1

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Sonographic Technology: Now where?

2

DISCLOSURE

Frederick W. Kremkau, Ph.D.
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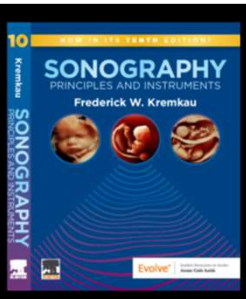
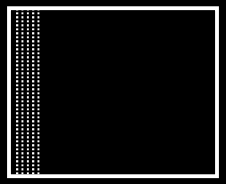


3

Serial, line-by-line, image formation

THE OLD PRINCIPLE



4

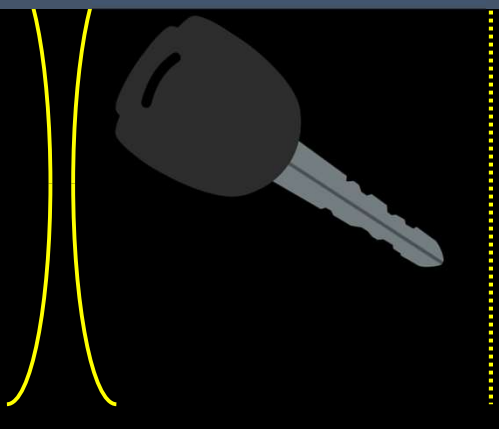
~~Serial, line-by-line, image formation~~

THE NEW PRINCIPLE

5

Provocative statement:
We can now launch a few wide, unfocused beams
and the result is?
The entire image is in focus!!

physical beam *vs.* virtual beam



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NEW PARADIGM

Old Principle

1. Launch pulse
   - focused physical beam
2. Receive echoes
3. Write scan line
4. Repeat many times

OLD PARADIGM

New Principle

1. Launch pulse
   - unfocused physical beam
2. Receive echoes
3. Repeat a few times
4. Compute and store echo information from each pixel location.
5. Display echo information for all pixels.

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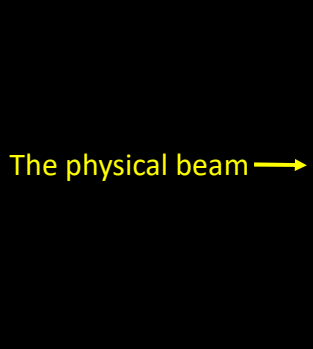

HOW is this done?
Computationally

1. Complicated
2. Proprietary
3. Variety

Computational Retrospective Beamforming
Using Graphics Processing Units (GPUs)

Massive, Rapid, Parallel, Retrospective, Virtual Beamforming
…500 billion calculations in just one second!

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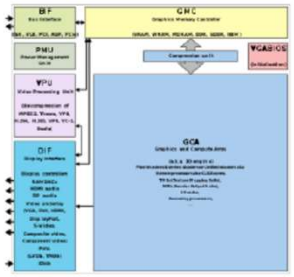
NVIDIA Looks to Revolutionize Medical Imaging with Virtual GPUs

Graphics processing unit

A **graphics processing unit** (**GPU**) is a specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display device. GPUs are used in embedded systems, mobile phones, personal computers, workstations, and game consoles. Modern GPUs are very efficient at manipulating computer graphics and image processing, and their highly parallel structure makes them more efficient than general-purpose CPUs for algorithms where the processing of large blocks of data is done in parallel. In a personal computer, a GPU can be present on a video card, or it can be embedded on the motherboard or—in certain CPUs—on the CPU die.[1]

The term GPU was popularized by Nvidia in 1999, who marketed the GeForce 256 as "the world's first GPU", or Graphics Processing Unit,[2] although the term had been in use since at least the 1980s.[3] It was presented as a "single-chip processor with integrated transform, lighting, triangle setup/clipping, and rendering engines".[4] Rival ATI Technologies coined the term "**visual processing unit**" or **VPU** with the release of the Radeon 9700 in 2002.[5]



Components of a GPU

An example of the Project Clara technology in action was demonstrated at GTC in Tuesday's opening keynote by NVIDIA CEO Jensen Huang, where a 2D ultrasound of a beating heart was converted to 3D cinematic rendering, complete with annotations of injection fraction, systolic and diastolic volume and stroke volume. Supposedly the whole thing can run on a few V100 GPUs – the equivalent of about half a petaflop's worth of deep learning performance.

