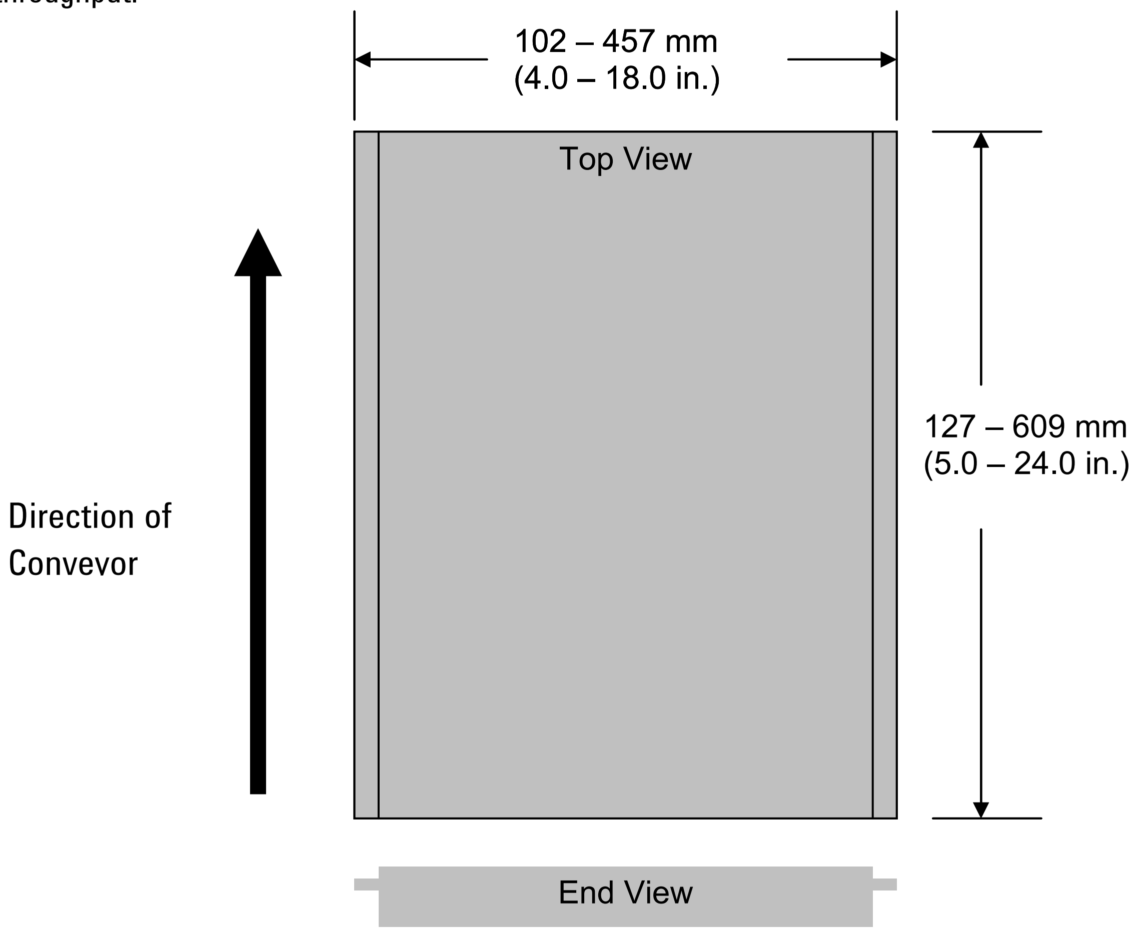
Reasons for using board carriers in the 5DX:

There are 3 main reasons for using a carrier when testing boards in the 5DX:

