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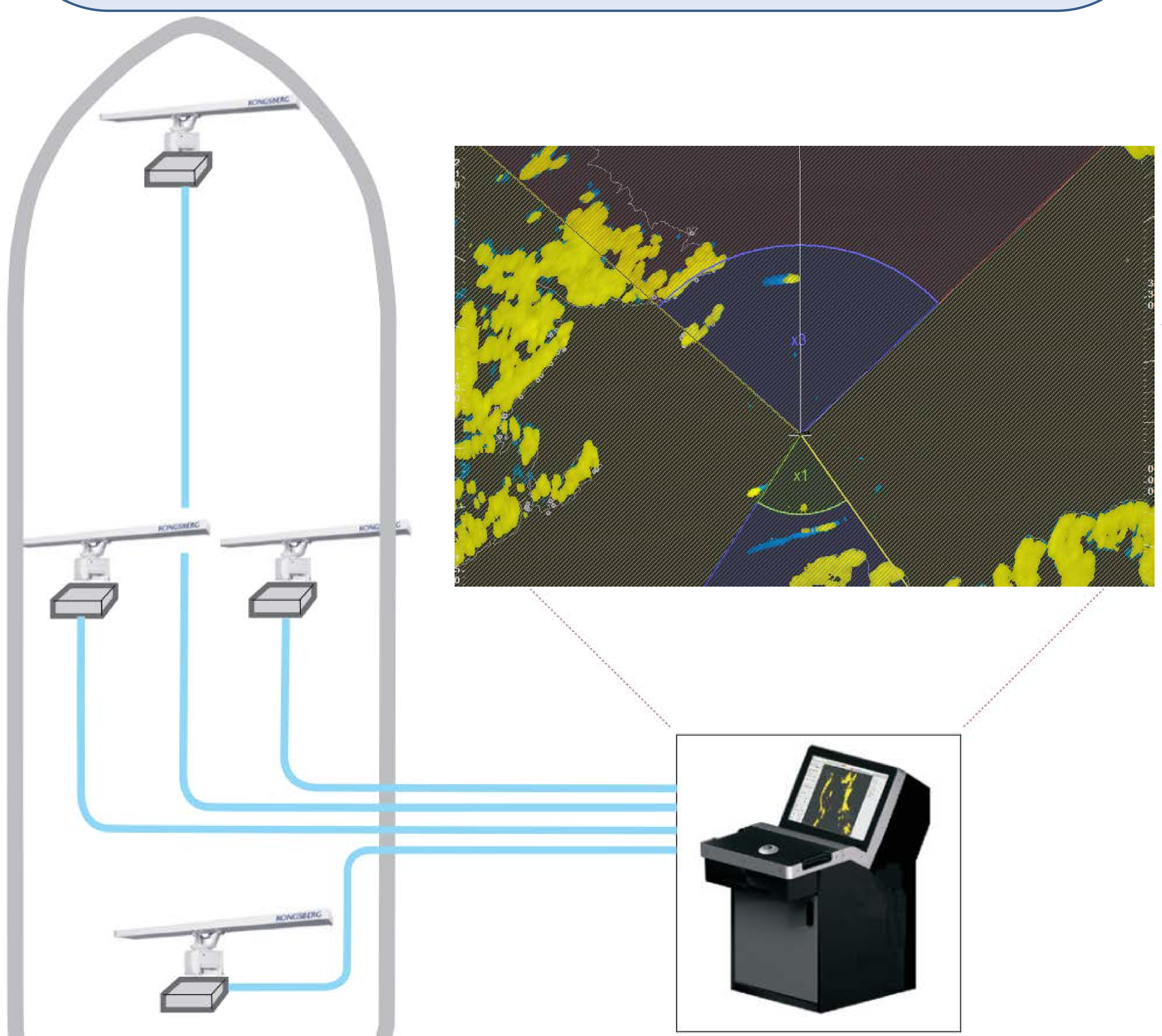
GPU TECHNOLOGY CONFERENCE