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Computational Retrospective Beamforming
Using One or More Graphics Processing Units (GPU

Blahhh!

The mathematical details of how this

Wave propagation in heterogeneous tissue

$$\nabla \cdot \frac{1}{\rho} \nabla p_* - \kappa \ddot{p}_* = -\frac{\partial^2}{\partial t^2} [\rho$$

Introduce "normalised"

$$\nabla \cdot \frac{1}{\rho} \nabla p_* = \frac{1}{\sqrt{\rho}} \nabla$$

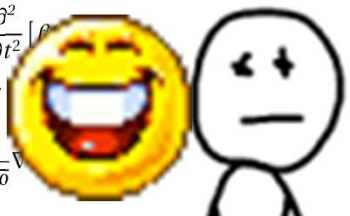
Resulting wave equation:

$$\nabla^2 p - \frac{1}{c^2} \ddot{p} = g p - \frac{\beta}{\sqrt{\rho} c^4} \frac{\partial^2 p}{\partial t^2} - \frac{1}{c^2} \frac{\partial^2 p}{\partial t^2},$$

with

$$g = \sqrt{\rho} \nabla^2 (1/\sqrt{\rho})$$

Since $P_i(-$



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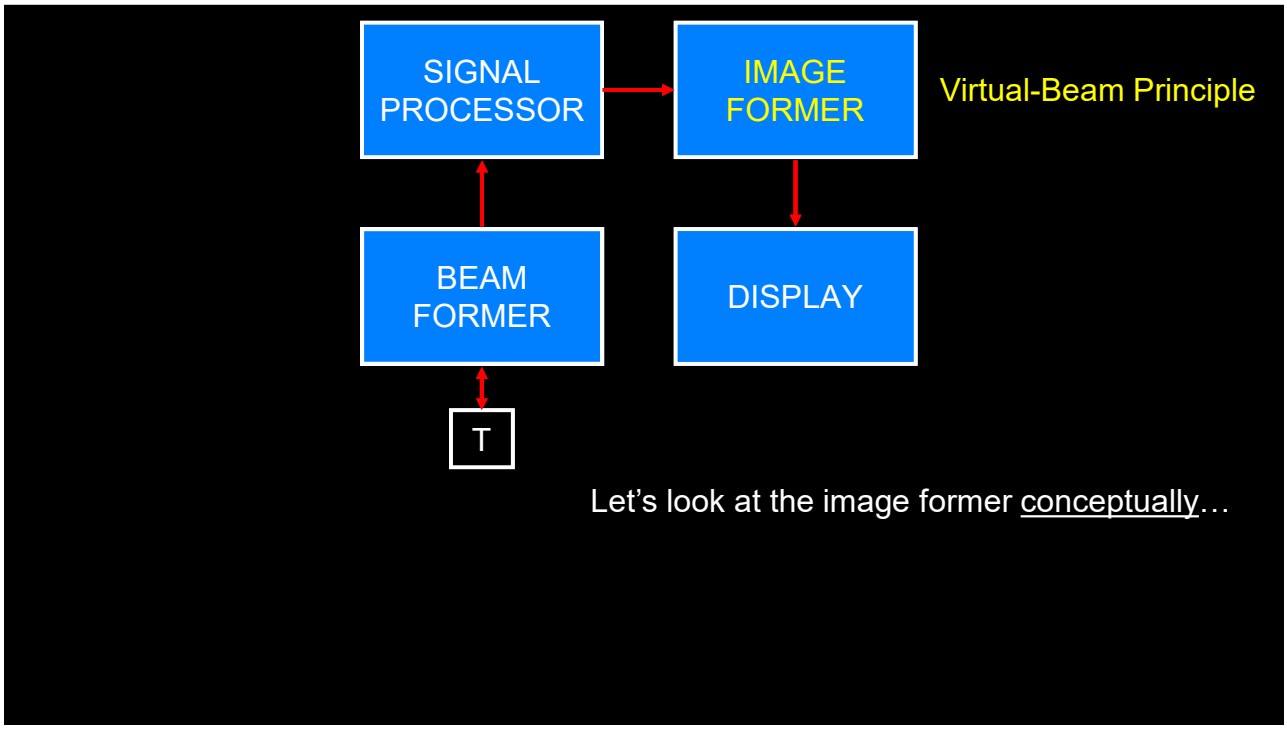
SIGNAL PROCESSOR
IMAGE FORMER
Virtual-Beam Principle
BEAM FORMER
DISPLAY
T
Let's look at the image former conceptually…