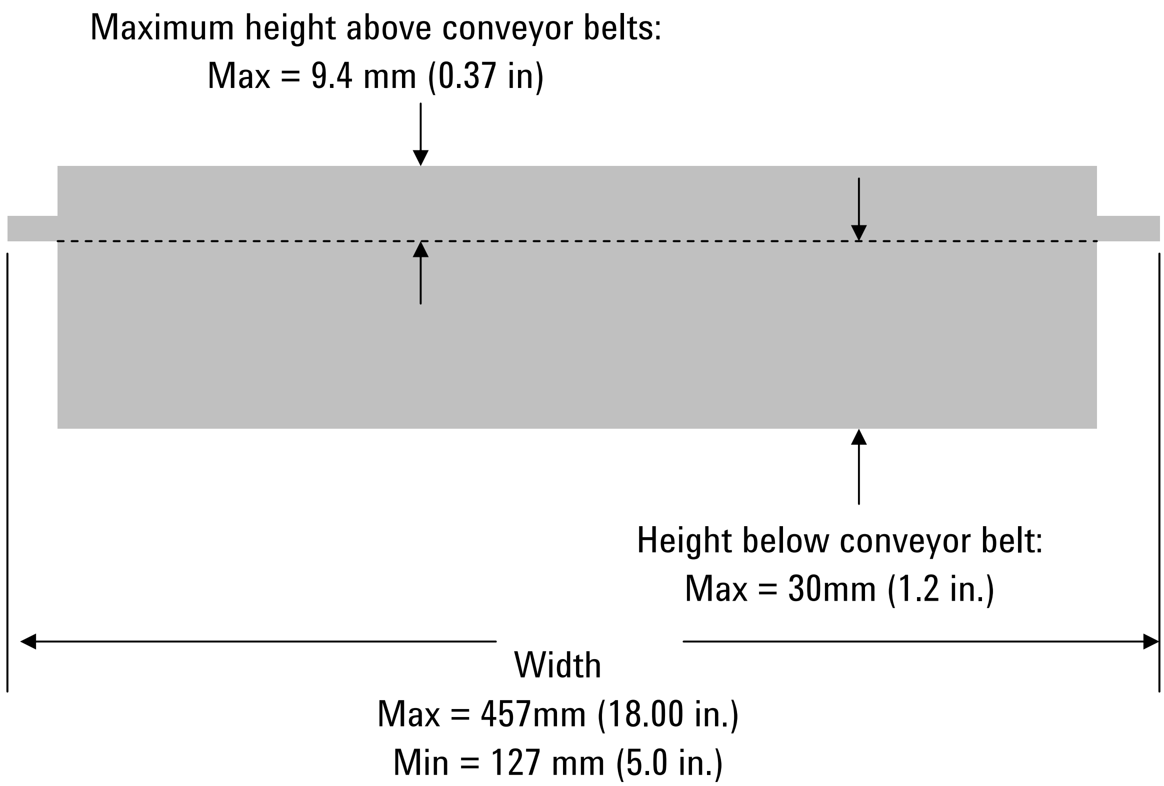
1) The board to be tested cannot be conveyed through the 5DX due to overhanging components, non-parallel sides, or a board size below the 5DX's minimum allowable size of 107 x 127 mm (4.0 x 5.0 in.). This is a common situation if boards have been depaneled before AXI.
2) The board does not have sufficient thickness or stiffness to be conveyed and remain flat during test. The carrier would be designed to provide this additional structural rigidity. Flex circuits and very thin boards (less than .020" thick) fall into this category.
3) The need for the highest possible production throughput of small boards from the 5DX. Many small boards can be put on a large carrier. Multiple boards in the carrier amortize the time used by the load/unload cycle of the 5DX, increasing throughput.
    a. The carrier must secure the boards for test so that they do not move in the fixture.
    b. The clamping used for this can often be used to reduce board warp during inspection, which can reduce the number of surface map points needed and minimize false calls. This also increases throughput.
    c. Panel Based Alignment can sometimes be used with carriers to reduce overall alignment time, although the precision of the carrier and the positioning of the boards on the carrier must be extremely precise.
    d. Point "a." is always true for multiple board carriers. Points "b." and "c." are optional, independent, and require more specialized carrier design.

Carrier Design: Maximum and minimum dimensions
Maximum Size: 457 x 609 mm (18.0 x 24.0 in.)
Minimum Size: 102 x 127 mm (4.0 x 5.0 in.)

Note: The 5DX inspects an area 17.5 inches wide by 18 inches long. For panels or carriers longer than 18 inches, the system inspects the leading half of the board, moves the panel to the other panel stop, and aligns, surface maps, and inspects the trailing part of the board. If a carrier is being used to maximize throughput of the 5DX, a maximum carrier size of 18 x 18 inches is recommended, since the repositioning operation will reduce throughput.



