TUTORIAL F02

Designing & Using Features for Fixture Calibration

DISCUSSION
Many times the robot programmer is presented with a situation such as shown in Figure 1. There is a comlex 3-Dimensional path to be programmed, but how to do it. Here we will show you the basic steps.

THEORY
Robot locations are ALWAYS in Robot World Coordinate System coordinates. That is, the point in space on a user's robot path is represented by

[X, Y, Z, rotX, rotY, rotZ]

where point is represented by X, Y, Z values relative to the robot, and also the point has an orientation (rotations of the X-Y-Z axes) in space relative to the Robot World Coordinate System.

This is called ***tranformational mathematics*** and is pretty complex stuff. The robot programmer can take advantage of these ***transforms*** and create arbitrary Coordinate Systems on your workcell parts. If the physical parts are designed and built to support these arbitrary Coordinate Systems, then the task of teaching robot locations can be made very simple.

Further, if the robot path points are made relative to a teachable arbitrary Coordinate System, then it is a very simple matter to re-calculate the robot path points. This would be a tremendous benefit in the event of system changes, retrofits, damage, or whatever Fate throws at the poor hapless robot programmer.

For this example:

- a fixture was designed with three simple locating features.
- In this case (Figure 1) three cruciform slots were milled into the surface of the Fixture Plate Insert.
- The purpose of these three slots is to provide a repeatable, accurate, and easily-teachable physical feature to teach three arbitrary points in space.
- The three arbitrary points would then be used by the RobotWorks user and robot programmer to create an arbitrary Coordinate System on the Fixture Plate Insert.
- The use of a local Fixture Coordinate System isolates point teaching errors and allows calcaulation of path points. All that is necessary to develop the robot scoring path would be to accurately teach three locations in the Robot World Coordinate System. This allows calibration of the physical part to the CAD part.

This theory of application uses the strength of a robot arm. That is, a robot arm is a repeatable device, not an accurate device. If a robot path point can be taught, then it stands to reason that the robot can return to that taught point within the robot's repeatability specification.

FIGURE 1: A sample part fixture. Figure shows robot with precision pointer attached, teaching Fixture Coordinate System points. The Fixture Insert was designed to have three locating features machined into it to be used at teaching points.

Don't be intimidated by the mathematics. Only know that a robot path point can be made relative to other points and features in space. See Figure 2.

