Accelerated Testing of Locking Electrical Connectors

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Introduction

- Selection of electrical connectors for a harsh outdoor environment requires extensive testing to validate robustness.
- Each application has it's own special set of requirements which make a standard selection unlikely even for derivative products.
- Stresses such as high vibration, repetitive impact, and dirt intrusion are factors

Application

- The electrical connectors to be selected were for digital communication in an all weather, half ton, hydraulic driven robot with an internal combustion power source

- Sources of stress for the connectors were
  - Engine vibration
  - Foot impact with ground
  - Hydraulic rhythm
  - Frequent Impact with surrounding obstacles

The Challenge

- Digital communication connections that were exposed to the elements and in a chassis with continuous vibration and impact would likely have a high failure rate if not properly validated and optimized.

- This was confirmed with field testing that saw frequent broken or intermittent communication issues

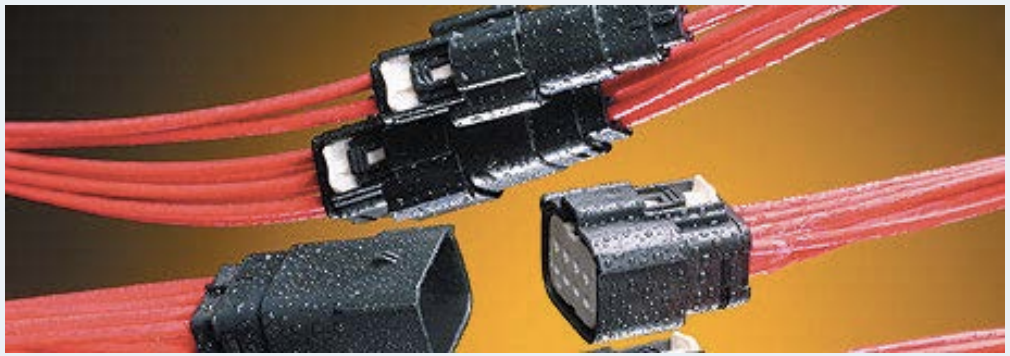
- The gating factor for the development program was being able to do testing quickly so design iterations could maintain with the program pace.

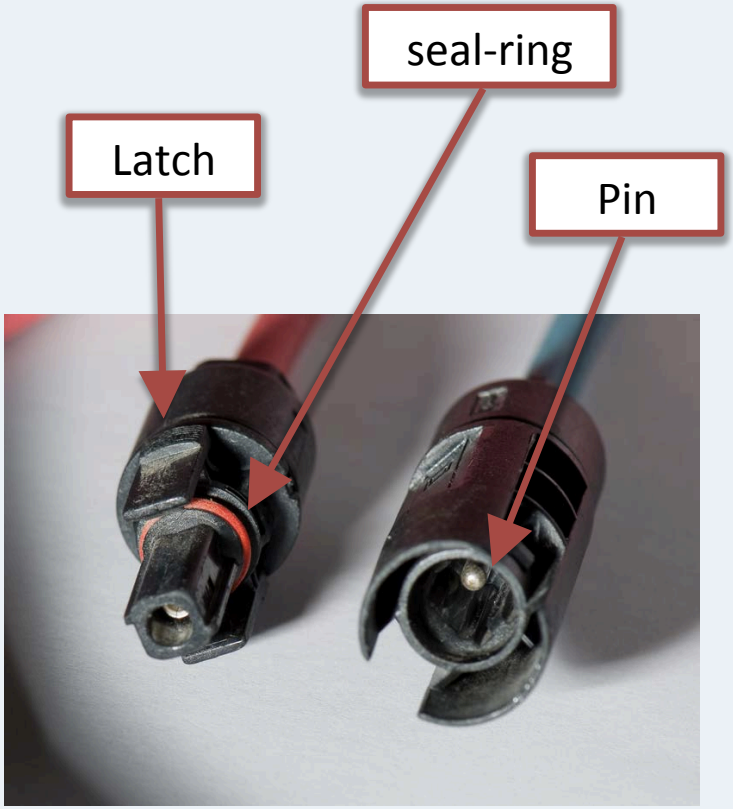
Types of Connectors

- There were two types of all weather connectors being considered
- Latch-lock
  - Latch-lock have a latching prong that hold the connector in place
- Cam-lock
  - Cam-lock connectors have a twisting collar that passes an over-center feature during rotation (cam) and locks the connector

