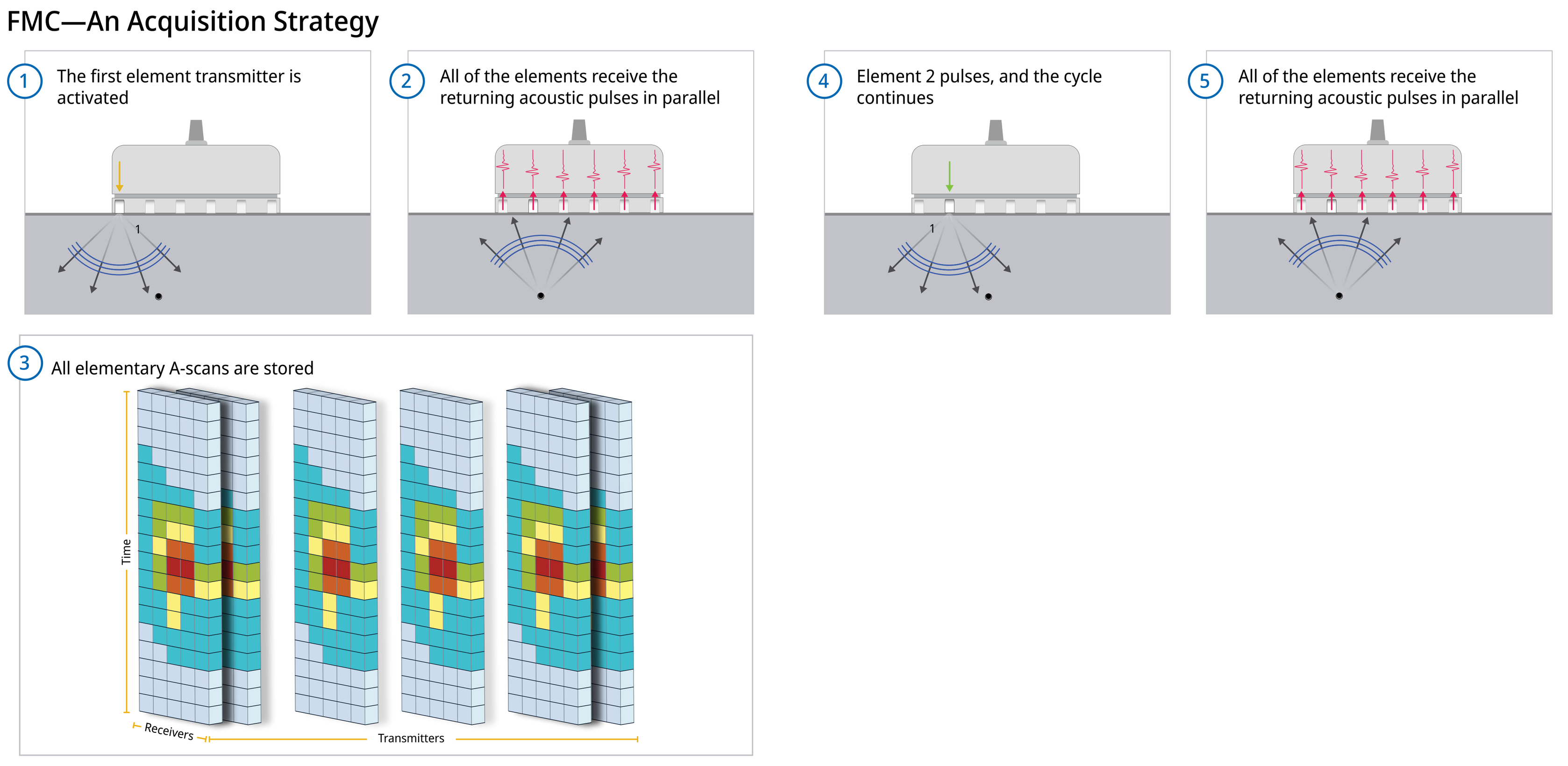
Understanding FMC and TFM Technologies

Why TFM?