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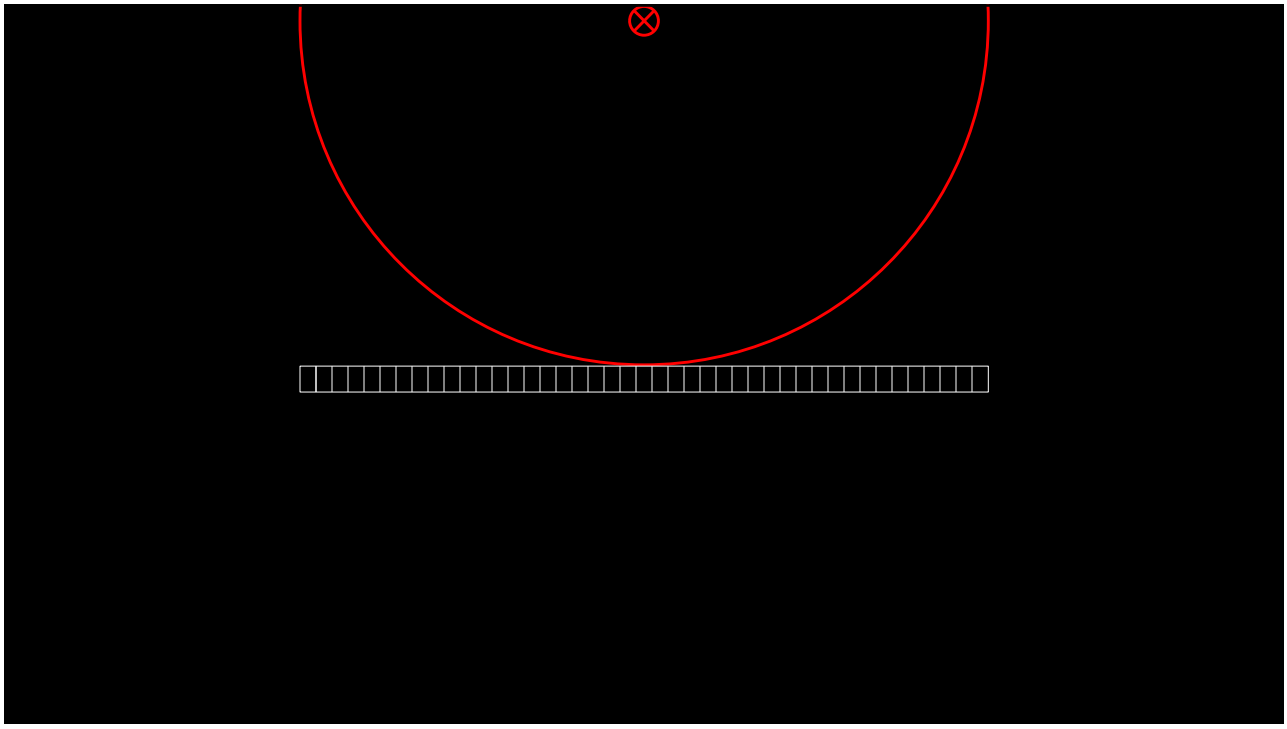