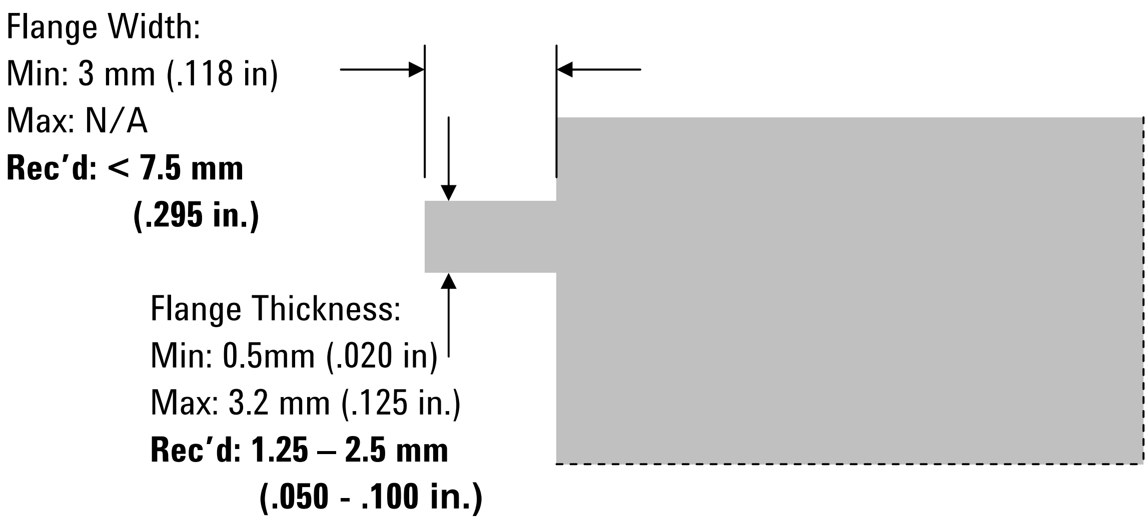
Maximum carrier height above top conveyor surface: 9.4 mm (0.37 in)
Maximum carrier height below top conveyor surface: 30.0 mm (1.2 in.)
Maximum weight of loaded carrier:4.5kg (10 lb.)



The carrier flanges protrude from the sides of the carrier and allow it to be carried by the conveyor and secured by the clamps in the 5DX.

Carrier flange thickness:
Minimum/Maximum: 0.5 – 3.2 mm
Recommended: 1.25 to 2.5mm (.050 - 0.100 in.)
Carrier flange depth: Minimum: >3 mm (.118 in.)Recommended: > 4 mm (0.158 in.)

Carrier Flange Detail



Carrier Design: Carrier Materials

The carrier is a piece of precision tooling for the test process. It is important that the carriers be stiff, strong and robust enough to withstand handling in a production environment and hold the boards under test repeatably. Carriers must also be built from materials made of low atomic-weight elements such as aluminum or organic-based plastics and fiberglass to reduce unwanted absorption of the x-rays used during test. Materials recommended are aluminum tooling plate such as MIC-6 and 6061-T6 aluminum plate which are dimensionally stable during machining. Glass fiber reinforced plastics and epoxies have also been used successfully. Use of steel, stainless steel, brass or other materials with high atomic weight elements for the body of the carrier should be avoided. A small quantity of these materials in hardware such as screws, etc. in the carrier is usually acceptable. Overall top and bottom thickness of the carrier should be kept below the specified maximums to reduce unwanted shading of the x-rays and overall weight of the carrier. When possible, remove carrier material underneath the area where the boards will be held to allow the x-rays to pass through unimpeded to the imaging system. This will eliminate the effect of x-ray absorption by the carrier.

Carrier Design: Positioning of the boards on the carrier:

Case 1: A single board or small number of boards in the carrier. Board-Based Alignment will be used (and not Panel-Based Alignment,) so relative position of the boards to the fixture or to each other is not critical.

Case 2: Many boards in the carrier with high throughput being critical. Panel-Based Alignment is desirable to reduce the amount of time used for alignment *if maximum throughput is required.* The position of the boards relative to each other and relative to the carrier are both extremely critical and must be repeatable from carrier to carrier for Panel Based alignment to be successful in a production environment.

