Development of the Wireless Cassette FPD AeroDR® XE

Abstract
In radiography, the shift from Computed Radiography (CR) to Digital Radiography (DR) has accelerated. After launching its 14"x17" AeroDR panel in 2011, Konica Minolta introduced the 17"x17" AeroDR panel in 2012 and followed that with the 10"x12" AeroDR panel in 2013. Thus, Konica Minolta has continuously introduced new products in response to the varied workflows of customers, earning a spotless reputation--especially with regard to weight and electrical charging performance.

DR cassettes are both expensive and heavy compared to conventional CR cassettes, and they remain a burden to doctors, technicians, and nurses, all of whom must divert their attention from clinical care to operate and handle the equipment. To overcome that, we developed the tough, lightweight and waterproof AeroDR XE, to be simple, reliable and robust with a short-cycle system which enables clinicians to focus entirely on the imaging process while shortening the patient's total treatment time. The AeroDR XE is transferable from system to system so that cassettes may be used on ward rounds with the same ease as within the general radiography room, enabling seamless operation.

This paper describes the advanced technologies and capabilities of the AeroDR XE.

1. Introduction
In 2011, Konica Minolta released the AeroDR 14"x17", a lightweight wireless DR system with high charging and performance power. We then expanded our lineup with the AeroDR 17"x17" in 2012, following that with the AeroDR 10"x12" in 2013. These systems enable imaging within all hospital environments--from hospital rooms during ward rounds (portable imaging) to operating rooms to the NICU.

Compared with conventional CR cassettes, DR cassettes are expensive and heavy and require users to pay close attention during handling. This places a burden on doctors and technicians, who prefer to focus their attention on patients. ER and operating room imaging carry similar inconveniences: unexpected splatter of cassettes due to incontinence or bleeding has been reported, necessitating the development of a product that can withstand such contact.
*See AeroDR XE Operation Manual

By creating a lighter, more robust and increasingly water resistant (IPX6) product, and by shortening the cycle time, we have developed a system that, in addition to enabling imaging with increased stability, reduces the burden on patients by shortening the imaging duration.

In larger hospitals, we have observed environments with numerous network segments that are separate from the general radiography room, the hospital ward, and the operating room. Conventional systems have been unable to share information between different networks, forcing users to use multiple panels.

The AeroDR XE system permits roaming from site to site. Seamless operation is enabled, allowing imaging within the general radiography room and during patient rounds using the same panel.

2. Panel Technology
2.1 Technology to Increase Drop Resistance
The versatile 14"x17" cassette is useful in every scenario, including standing/lying bucky imaging, bedside imaging during patient rounds, operating room imaging and in the event of an emergency. We have anticipated cases and where cassettes might be inadvertently dropped from table height. In actuality, there have been cases where users have accidentally dropped cassettes when improperly inserting or removing them during standing bucky imaging. In light of this, we examined how to help ensure drop resistance to avoid cassette malfunction in these operational scenarios.

The external trim of cassettes is tubular in structure and consists of a carbon material similar to that of conventional machines. The long side is cap-shaped with a resin protective cover.

Risk is increased when dropping a cassette on its corner, so we redesigned the corner elements. Our basic premise was to eliminate damage by reconsidering the spatial distance between the shock absorber and the internal structure, then changing the shape and thickness of the resin protection bar.

With a drop resistance degree 1.5x greater than that of traditional 14"x17" plates, we have developed a resin shape and thickness with effective energy absorption, as demonstrated in a drop simulation. We have also evaluated shaping issues caused by thickening, and to minimize collisions we constructed a cushioning material for the spaces that cannot absorb shock due to structure thickening. To instantly absorb shock, we adopted a foam cushioning material that prevents collision and excessive deformation to the internal structure (Fig. 1).