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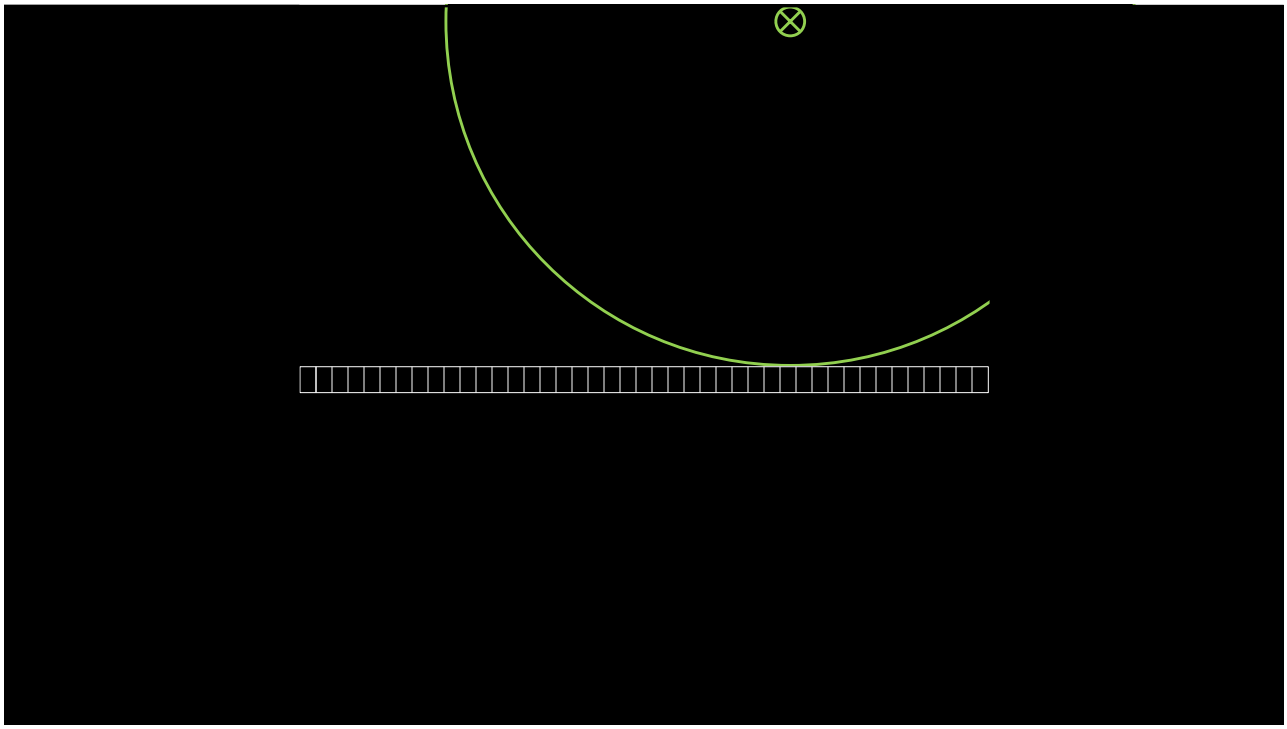