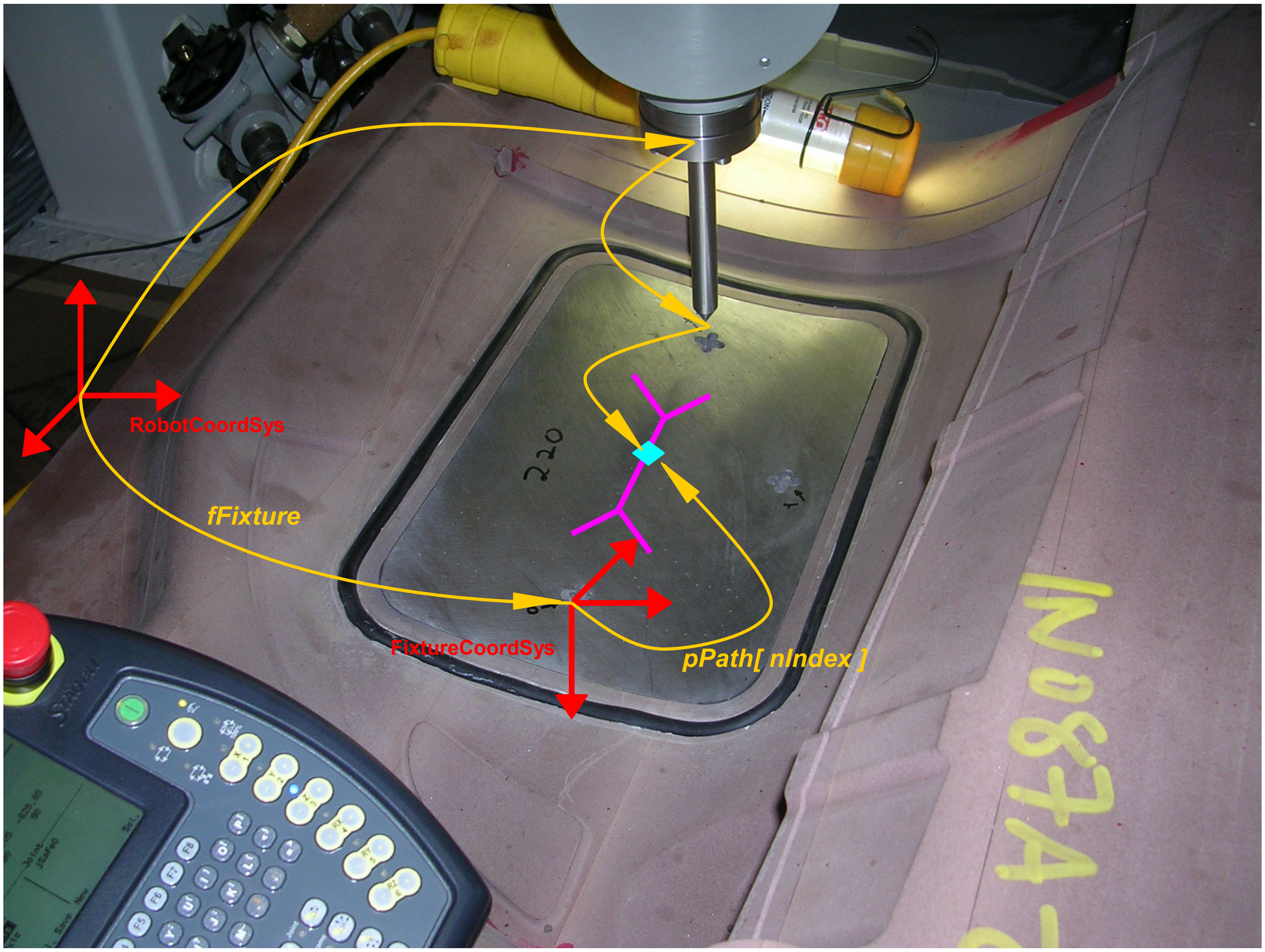

Figure 2: Path location transformations. This is the principle for the proposed method. The Fixture Coordinate System is taught from three arbitrary features located directly on the Fixture Plate Insert.