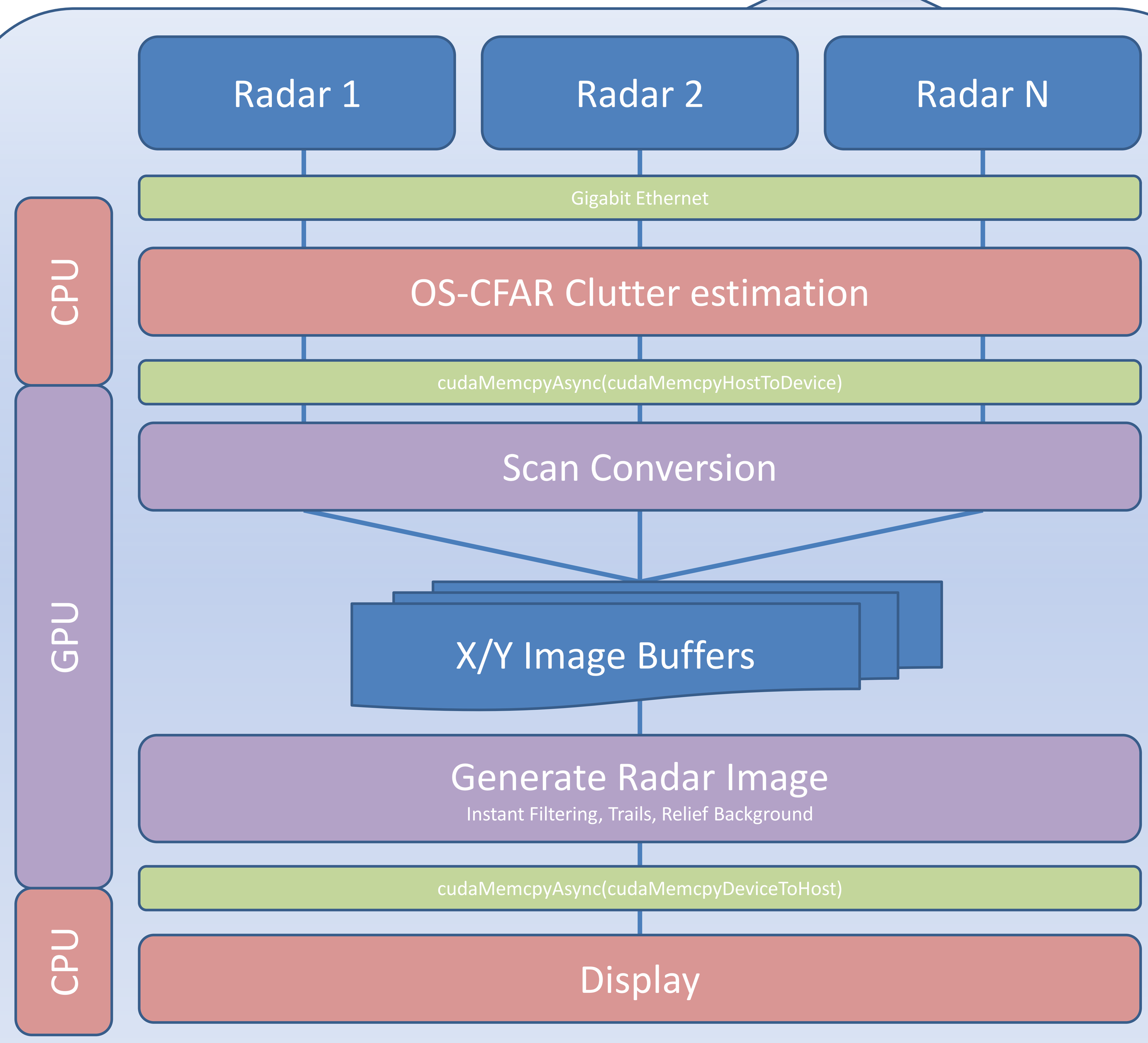
Composite Radar Picture - 360° Situational Awareness

KONGSBERG

Introduction

The new radar concept, K-Bridge 'Composite Picture' Radar CP360, is now fully integrated into the K-Bridge navigation system. With the CUDA accelerated image and signal processing, a seamless combination is achieved of up to four radar antennas in a single presentation. The radar display can perform at 60fps on a standard desktop PC with a mid-range GPU.
Using the 2GB device memory for buffering signals, we have developed such innovative features as "Relief background" for weak target detection and "Instant Filtering" for immediate response on the display to adjustments of signal processing settings by the operator.