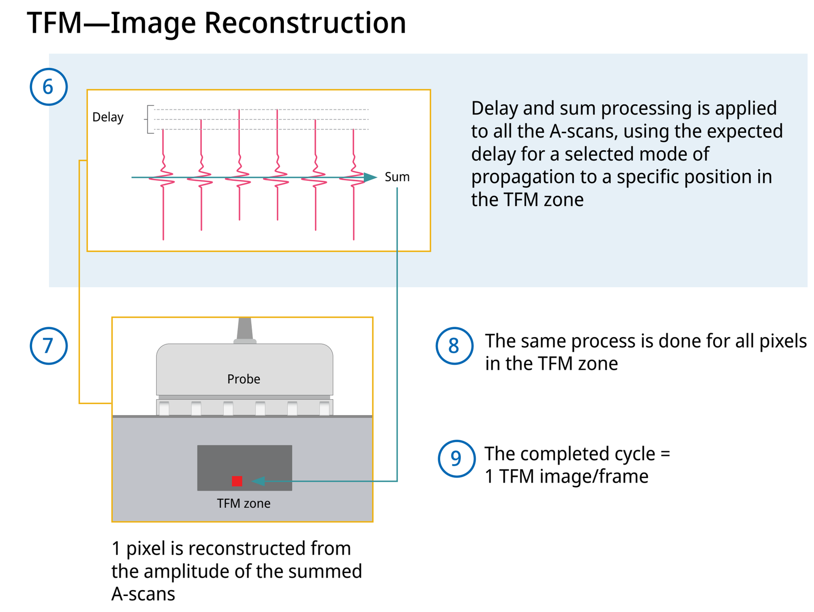
Phased array ultrasonic testing (PAUT) offers the capability to electronically steer and focus beams pulsed from a probe, producing multiple A-scans that are assembled in frames at a relatively high rate. However, one drawback is that the frames are focused at a single, constant depth. Reflectors located outside the focal region appear blurry and somewhat larger than an identical reflector in the focal zone.

The total focusing method (TFM), which uses data obtained through full matrix capture (FMC), helps solve this resolution problem while maintaining an acceptable productivity level. TFM processing retains only the amplitude at focalized points in the region of interest (the TFM zone), producing a highly resolved image everywhere in this zone and not just over a single line of depth.

FMC—An Acquisition Strategy



TFM—Image Reconstruction



Total Focusing Method Modes

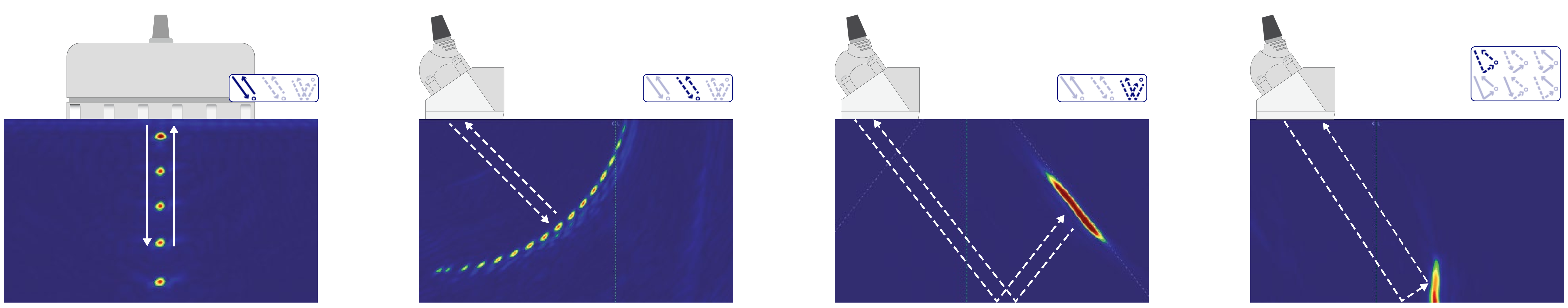
Pulse-echo

TFM pulse-echo (PE) inspection is similar to phased array inspections that are either by first-leg longitudinal waves and shear waves or second-leg shear waves. In TFM pulse-echo modes, the sound propagates either directly from the probe to the defect and back or directly from the probe to the back wall, to the defect, back to backwall, and back to the probe.

PE longitudinal waves are typically used in zero-degree contact applications, such as corrosion detection. PE shear waves can be used to monitor volumetric defects, such as inclusions and porosity. Second-leg shear waves can be used to detect angled flaws, such as along weld bevels.