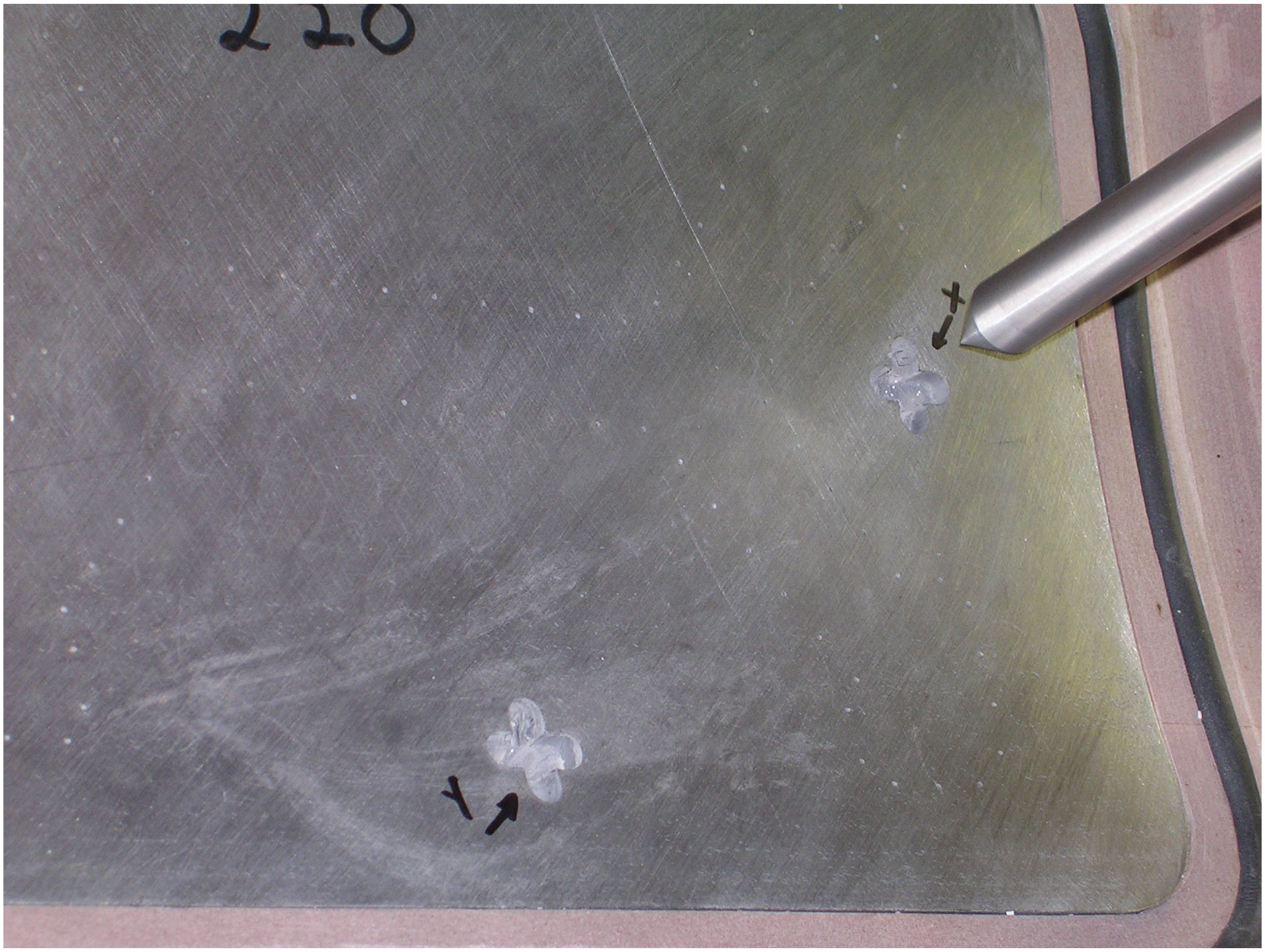

FIGURE 3: Closeup of cruciform features. One of the corner points of each feature is arbitrarily selected and used to teach a Fixture Coordinate System point.

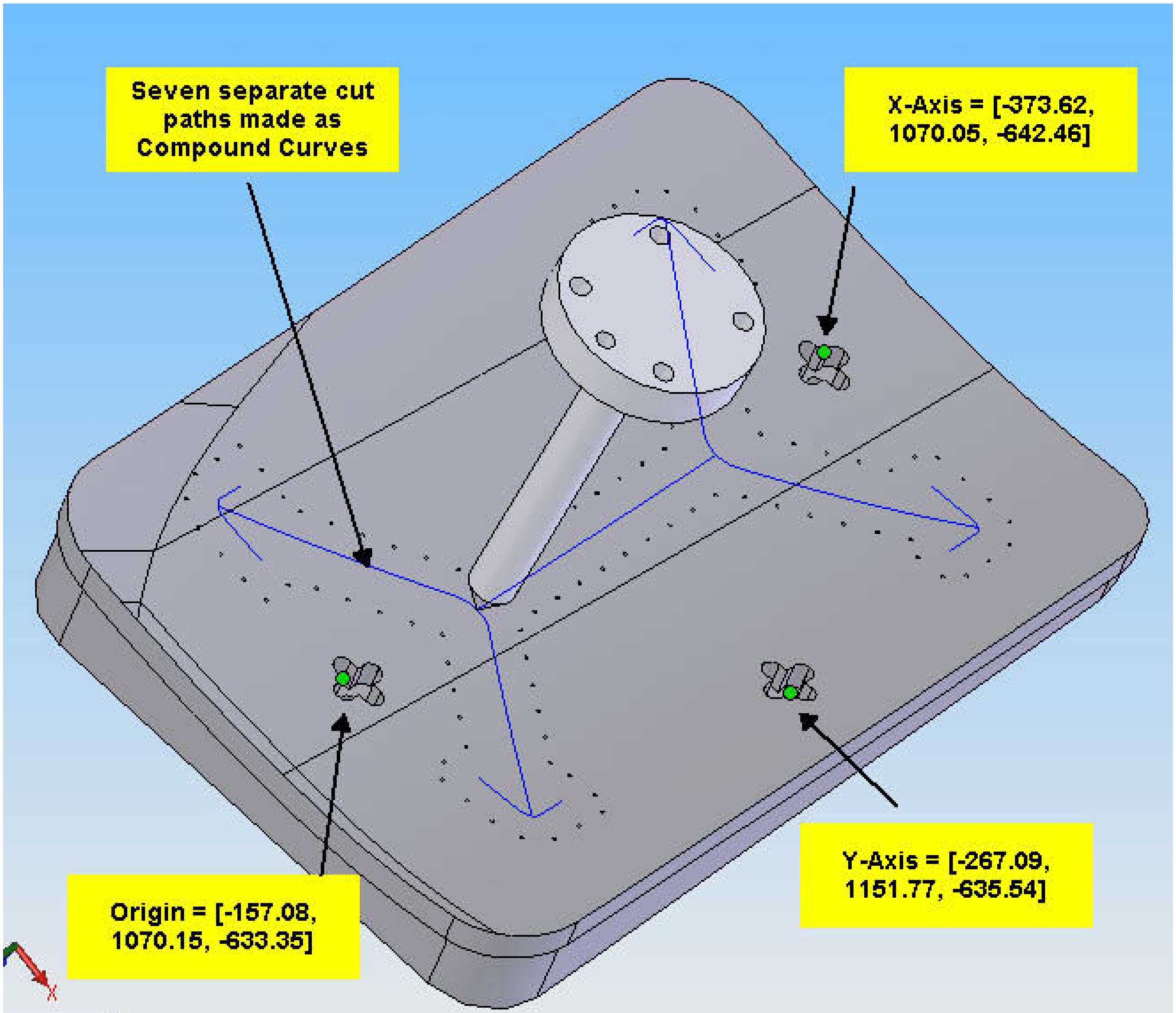

Figure 4: CAD representation of Fixture with Coordinate System location features. The location and orientation of the Fixture Coordinate System is ARBITRARY.

