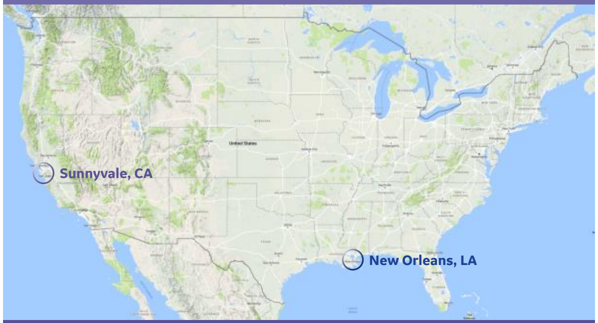
Invenia™ ABUS

Automated Breast Ultrasound

Won-Mean Lee
Senior Software Engineer

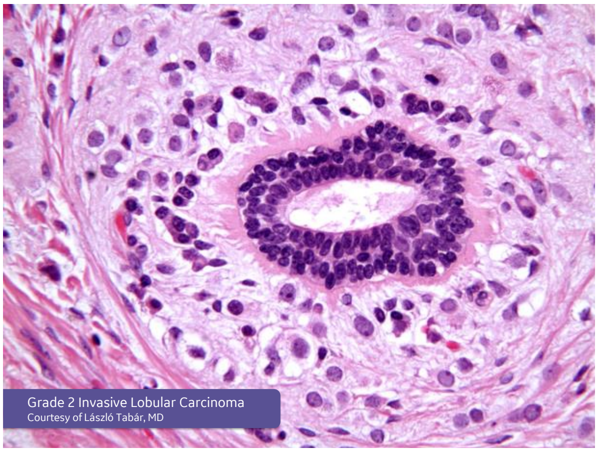
imagination at work



imagination at work

Unmet Clinical Need

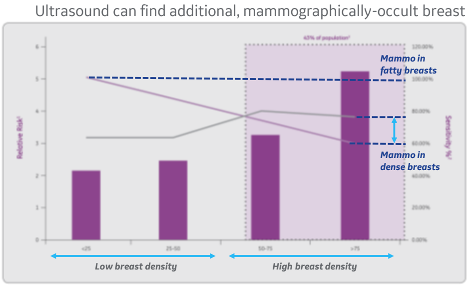
imagination at work



Grade 2 Invasive Lobular Carcinoma
Courtesy of László Tabár, MD

The Clinical Need for Supplemental Screening

Ultrasound can find additional, mammographically-occult breast cancers



1. Kolb et al. Radiology. October 2002.
2. Richard J. Santen, M.D., and Robert Mansel, M.D., Ph.D.: Benign Breast Disorders. N Engl J Med 2005; 353:275-285.
3. Boyd, et al. NEJM Jan 2007.
4. Tabár L, et al. Swedish two-county trial: impact of mammographic screening on breast cancer mortality during 3 decades. Radiology. 2011; 260:658-63.

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Different Tests for Different Breasts

Patient Risk

- Dense breasts increase cancer risk 4-6x[1] affecting >40% of US women[2]
- Each woman's risk factors are different
  - Personalized screening approach needed

Clinical Dilemma

- For every cancer found, a cancer is missed in extremely dense breast tissue[3]

- Supplemental screening finds more cancers, but needs reasonable callback and biopsy rate
- Dense tissue also is challenging for diagnostic and surveillance exams

Societal Impact

- Early detection enables[4]
  - Less invasive treatment
  - Lower morbidity
  - Reduced treatment cost
- Awareness and density notification legislation is growing

1. Boyd, et al, NEJM Jan 2007.
2. Pisano et al. Diagnostic Performance of Digital versus Film Mammography for Breast –Cancer Screening. NEJM 2005;353:1773.
3. Kolb et al, Radiology, Oct 2002
4. Bluhmen H, Fitch K, Polkus V. Am Health Drug Benefits. 2016;9(1):21-30.