Snap Fit Connector

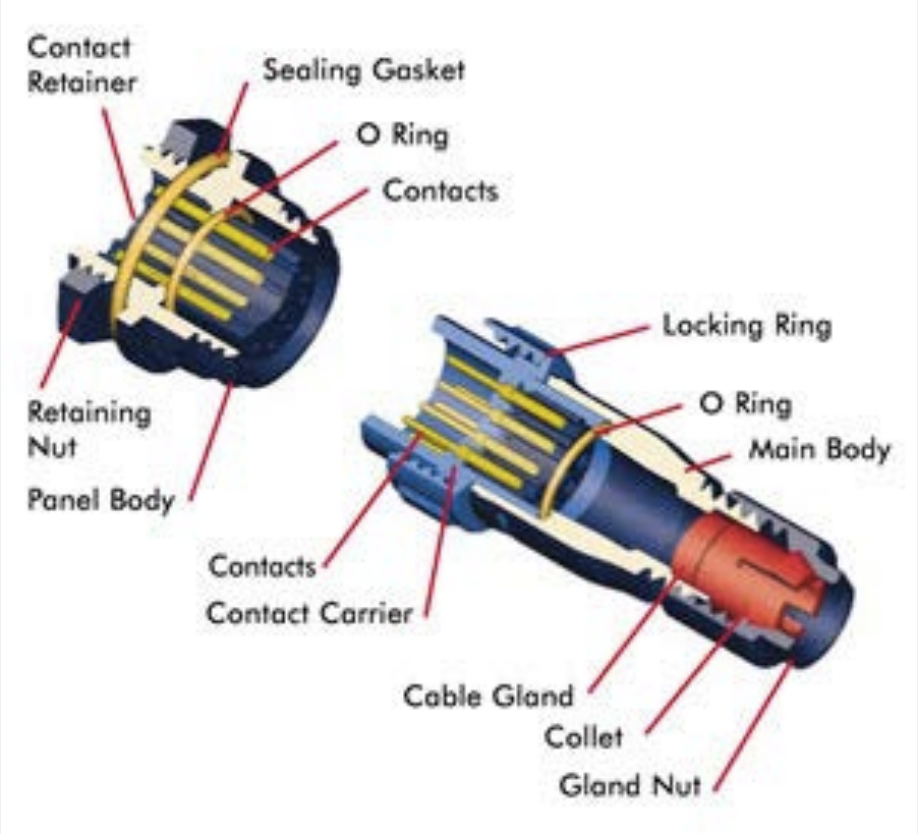
- Features of a common latch-lock weather proof connector





Cam Lock Connector

- Features of a common cam-lock weather proof connector



Design Trade Offs

- Both Design could be made weather proof with sealing o-rings or gaskets
  - The latch lock were light and easy to insert
  - The Cam-lock can handle higher loads but were heavy and create larger harnesses
- The initial selected design was a latch-lock type of connector with a sealing boot
- Instances of intermittent and failed connections were reported in field testing with the robot with this design

The Testing Need

- A test method that could be done quickly and in a lab environment was needed to assist with selecting a weather proof design robust enough to handle the impact and vibration environment of this application

Impact Testing

- The initial test was based on the premise that a single or short sequence of impacts could be used to correlate connection failure to long term repetitive vibration stress
- Using 50g's as an increment the test was done to the candidate connectors
- It wasn't until 300g's that a failure was observed in the standard latch (weakest) connector
- But the impact tester was taken to it's limit before any other failures could be observed