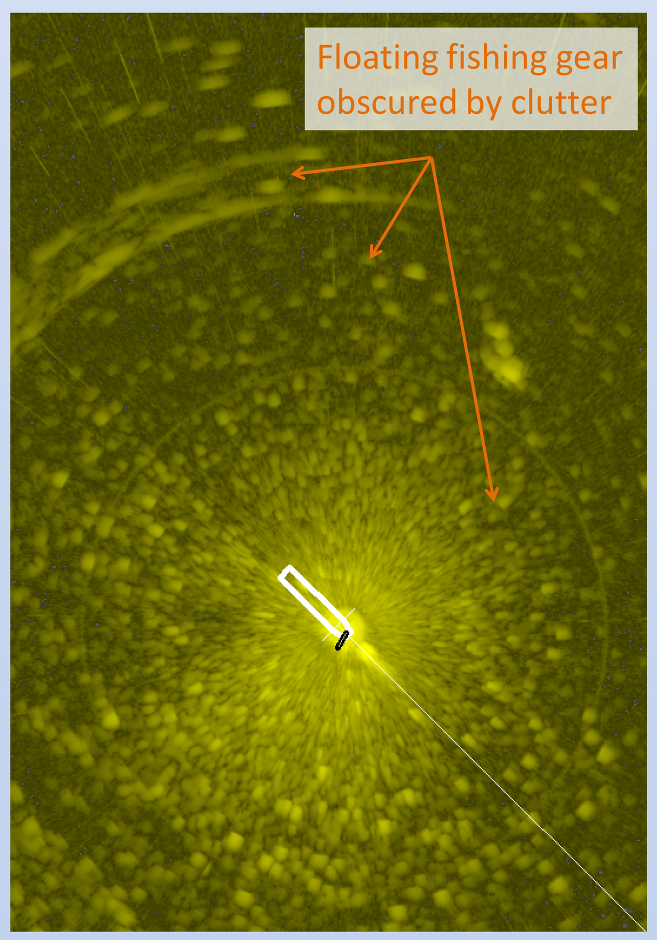
Data flowchart showing how data is transported between devices and where the different processing stages are implemented. Each radar data stream is scan converted and stored in common buffers, where each stream updates its dedicated sector. Asynchronuous memory transfers and some double buffering are used to gain speed and ensure a maximum overlap of CPU and GPU operations.

Radar image processing and presentation

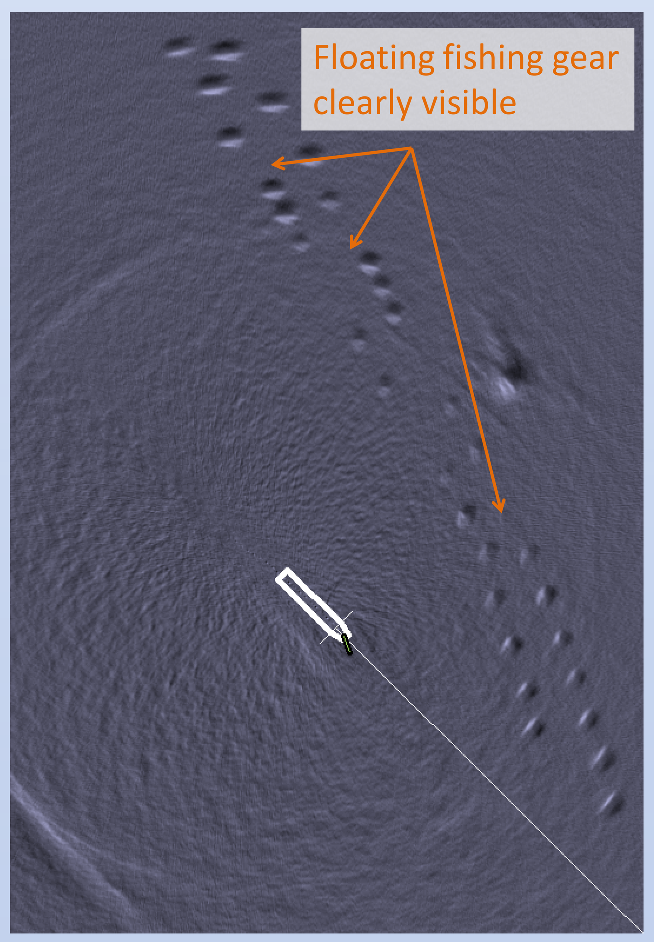
Marine radar systems are required to provide a set of signal processing functions to enhance the radar's detection performance. These functions include interference rejection, sweep-to-sweep processing for maximum signal-to-noise ratio, and scan-to-scan processing for sea clutter rejection.

In addition to these mandatory filtering routines, and thanks to the GPU processing power, KM have implemented some new and innovative functions to enhance both the user experience and the performance of the radar.