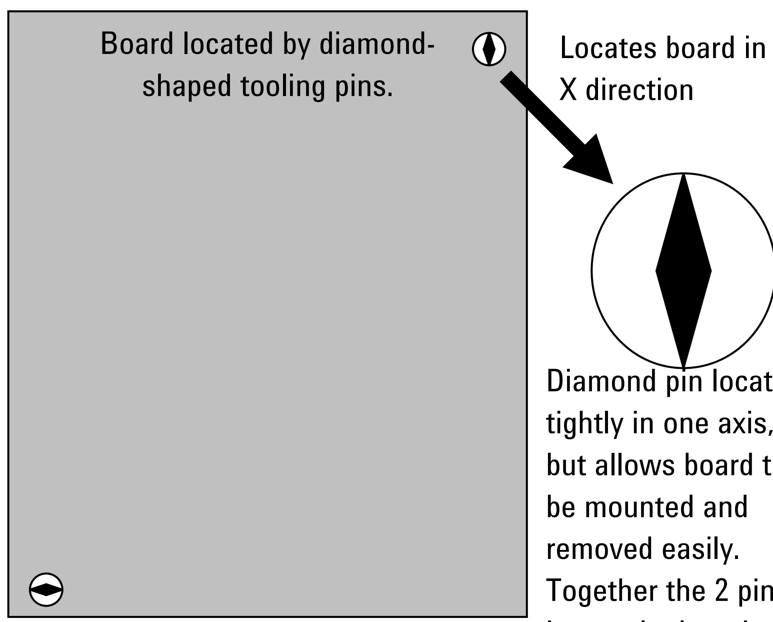
Carrier Design: Aligning the boards to the carrier

Case 1: Board-based alignment

A total of 2 or 3 round tooling pins fitting tooling holes in the boards is usually sufficient. Recommended pin diameter = minimum hole diameter minus .003".

Case 2: Panel-based alignment

The tooling holes on the boards and the alignment pins on the carrier must work together to position the board as accurately as possible. The alignment pins need to fit the tooling holes as tightly as possible in order to predictably position the boards on the carriers for accurate alignment, but must also allow the easy placement and removal of the boards from the carrier. Use of 2 diamond-shaped tooling pins per board, oriented at 90 degrees with respect to each other, is one effective method (see figure). Details on diamond tooling pins can be found in most machining and manufacturing handbooks, and tooling manufacturers know several other methods of accomplishing this precise level of alignment.