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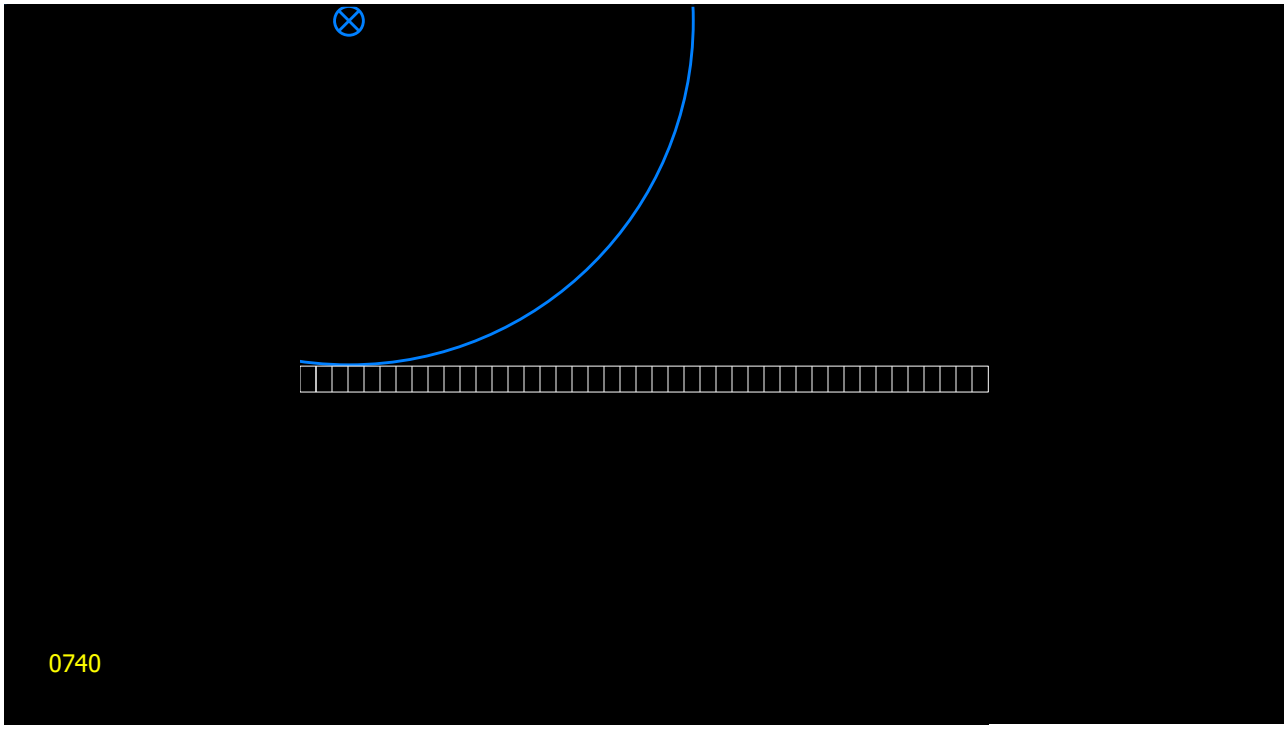

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IMPACT

- Detail resolution improved dramatically
  - ✓ Laser-thin virtual beam
  - ✓ Entire image in focus
- Contrast resolution improved
  - ✓ Section Thickness ↓
- Temporal resolution improved significantly
  - ✓ Broad physical beam (fewer pulses required)
  - ✓ No multiple focus needed
  - ✓ Frame rates > 1000 s^{-1}
    - Real-time volume imaging (4D)
    - Quantitative shear-wave elastography

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IMPACT

- Sensitivity and penetration improved
- Artifacts reduced
  - ✓Speed correction throughout the image
  - ✓Section thickness reduced
- Doppler operation improved
  - ✓Simultaneous gray-scale, color Doppler and spectral Doppler (no time sharing)
  - ✓Color flash reduced or eliminated
  - ✓Flow velocity vector mapping
  - ✓Retrospective sample volume
  - ✓Automatic aliasing correction

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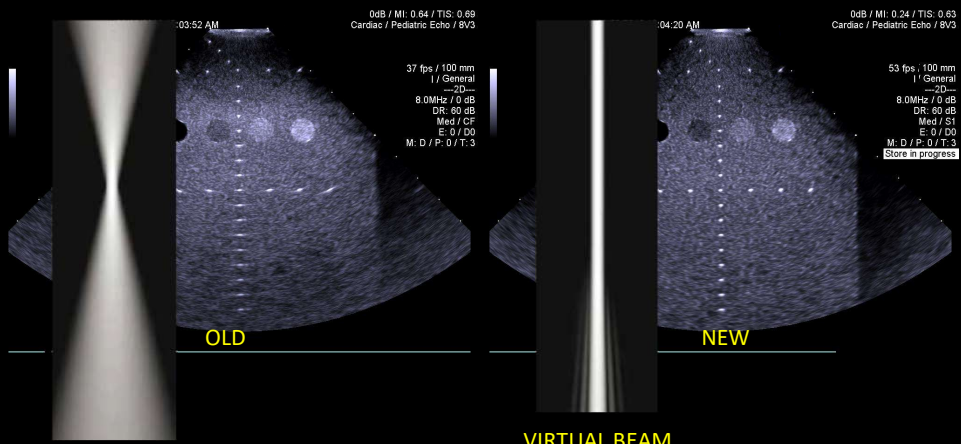