Self-tandem

In TFM self-tandem (ST) inspection, the beam path goes from the probe, skips off the back wall, hits the defect, and then travels straight back to the probe. Reflections off the back wall or a defect generate mode-converted signals. In self-tandem modes, the image is calculated using a combination of these longitudinal wave (LW) and shear wave (SW) mode-converted signals. They are typically used for vertical or angled weld bevel flaws.



What to Consider When Using TFM

Setting the TFM Zone

The TFM zone is the area of the part where the technician chooses to view the image. This is adjusted by the technician and can be moved anywhere within the part volume.

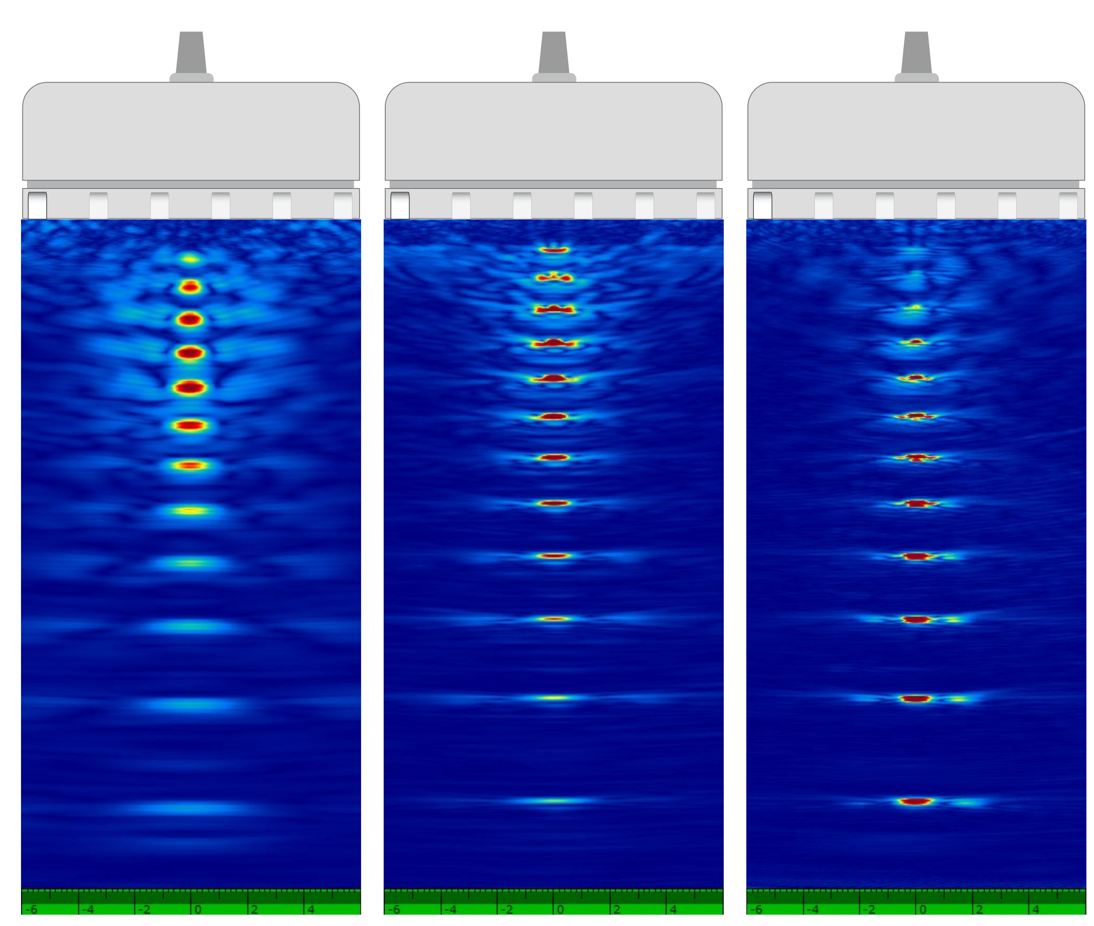
Set Zone

Min index	-9.00 mm	Max. index	9.00 mm
Min. depth	0.01 mm	Max. depth	12.00 mm

If the TFM zone extends beyond the near-field depth of the probe, the pixels in that portion of the image will appear out of focus. Learn more about the limitations that the probe imposes on the TFM in "Choosing the Right Probe."