Relief background layer



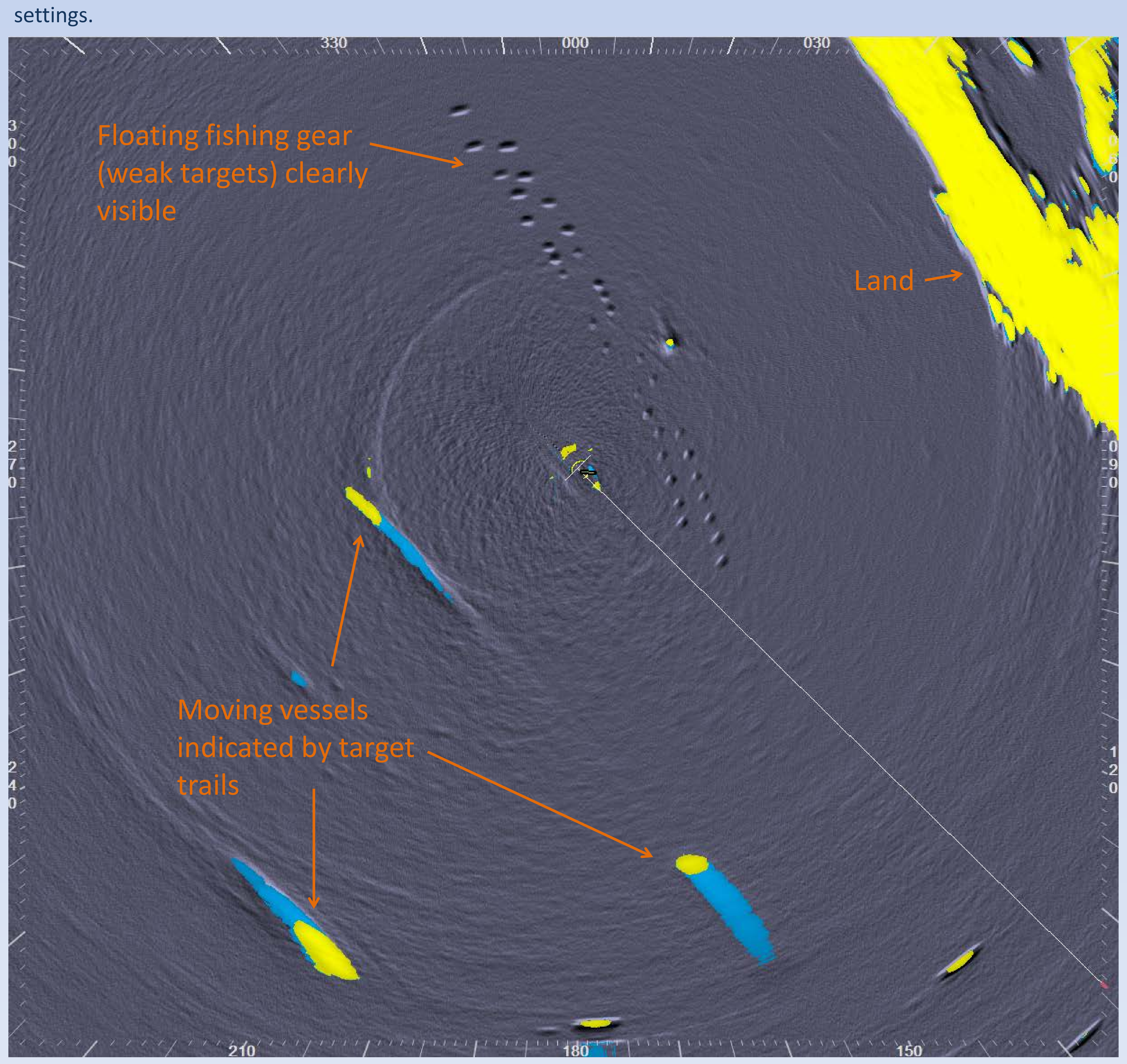
Raw radar video, containing heavy sea clutter and some stationary weak targets (floating fishing gear). Targets and the clutter both have the same signal strength.



Relief background can be used as a complement to the filtered radar video in the final presentation. Relief background is particularly useful for clarifying land masses and stationary targets on the display.