CONVENTIONAL FOCUSED BEAM

VIRTUAL BEAM

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Nikon

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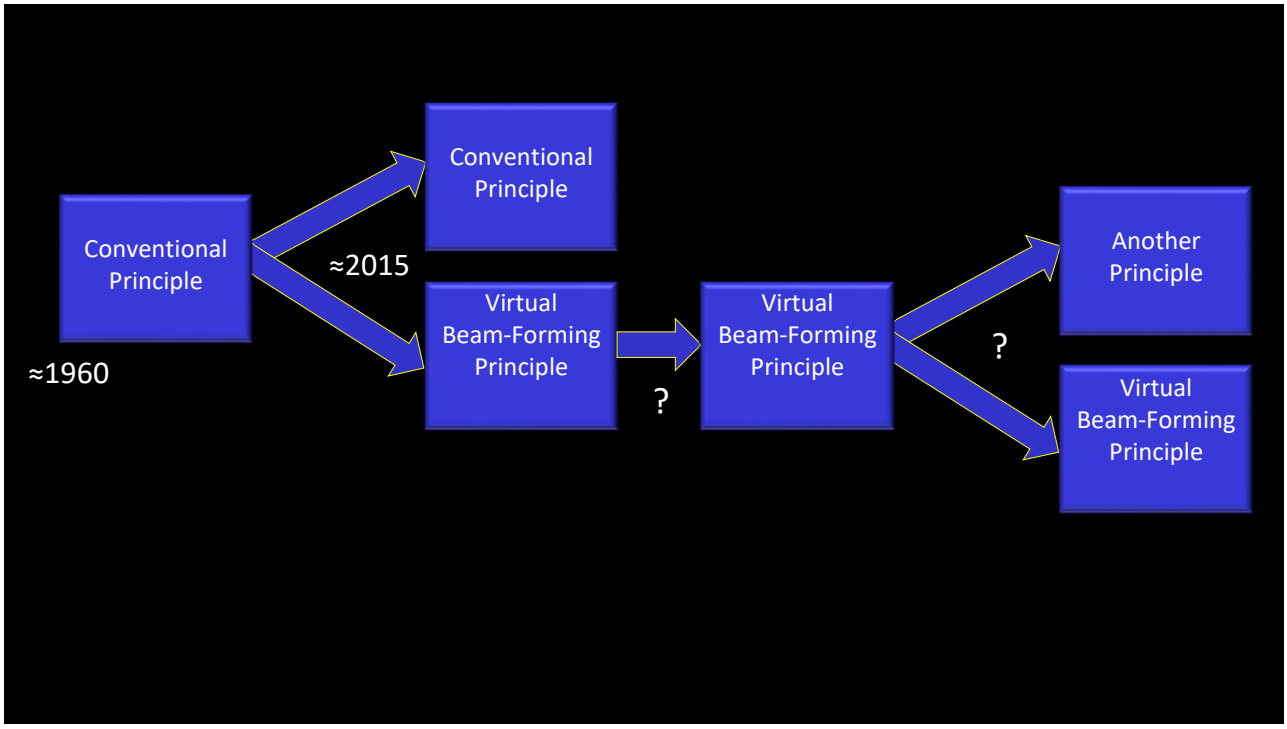
Conventional Principle
≈1960
≈2015
Conventional Principle
Virtual Beam-Forming Principle
?
Virtual Beam-Forming Principle
?
Another Principle
Virtual Beam-Forming Principle