Choosing the Right Probe

Probe characteristics are as influential in TFM imaging as they are in conventional UT or phased array imaging. Despite that TFM beamforming is achieved synthetically (in transmission and reception) based on FMC data, factors such as the size of the probe aperture, element pitch, and the frequency have an important impact on the TFM imaging results. The TFM uses the same probes as the phased array technique, so the focusing of the TFM zone is limited by the same physical principles. Typically, higher frequency probes can focus further into the part and lower frequency probes focus nearer to the probe. Probes with larger apertures can focus further from the probe and smaller apertures, closer to the probe.



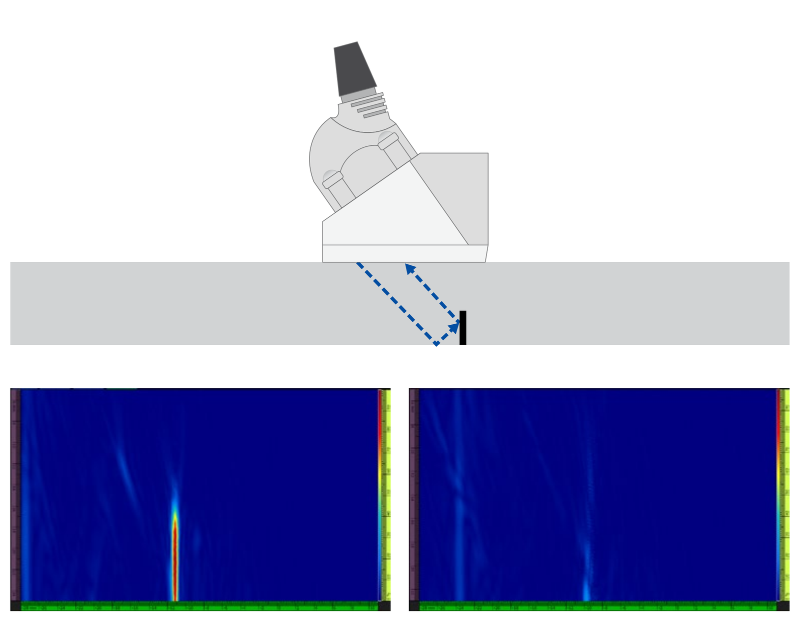
2L64-A2 – pitch 0.75 mm
Good resolution and sensitivity near the surface

5L64-A2 – pitch 0.6 mm
Good resolution and sensitivity near middle zone

7.5L60-PWZ1 – pitch 1.0 mm
Good resolution and sensitivity distant zone

Impacts of Part Characteristics

The amplitude displayed on the TFM image depends on the correspondence between assumed and true part characteristics. In PE modes, if the user enters a part velocity that differs significantly from the true value, the TFM results can contain misplaced indications, and the modeled focalization will not be in line with the actual one, affecting the displayed amplitude. In ST modes, an error in the input wall thickness value severely affects the amplitude because the transmission and reception beams will not cross at the expected position.

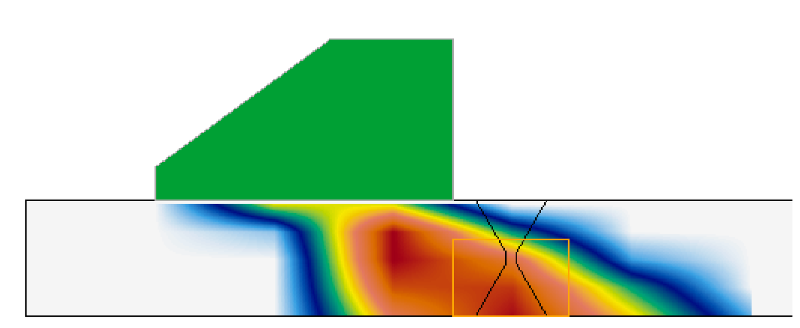


ST mode image of a 20 mm thick block with the wall thickness value correctly input as 20 mm

ST mode image of of a 20 mm thick block with the wall thickness value incorrectly input as 22 mm

Scan Planning Using AIM

The OmniScan™ X3 flaw detector's Acoustic Influence Map (AIM) enables users to see the predicted acoustic sensitivity distribution of different modes in the TFM zone in advance. It can also help users ensure that the probe and wedge configuration is effective for their inspection. They can use this to create a more effective scan plan.



EvidentScientific.com

920-207B_EN - Posters_TFM-FMC_EN_2023_02. Printed in the USA.