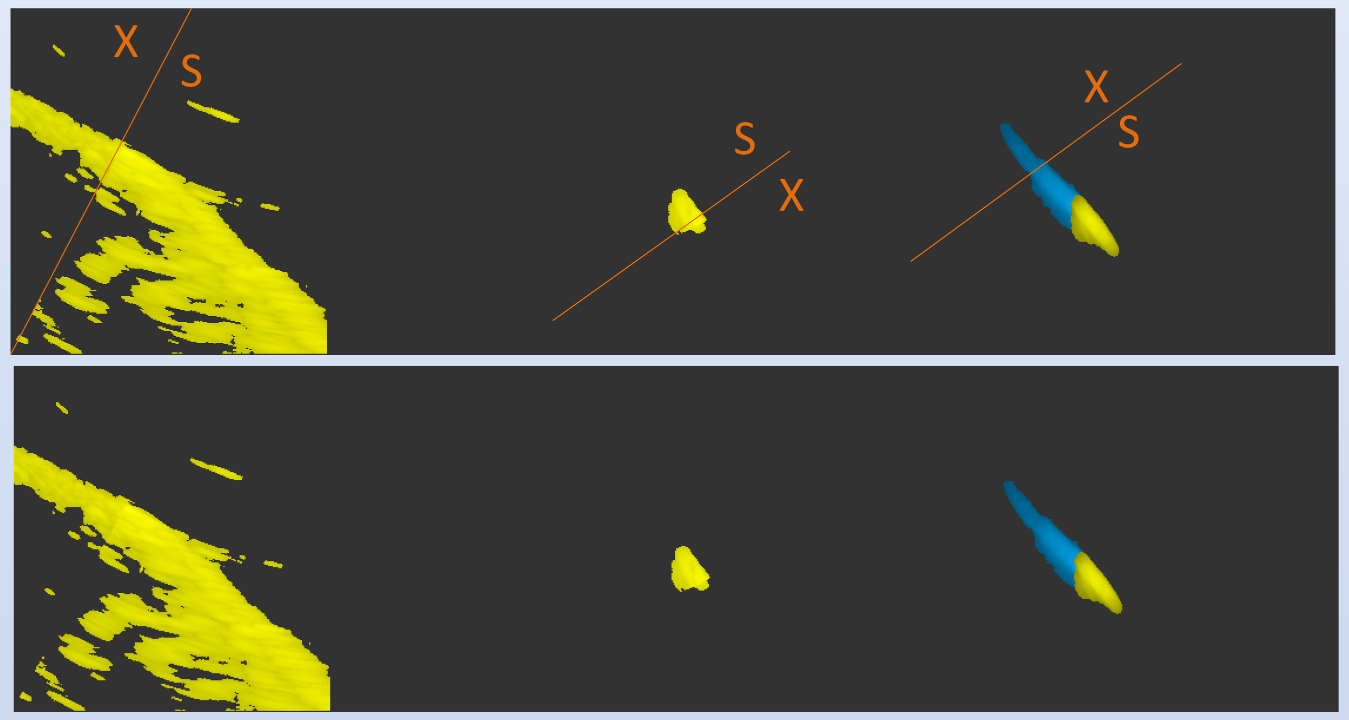
Instant filter response

K-Bridge Radar operator stations use GPU memory for buffering data. For each new radar image to be produced, filter results are re-calculated and this enables the radar display to respond immediately to the gain and clutter controls - on most radar systems the results of changes to the gain and clutter settings are visible only in the next antenna scan. On CP360 displays, even target trails (blue color below) are updated when the operator changes the clutter settings - conventional radar systems take several minutes to build up target trails after a change of filter settings.