Major Publications 2015-2016

SomoInsight Study (Brem, Radiology, March 2015)

- In asymptomatic screening, ABUS + Mammo detects significantly more cancers in patients with dense breasts than Mammo alone (55% relative sensitivity increase, or additional 1.9 per 1000)

EASY Study (Wilczek, EJR, June 2016)

- Adding ABUS to Mammo in women with BI-RADS densities III and IV found additional 2.4 cancers per 1000 without raising the recall rate significantly (57% relative sensitivity increase)

ABUS FDA PMA Reader Study (Giger, AJR, April 2016)

- Adding ABUS to Mammo increased sensitivity by 110% for cancers originally missed with Mammo alone in patients with no prior interventions
- Increase in sensitivity did not show a statistically significant decrease in specificity

Ongoing ABUS Research

GE sponsored projects in Discovery, Development and Expansion:
- Product development testing & feedback
- Case collection and studies for enhanced claims

Investigator sponsored projects in Acceptance:
- Region-specific clinical evidence
- Screening & diagnostic
- Driving practice guidelines & adoption

New Products → **Existing Products**

Discovery
Technology development and innovation; disease-focused, exploratory concepts

Development
Product development; safe & effective use; regulatory clearance

Acceptance
Evidence to support clinical use; adoption to practice guidelines and reimbursement

Expansion
Post-market expansion of intended uses or indications for use

Regional Studies

- 2 active studies in **China**
- 2 active studies in **USA**
- Active studies in **Korea, Thailand, Sweden**
- Studies ramping up for **Japan, Austria, Netherlands, Brazil and France**

Areas of focus

- Value of adding ABUS to current screening practice
- Comparison of ABUS to DBT and HHUS
- Cancer detection, recall rate
- 2 view vs 3 view in small breast
- ABUS in BIRADS 0 / diagnostic
- ABUS adoption tools
- Influencing local guidelines

Invenia™ ABUS System

Image Acquisition with Invenia™ ABUS

Invenia™ ABUS Scan Station

Invenia™ ABUS Imaging Architecture

- Extraordinary image quality
- Operator-independence for reproducibility
- Screening environment analogous to mammography
- Year-over-year longitudinal fidelity

Reverse Curve™ Transducer

- Conforms to female anatomy
- Improved compression, user comfort and tissue contact
- 15 cm field of view with 6-15 MHz bandwidth

Intelligent Imaging Algorithms

- Single button optimization for reproducible image quality

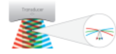
Invenia™ ABUS Review Software

Tools for Streamlined Review

- Whole breast coronal view for quick orientation using the nipple and chest wall
- Patented 2.0 mm coronal slice viewing for detecting abnormal terminal ductal lobular units (TDLUs) and architectural distortions in smaller invasive cancers
- Radial slice viewing for accurate lesion characteristics, including size, margins, spiculation, and shadows
- 3D volume visualization
- Customizable hanging protocols
- Separation of acquisition and interpretation

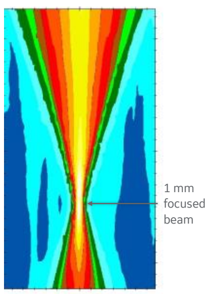
Invenia™ ABUS Technology

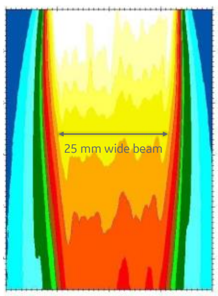
Invenia™ ABUS Technology



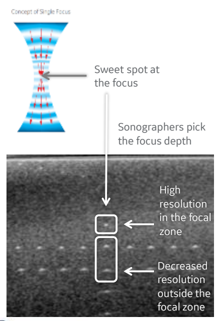
Features	Advantages
Powerful imaging architecture	Transmits wide ultrasound beams rapidly across the whole breast volume
Image reconstruction powered by NVIDIA™ GPUs	Software beamforming uses wide ultrasound beams and dynamic focusing to create volumes with superb spatial resolution at every depth
Quick data acquisition	Creates full volumes in less than 60 seconds and allows for 15-minute exams with medium-sized breasts
Intelligent Imaging Algorithms	Nipple shadow compensation, speckle reduction imaging (SRI), and breast border detection streamline reading workflow

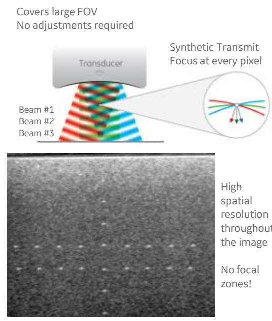
Focused Beams   Wide Beams





Focused Beams   Wide Beams

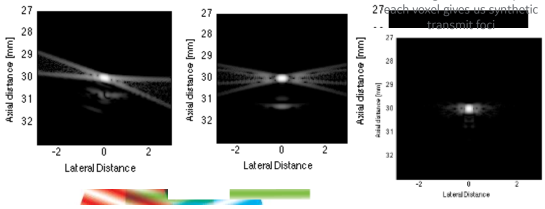




Invenia™ ABUS Image Reconstruction

Why do we use beam steering?