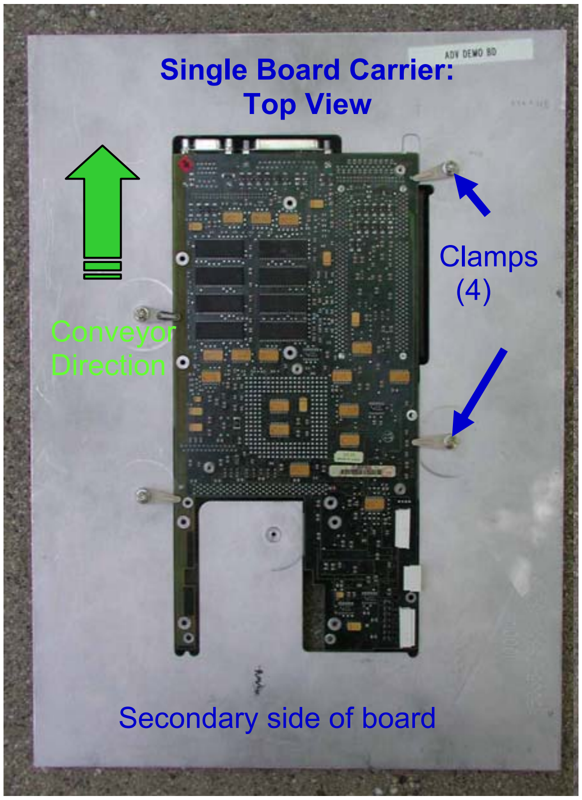


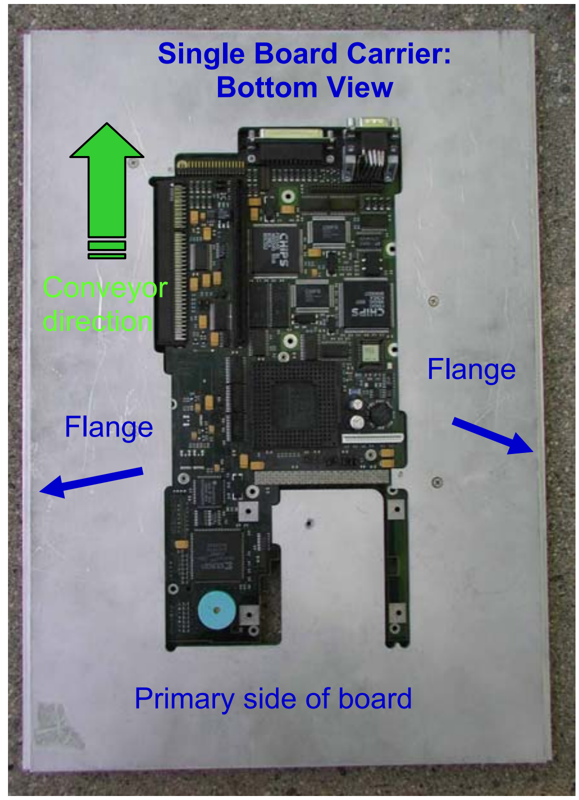
Placement of the tooling pins for each board relative to other boards is also critical in order to position the boards on the carrier where the 5DX program expects them.

The total tolerance for tooling-pin location plus tooling pin-to-tooling-hole tolerance must be less than 50% of the smallest pitch part on the board.

Example: The smallest pitch on the board is a QFP with a .0197" pitch. The total of the tooling pin location tolerance plus the difference between the tooling pin diameter and the tooling hole diameter must be <.0099". The smaller the tolerance in the board/tooling pin/carrier system, the more reliably the boards will be aligned and tested correctly.

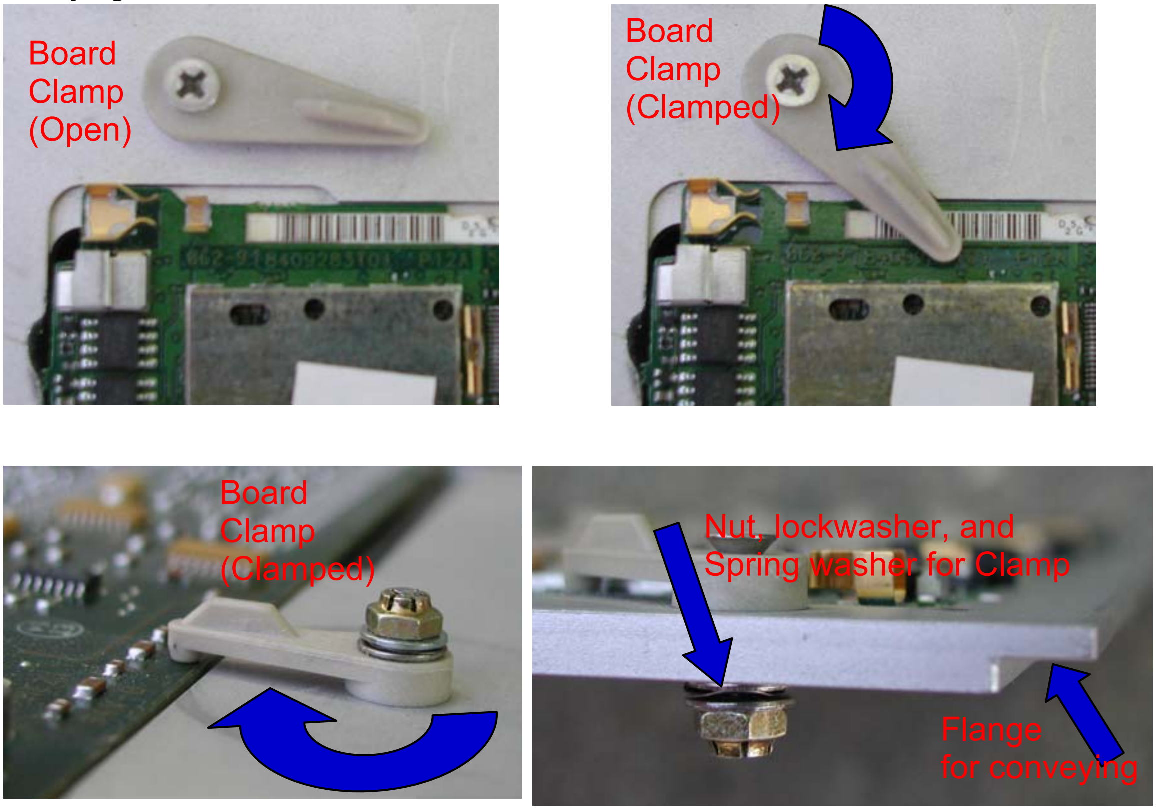
Typical Carrier Design:



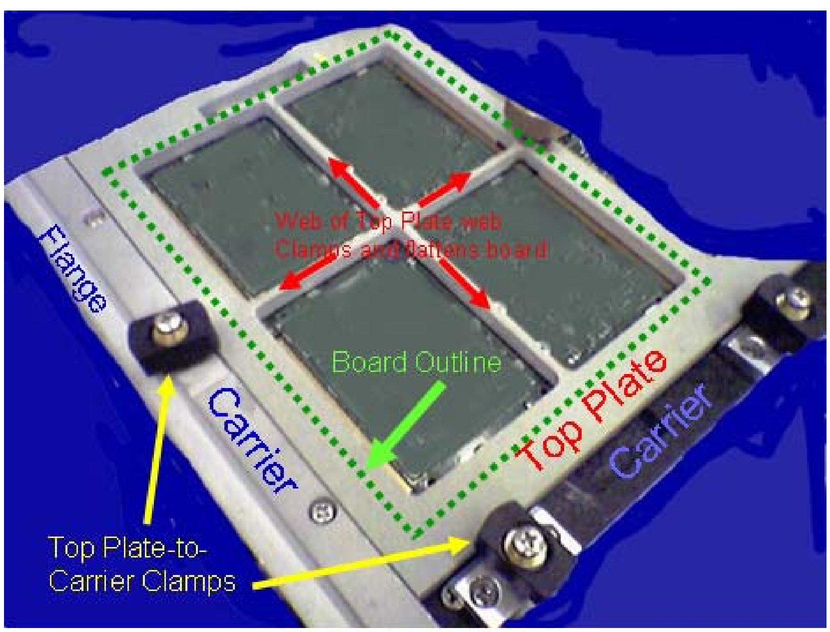


Case 1: The board shown above is tested with the primary side of the board toward the bottom of the 5DX. Several of the connectors and other components are taller than allowable for top side clearance.

Clamping the boards into the carrier:

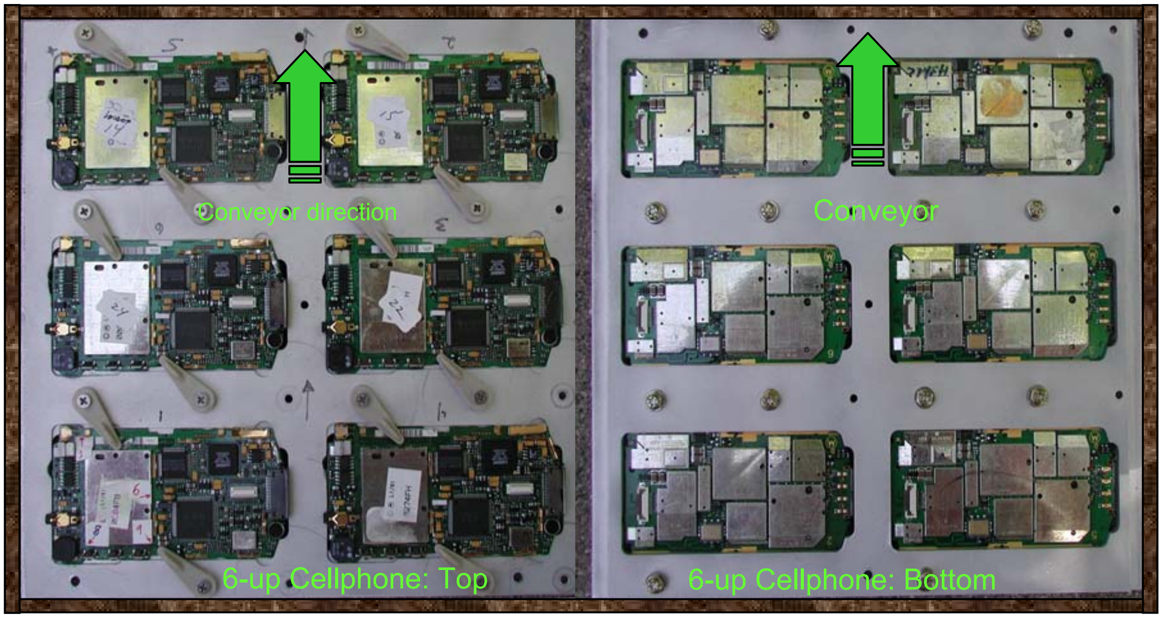


Case 1: Boards are sufficiently flat for x-ray testing (< 1% warp in any linear dimension) Small hold-down clamps are usually sufficient to prevent board motion during test.