METHOD

- Have the workcell design add three simple features to the object in question.
  - These can be permanent features as shown above, or removable features like temporary pins used only for teaching.
- Build a suitable accurate pointer for your application. Attach the pointer and invoke the tool transform for the pointer.
- Teach and record the locations of the three locations.
- Modify the CAD model to add a User Coordinate System to the workcell part in question.
  - Orientation is arbitrary.
- Use the X-Y-Z values of the three locations to constrain the workcell object in your SolidWorks workcell assembly model.
  - First Point:
    - mate the point with X-Distance value to the Y-Z Plane
    - mate the point with the Y-Distance value to the X-Z Plane

    - mate the point with the Z-Distance value to the X-Y Plane
- Second Point:
    - do similar mates for X-Distance & Y-Distance
- Third Point
    - do similar mate for the Z-Distance
- Use RobotWorks to create your path points
    - Select the suitable tool
    - Select the suitable Frame of the workcell part in question.
    - Select the path creation features
- After path development and modification is complete, Convert Path To Robot and make the path points relative to the Frame.
- Create a robot program that uses relative transformation points. This will take advantage of the User Coordinate System you created and save you hours of teaching work.

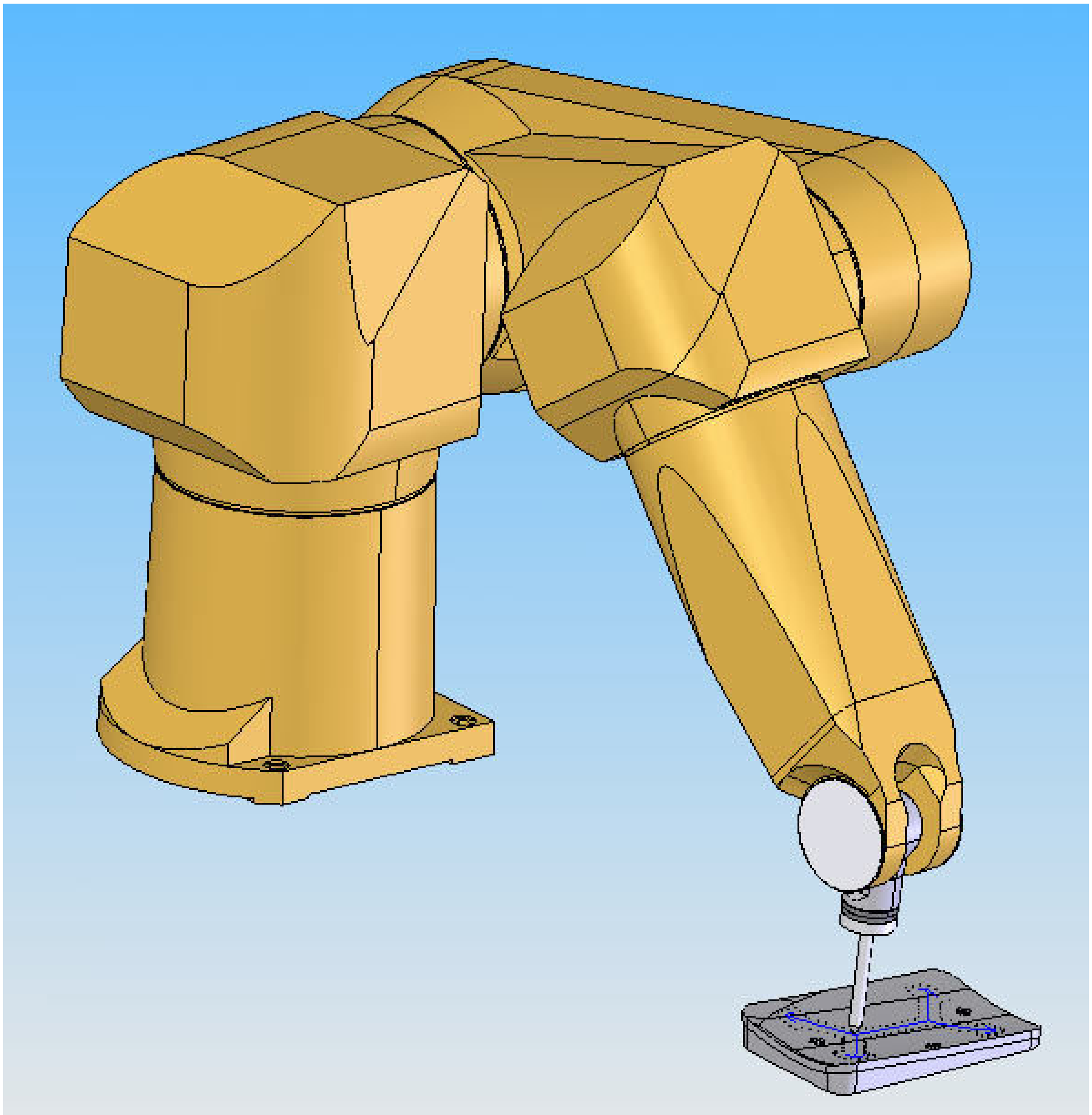

Figure 5: CAD representation of schematic workcell. This is a quick method of determining reach and suitability to task before teaching & programming is started. RobotWorks automatically determines if sufficient reach is available for the application.

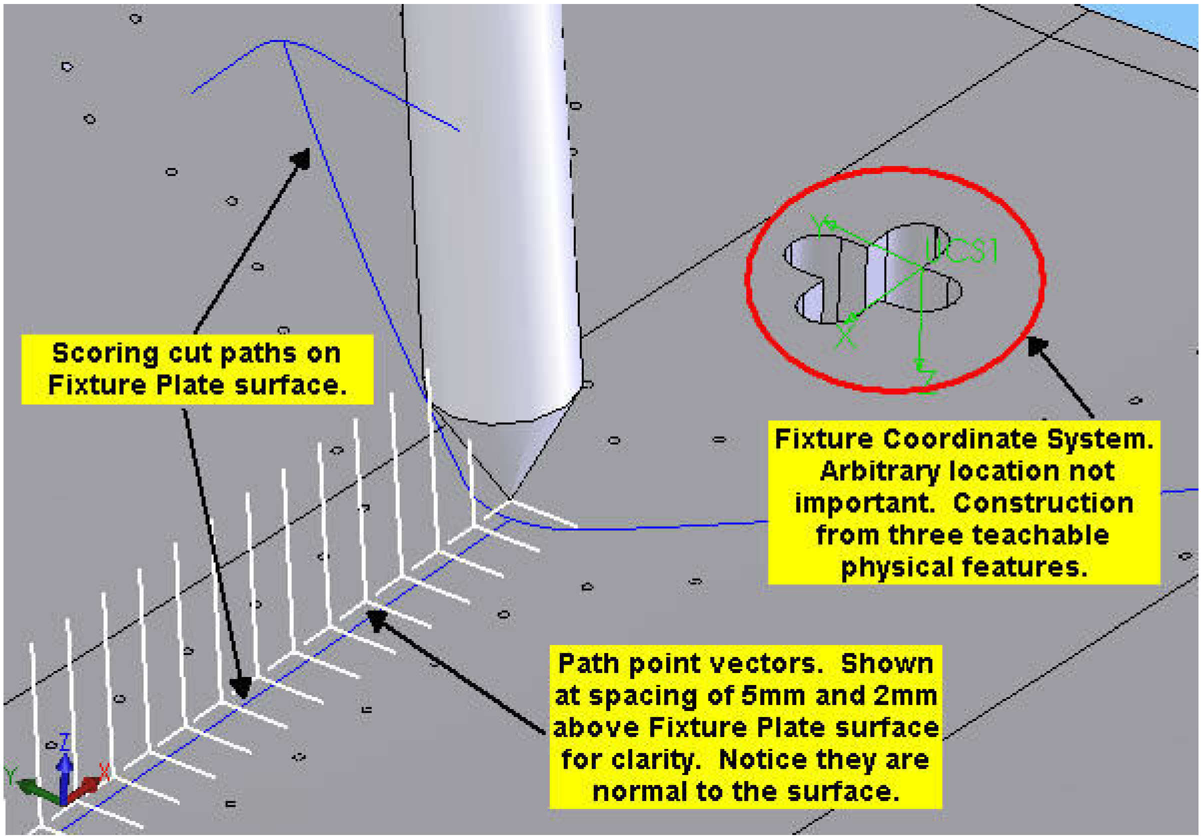

Figure 6: Fixture detail, showing path point vectors.

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