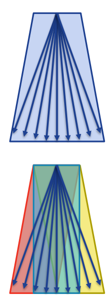
Calculating transmit delays for each voxel gives us synthetic transmit foci



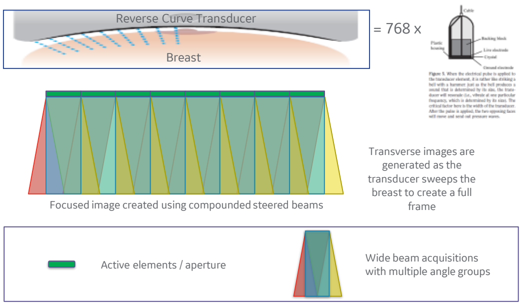
Incoherent Compounding

Coherent vs. Incoherent

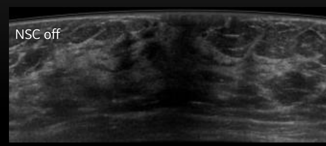
- Coherent compounding gives great spatial resolution but produces a distinctive speckle pattern
- Incoherent compounding (Crossbeam™ technology in GE Logiq™ systems) combines the steered beams in three separate angle groups
- This improves contrast resolution of breast structures by smoothing out the speckle patterns



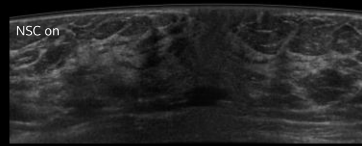
Invenia™ ABUS Imaging Architecture



Nipple Shadow Compensation

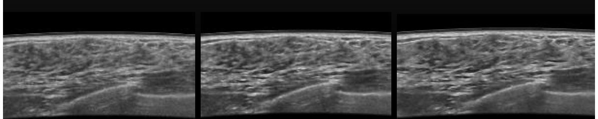


Minimizes nipple shadow and allows reading near the nipple



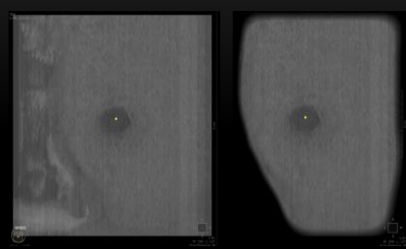
Speckle Reduction Imaging (SRI)

Decreases speckle noise
Minimizes distractions caused by noise



Speckle off | Speckle level 1 | Speckle level 2

Breast Border Detection



BBD off | BBD on

- Estimates boundary between breast tissue and the background
- Removes out of breast areas and nearfield artifacts
- Reduces reading time spent on these areas

Invenia™ ABUS Image Quality Control

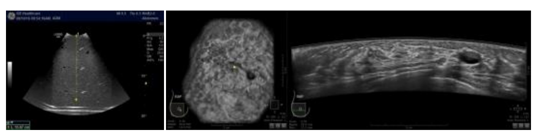
New System, Familiar Tests

B-mode Image Quality

- Despite advances in software image reconstruction and algorithms, the core technology in ABUS is the familiar pulse-echo ultrasound
- Similar image quality requirements as handheld ultrasound
- Image artifacts, uniformity, penetration, spatial resolution, contrast resolution, speckle noise

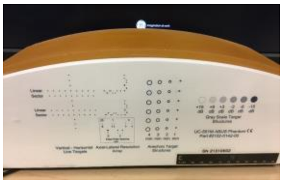
Invenia™ ABUS Image Quality Control (IQC)

- Largely follows the precedence set by GE Logiq™ systems
- Image uniformity and penetration is pre-optimized



Invenia™ ABUS IQC

IQC Parameters
- Display monitor fidelity
- Image artifacts
  - Electromagnetic noise
  - Dead transducer elements (coronal lines)
- Spatial resolution
  - Distance accuracy
- Contrast resolution
  - Dynamic range
  - Speckle