1,500 g Impact

- The impact tester was able to deliver 1,500 g's of force

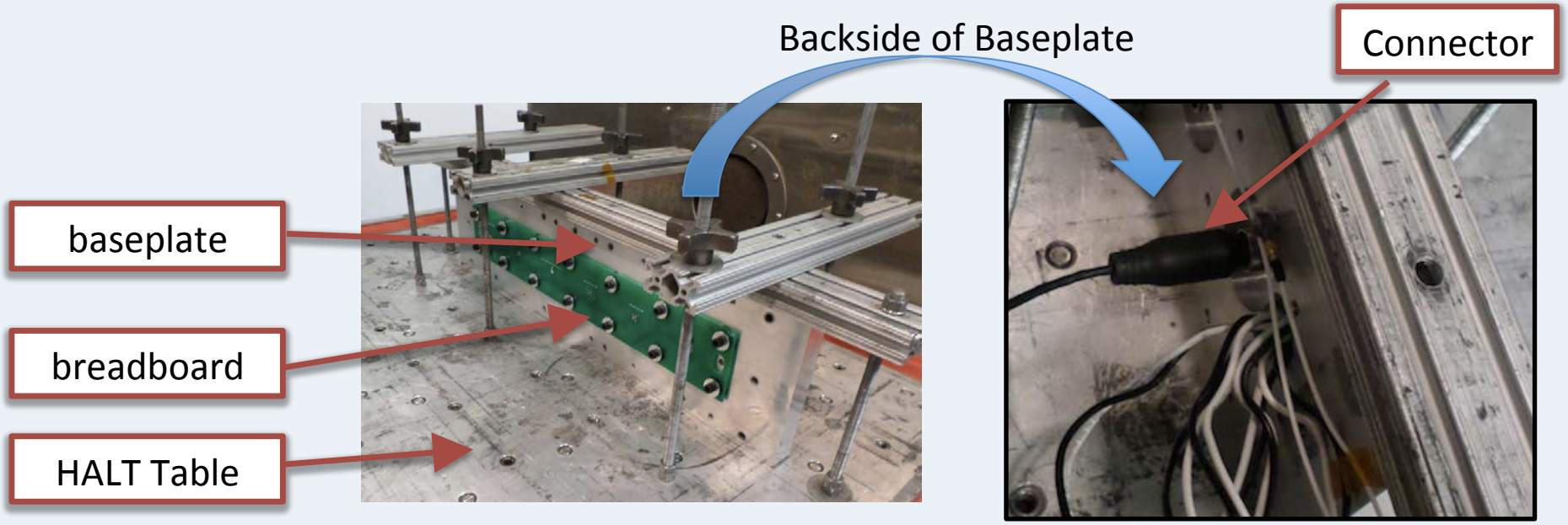
This is what 1,500 g's looks like!!
Click Image to Play Video

- All other locking connectors were able to withstand this impact, so test could not be used as comparator for all candidate connectors

Vibration

- Using a HALT chamber, six axis broadband vibration was applied to the " latch-style" and "cam-style" connectors

- Vibration was driven up to 90 Grms with no observed failures



The Challenge of Failure

- It was becoming apparent that creating enough stress using standard lab techniques to make a strength comparison between locking connectors was difficult
- The effects of long term vibration and repetitive impact in the robot application was difficult to duplicate in a shortened controlled time frame.