Case 2: A top plate or other system of clamping the boards to the carrier will prevent the boards from moving during test, and can reduce false calls and the need for additional surface map points by flattening the boards. A portion of such a carrier is shown in detail.

Boards are placed on the tooling pins of the carrier, the top plate is added, and the clamps holding the top plate to the carrier are secured. Tooling pin aligning the board are under the top plate and not visible in this photo. This carrier is machined from aluminum, and the top plate is machined from glass fiber reinforced epoxy (fiberglass) for light weight.

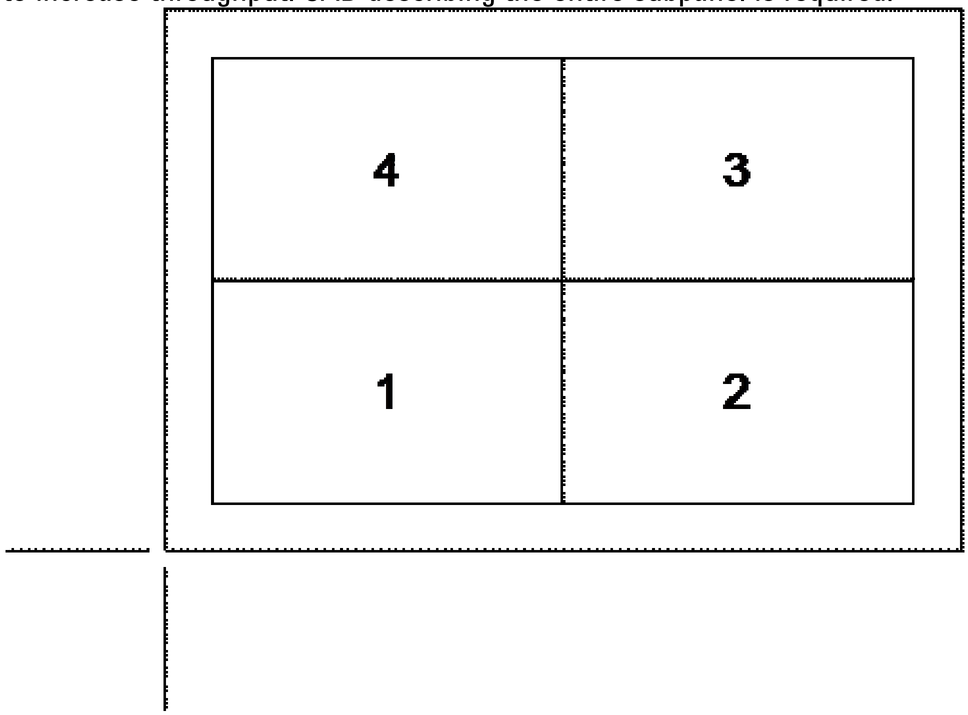


Case 3: An example where high production throughput is required from the 5DX, and the boards are small enough that several can be put on a carrier.

CAD Information:

1) CAD for the design of the board or panel. This can be in any of the industry standard formats which are acceptable to RSI's CAMCAD, including but not limited to Mentor Graphics, Cadence Allegro, and many others. For more information on CAMCAD for the 5DX, go to www.rsi-inc.com.
2) The CAD *must* be for the board as it will be placed in the carrier, including all tooling holes and borders. If there are multiple images of the board on the physical subpanel which will be put in the carrier, all images must be described in the CAD. This is particularly critical when using Panel Based Alignment, since Board Based alignment is more forgiving to errors in CAD.

Example: The small subpanel shown has 4 identical images on it and will be depaneled after test. Several of these small 4-up subpanels will be put in a carrier to increase throughput. CAD describing the entire subpanel is required.



3) Maximum heights of the components on both sides of the board must be provided to ensure that there will be no interference with the 5DX during load, unload and test.

Summary:

There are different reasons for using a board carrier to test boards in the 5DX. Although production personnel must manually load and unload the carriers with boards, carriers can allow 5DX testing by allowing the boards into the 5DX and in other cases add accuracy to the test results of the 5DX. They can also maximize throughput of the 5DX. For the best results in designing and fabricating carriers for your application, please consult with your Agilent Expert Center or Agilent Partner 5DX Application Engineer to discuss your specific needs.