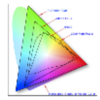
Recommended Phantom
- ATS Laboratories Model UC-551M Small Parts Phantom
  - Urethane rubber phantom shaped to match the Invenia™ ABUS curvature
  - 0.5 dB/cm/MHz
  - 1450 m/s ±1% @ 23°C

IQC Principles

Display Monitor Fidelity
- Scan Station uses Planar PT1785P-BK
- Workstation uses NEC P242W-BK

- Verify that there are no visible damage or dead pixel(s)
- Verify that the monitor's correct ICC profile is installed

- Backup any configuration prior to any changes
- Use the monitor's on-screen display (OSD) to correct any color, brightness, or contrast configurations
- If needed, use Windows Color Calibration or a SMPTE image for adjustment
- Verify any changes with clinical images



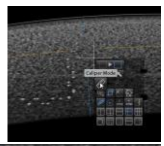
IQC Principles

Image Artifacts
- Check for any electromagnetic noise using a uniform section of the test phantom
- Electromagnetic noise shows up as bright arcs in the image
- Note: ultrasound reflection off of the bottom of the test phantom is expected

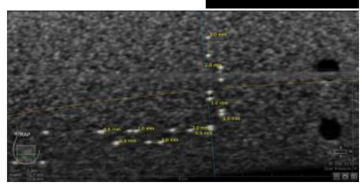
- Check for any dead transducer elements by performing a full scan
- Any faulty element should be dark and distinct in the coronal view

IQC Principles

Spatial Resolution
- Distance can be measured on the Workstation using the caliper tool



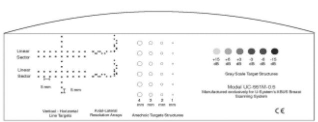
- Scan a test phantom and send the case to the Workstation
- Verify the distances between the linear line target (5 mm)
- Repeat for different depths and horizontal positions
- Verify the distances between the targets in the axial-lateral resolution arrays

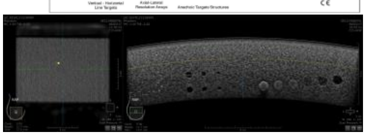


- Consider the transverse view pixel spacing (axial 82 μm, lateral 200 μm)
- Verify voxel sizes in the DICOM headers:
  (0018,0088) Spacing Between Slices
  (0028,0030) Pixel Spacing

IQC Principles

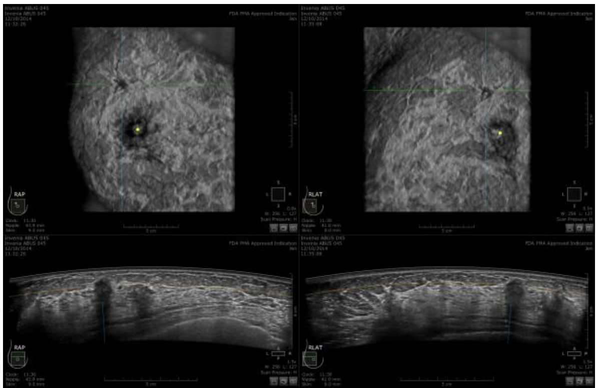
Contrast Resolution
- Default dynamic range of the system is 80 dB prior to compression and dynamic gain compensation (DGC)
- Verify that the +15 dB and -15 dB gray scale target structures are visible
- Verify that the anechoic target structures are very dark, with minimal speckle and noise