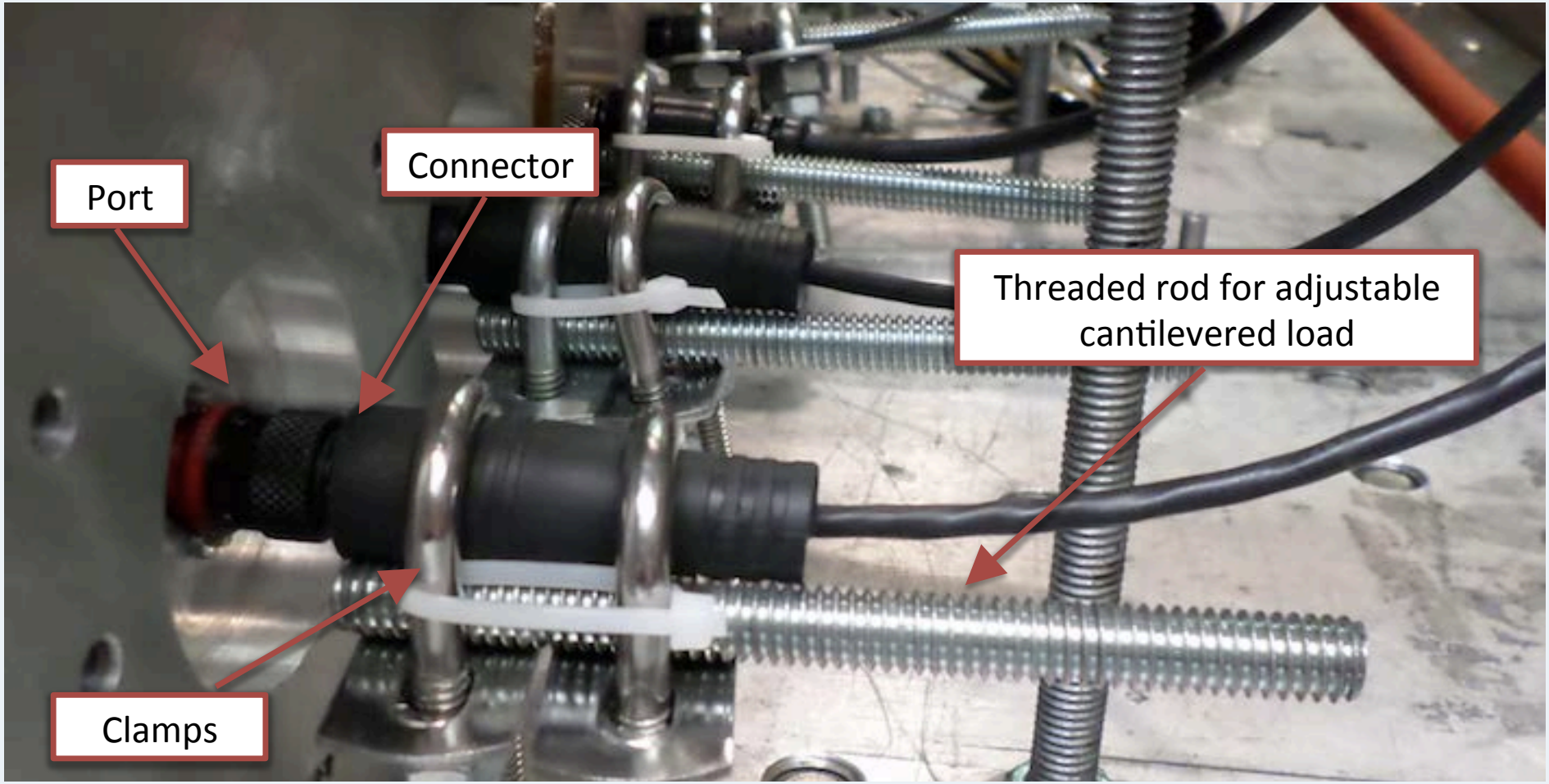
The Solution

- An additional stress amplifier was needed to create resolution between the robustness of the different connector designs
- This "accelerator" had to be adjustable in orders of magnitude so comparative performance could be discovered and then focused on
- The solution was creating an adjustable cantilevered load on the connectors to be used during HALT vibration or impact testing