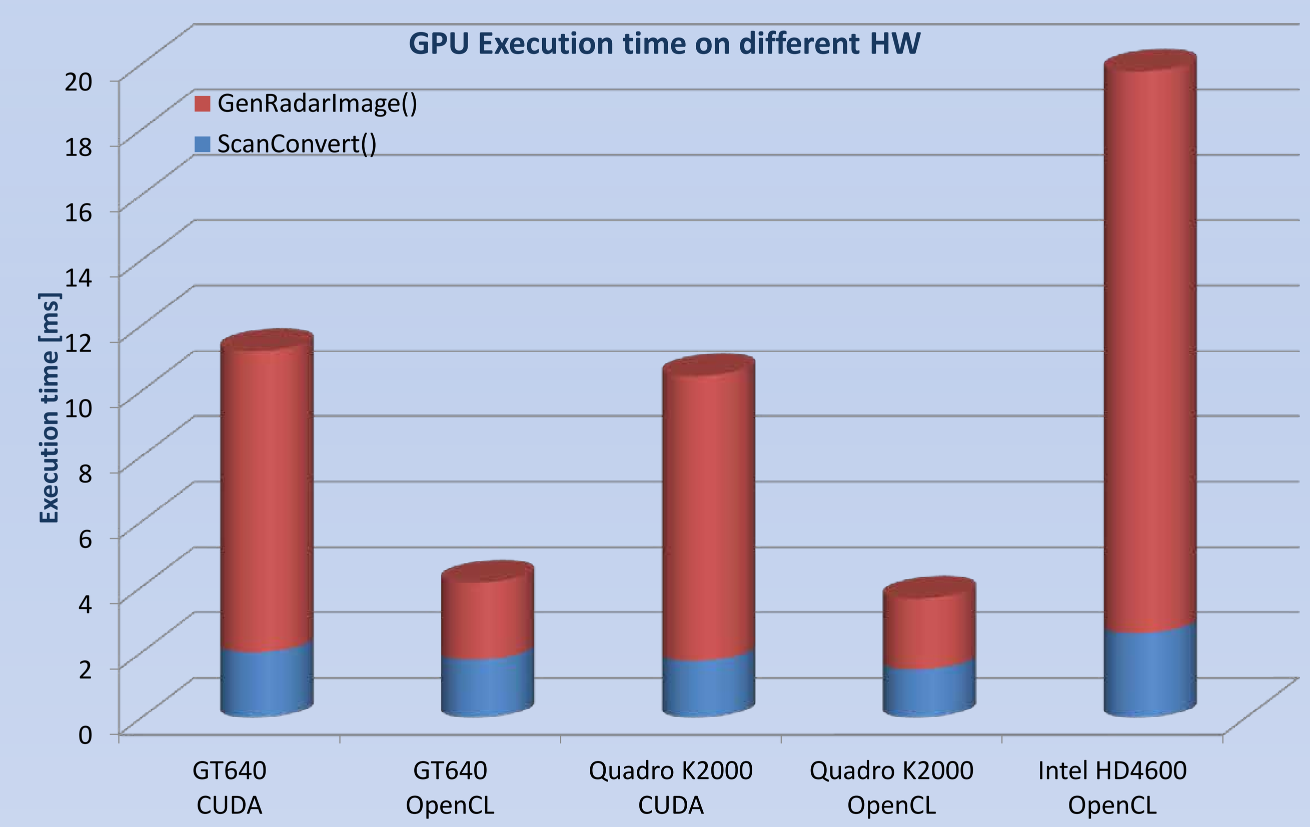
Final radar image, including clutter removal, relief background and target trails. This image is produced using recorded radar signals from the Oresund strait between Sweden and Denmark

Seamless transitions



These two images are identical except for some lines and labels superimposed on the first image for the purpose of illustration. Each image contains three examples of a seamless transition between antennas on the display. Here, an S-Band antenna is combined with an X-Band. (Note that the S-Band antenna has a larger beam width.)
The red lines show where the transition between each antenna occurs on the display. (The lines and labels do not appear on the display. The second image shows the transitions as they appear in fact.)
Left: Land masses
Center: Target echo. Note how the narrower beam of the X-Band antenna produces a smaller echo.
Right: Target with trail. In this example, the oldest trail has been generated by the X-Band and the newest trail by the S-Band antenna.

Performance results



Performance results running on standard desktop PC with Intel i7 processor. The radar processor has been implemented for both CUDA and OpenCL platforms. The OpenCL implementation performs slightly better than CUDA on the NVIDIA cards tested. But since implementation strategies differ with respect to the use of texture fetches vs global memory access, other implementations might yield a different result.

Conclusion and future work

The CP360 radar system is currently installed and running continuously (24/7) on some of the world's largest ships. The CUDA processing platform has proved itself very reliable and, thanks to a good hardware abstraction, it has the advantage of allowing the GPU to be replaced in the future (when new products enter the market) without any software customization being required.

Our CUDA implementation performs more slowly than the OpenCL implementation. However, we could probably optimize it by replacing some of the global memory-buffer accesses (which are relatively slow) with texture fetches.

In our experience, OpenCL performs especially well on NVIDIA GPU's. Some of the newer integrated graphics chips from Intel (HD 4600 and above) might also be fast enough for this radar system. However, one consideration is that, even though OpenCL is supported by multiple vendors, each vendor has its own OpenCL implementation and the software therefore has to be tested carefully on each platform to be used. The current system handles up to four radar data streams to each operator station. However, the software design is flexible and easily scales up if multiple or faster network adapters are in use and the operator station computer is equipped with a high-end CPU and GPU.