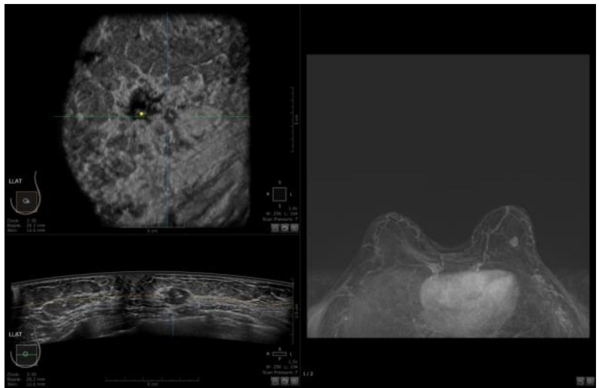


Invenia™ ABUS Imaging Demo

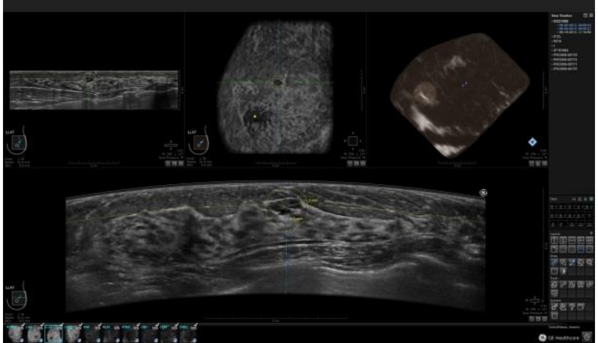
Invenia™ ABUS
Extra Slides



Mammo negative; Biopsy-proven IDC with multifocal disease

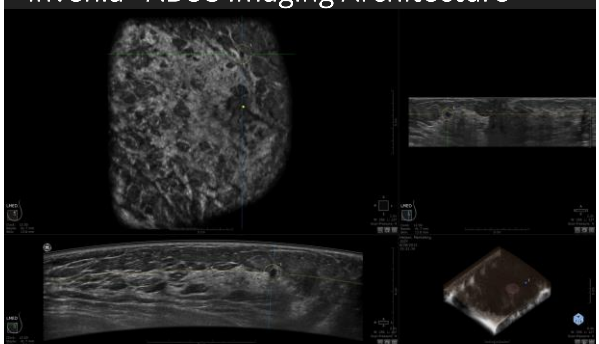


Mammo negative; Biopsy-proven IDC with MRI

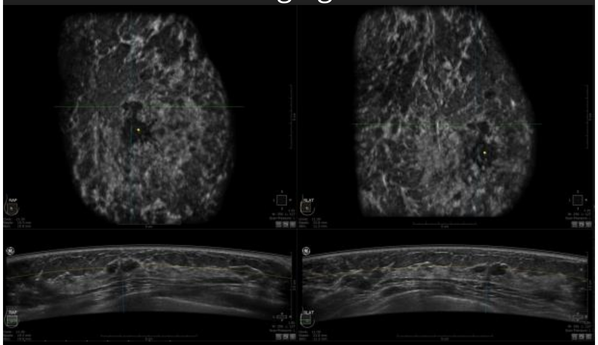


Biopsy-proven fibroadenoma

Invenia™ ABUS Imaging Architecture



Invenia™ ABUS Imaging Architecture



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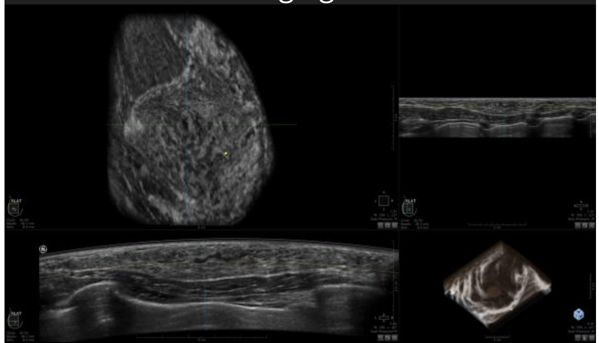
Invenia™ ABUS Imaging Architecture



Dense tissue; Normal duct

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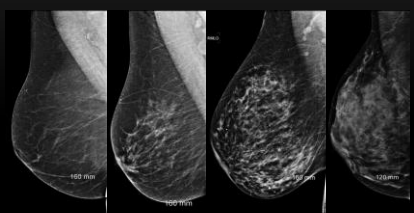
Breast Density Classifications



Predominately Fatty BI-RADS A	Scattered Fibroglandular BI-RADS B	Heterogeneously Dense BI-RADS C	Extremely Dense BI-RADS D

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SomoInsight Study (Brem et al.[1])

Detection of Cancer in Dense Breast Tissue

- A total of 15,318 women were included and classified as having breast density in BI-RADS category III (n=11,488, 75.0%) or IV (n=3,830, 25.0%)
- Breast cancer was diagnosed at screening in 112 women: 82 by full-field digital mammography (FFDM) and an additional 30 by ABUS

Adding ABUS to Mammo

- The addition of ABUS to FFDM yielded an additional 1.9 detected cancers per 1000 (95% CI 1.2, 2.7; p<0.001) screens

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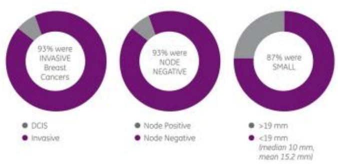
1. Brem RF, Tabár L, et.al. Assessing Improvement in Detection of Breast Cancer with Three-dimensional Automated Breast US in Women with Dense Breast Tissue: The SomoInsight Study. Radiology. 2015 Mar; 274(3): 663-73.