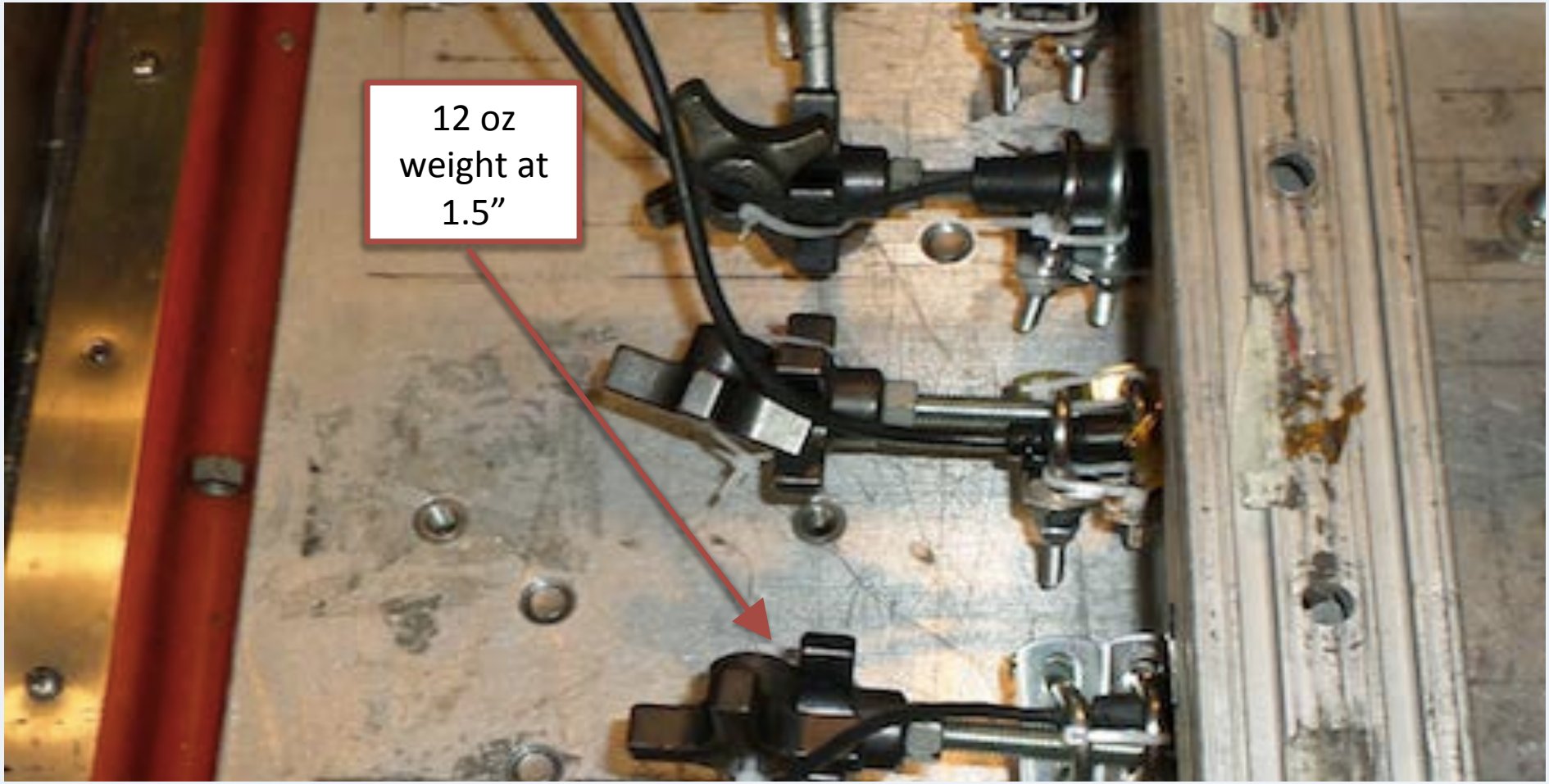
The Solution

- The variable cantilevered load was created by clamping threaded rods to the connectors
- Weights or varying size could then be added to the rods at varying distance to create a controlled amplifier
- If a group of failures are separated by a large margin the stress can be raised by an order of magnitude without breaking down the setup