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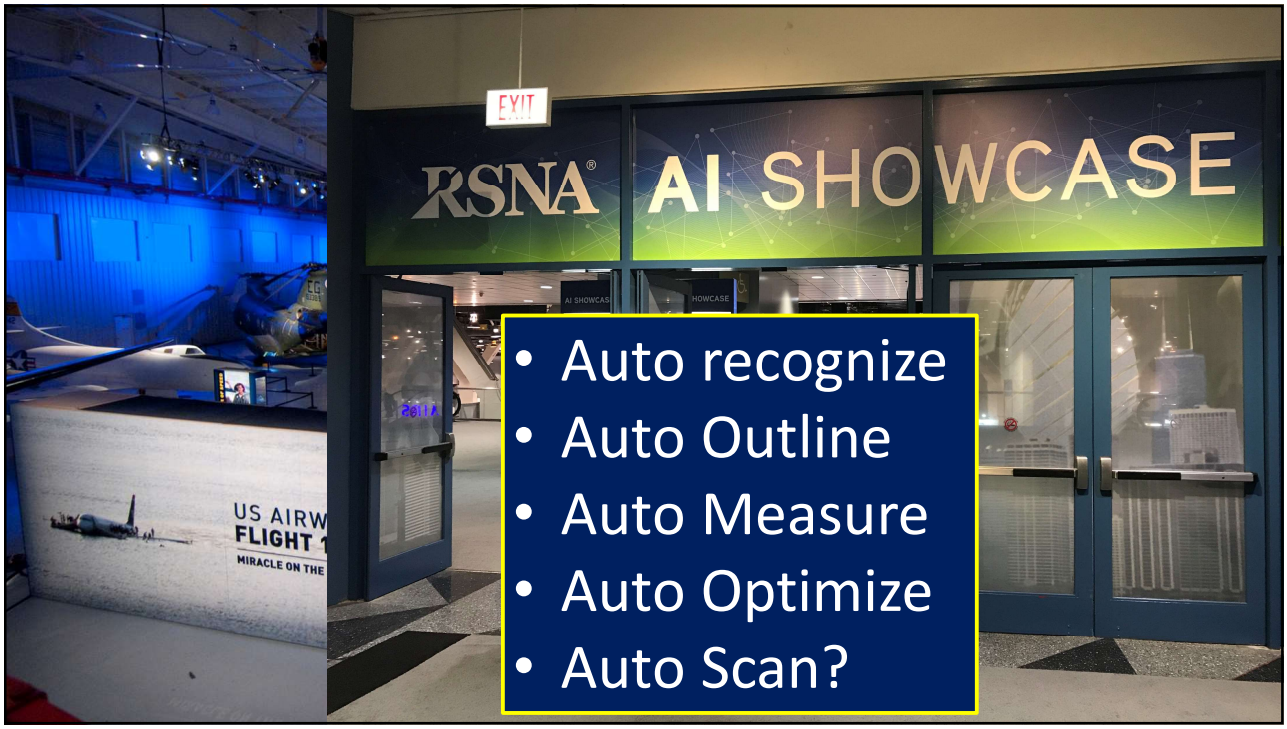

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POST TEST

New Principle

1. Launch pulse
   [physical beam forming]
2. Receive _____
3. Repeat a few times
4. Compute and store ____
   information at each ____ location.
5. Display echo information for all ____ .

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If you got that correct, you have won a wonderful, all-expense-paid, European vacation cruise!
See Alfred at the break.
But if you got it wrong, here is your

23

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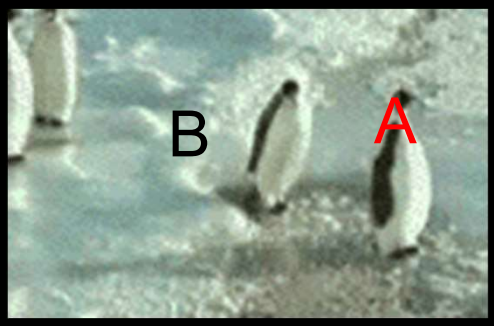
If you got it right, you are Penguin A! ☺



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27th Annual
MID-ATLANTIC ULTRASOUND SYMPOSIUM in OBSTETRICS and GYNECOLOGY
with a Pre-Symposium Interactive Course:
Acute Care Obstetrics: Focusing on Hypertension and Hemorrhage
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