SomoInsight Study (Brem et al.[1])

ABUS Screening

Screening with ABUS has a **55% relative increase in invasive breast cancers*** identified using supplemental ABUS and a 37% relative increase in cancer detection overall than mammography alone.



Invenia™ ABUS is approved for diagnostic ultrasound imaging of the breast in symptomatic women in China (CFDA Indication for Use)

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* Increase in sensitivity was associated with a decrease in overall specificity

1. Brem RF, Tabár L, et.al. Assessing Improvement in Detection of Breast Cancer with Three-dimensional Automated Breast US in Women with Dense Breast Tissue: The SomoInsight Study. Radiology. 2015 Mar; 274(3): 663-73.

EASY* Study (Wilczek et al.[2])

Adding ABUS to Mammo

- The study included 1,668 women with no prior history of breast cancer
- 6.6 cancers per 1000 women screened by FFDSM + 3D ABUS
- 4.2 cancers per 1000 women screened by FFDSM alone
- ABUS produced a relative increase of 57%
- Sensitivity +36.4% and specificity -0.7%

Callback Rate

- 2.3% callback rate for FFDSM + 3D ABUS
- 2.1% callback rate for FFDSM alone

Conclusion

- FFDM + ABUS significantly increases the breast cancer detection rate without raising the recall rate significantly

* European Asymptomatic Screening Study

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2. Wilczek B, Wilczek H E, Rasouliyan L and Leifland K. Adding 3D automated breast ultrasound to mammography screening in women with heterogeneously and extremely dense breasts: Report from a hospital-based, high-volume, single center breast cancer screening program", European Journal of Radiology 2016;85: 1554-1563.

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FDA PMA Reader Study (Giger et al.[3])

Enriched Reader Study

- ROC analysis
- 185 cases of which 52 were cancer and 133 were non-cancer
- 17 radiologists were presented with FFDM and then FFDM plus ABUS image sets

Adding ABUS to Mammo

- 110% sensitivity increase for cancers originally missed with FFDM and no prior interventions
- Overall, specificity decreased only slightly with the addition of ABUS from 78.1% to 76.2% which was not statistically significant


AJR

Automated Breast Ultrasound in Breast Cancer Screening of Women With Dense Breasts: Reader Study of Mammography-Negative and Mammography-Positive Cancers

Conclusion

- "The addition of ABUS to screening mammography showed a significant increase in cancer detection with a nominal, insignificant decrease in specificity."

Coverage in Aunt Minnie (June 9, 2016)

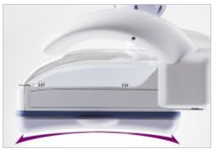
ABUS: An effective option for dense breast screening
By Kate Madden Yee, Aunt Minnie staff writer

3. Giger, ML, Inciardi, MF, et al. Automated Breast Ultrasound in Breast Cancer Screening of Women With Dense Breasts: Reader Study of Mammography-Negative and Mammography-Positive Cancers. AJR 2016; 206:1–10

Reverse Curve™

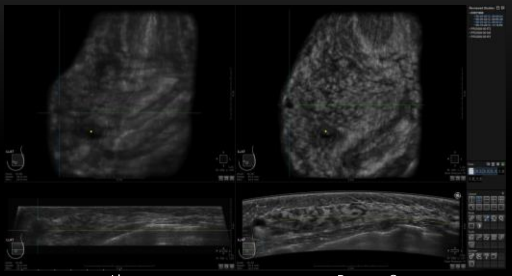
Designed to Match a Woman's Anatomy

- Uniform compression across the entire breast
- 15 cm wide field of view
- 6-15 MHz wide bandwidth
- Designed for patient comfort


Conforms to female anatomy


< 1 minute scan time per view

Reverse Curve™


Linear | Reverse Curve

Ergonomic and Intuitive

Icon Driven Touchscreen

- Intuitive icons
- Customizable workflow
- Touchscreen interface

Compression Assist

- Provides patient and operator comfort
- Multi-level compression with one-touch operation
- Promotes complete acquisition and study reproducibility

GE Healthcare Breast Portfolio