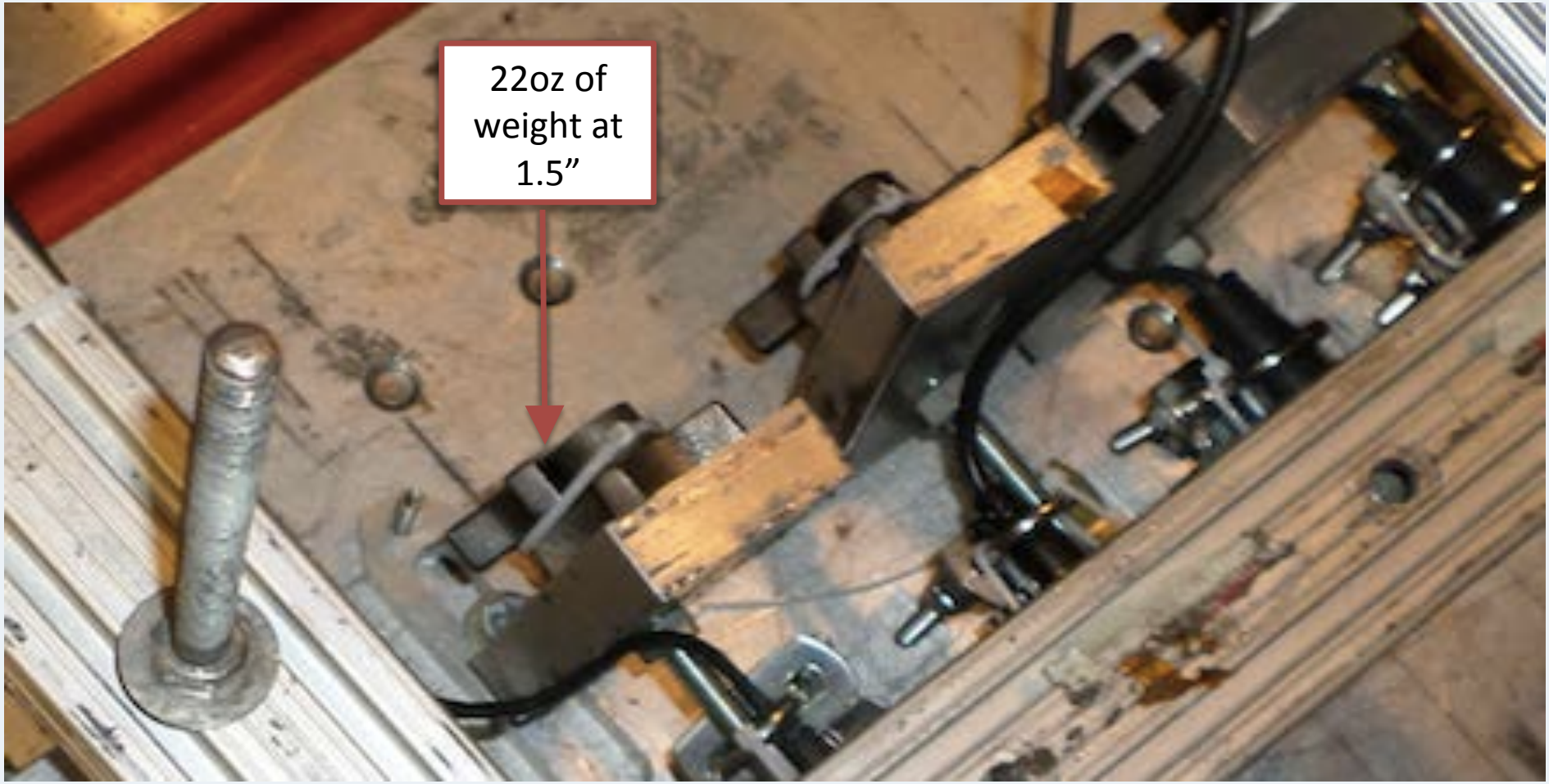
Cantilever Load Setup



12 oz of weight (3/4 lb)



22 oz of weight (1.5lb)



Results

- The accelerated test development initiative resulted in the ability to apply enough cumulative stress to replicate the failures observed in the field on any connector configuration