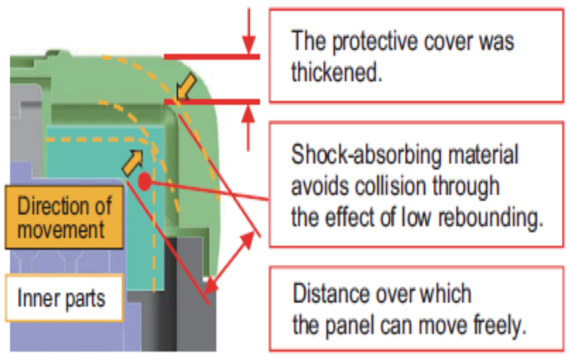

Fig. 1 Modified corner of the cassette. Breakage and internal damage to the cassette due to dropping can be avoided.

2.2 Technology to Create a Lightweight Exterior

Users require similar operability to CR and it is crucial to make the device lightweight. The exterior housing accounts for most of the weight of the AeroDR 14”x17”. Thus, attention was paid to reducing the external body weight while maintaining robustness. We maintained the tubular structure using a carbon ingredient similar to that of conventional machines and adopted a sand-wiching structure that forms a rigid layer between the outside and internal surfaces (Fig. 2).

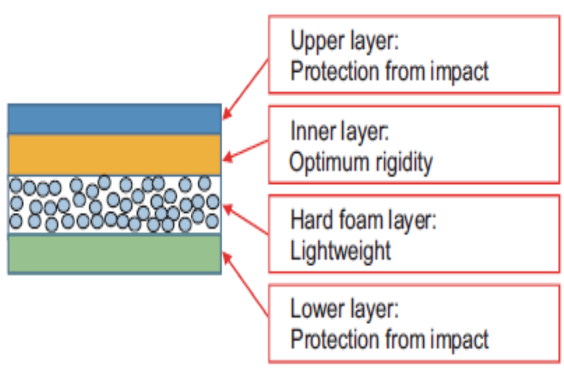

Fig. 2 Cross-section of the walls of the case. The case is lightweight, yet it provides strong protection.

To maintain structure stiffness, we used simulation to select the material used for both the internal and lower layers. For the surface, we studied the anticipated result of accidentally dropping an item at medial sites, and chose a robust material that ensures the greatest safely against shocks.

By combining other weight reduction techniques, we achieved a product weight of only 5.7 lbs without compromising the performance achieved by previous systems.

2.3 Heavy Load Resistant Technology

When bedside imaging is required or overweight patients must be imaged, the case may bend. During development, we considered how to strengthen resistance against bending. Most of the corner framework that comprises the external frame of conventional machines is metallic, however a resin is used for the parts that require wireless communication; a metal/resin/metal three-division structure is often selected. Through simulation, we optimized the thickness, shape, stiffness, etc., to convert this into a non-metal material that does not interfere with wireless communication and has a seamless integration structure (Fig. 3). Using a textile-strength resin with the appropriate strength and toughness, we achieved near-double stiffness for the entire corner framework compared with the construct of conventional machines.

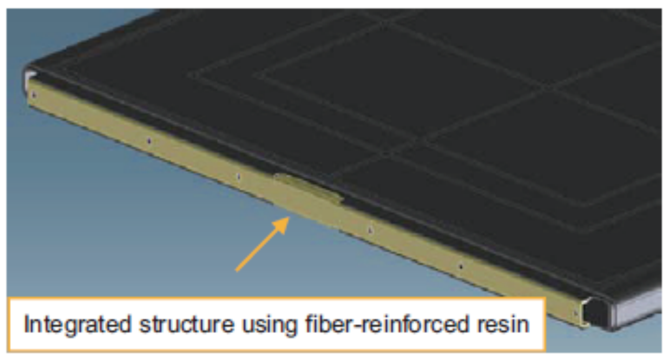

Fig. 3 An integrated structure using fiber-reinforced resin gives greater rigidity to the panel, as well as uninhibited wireless communication.

2.4 Waterproof Structure Technology

For emergency and operating room imaging, unexpected damage by liquids due to incontinence or bleeding has been reported, so development of a product that can avoid this issue was desired. We investigated how to develop a

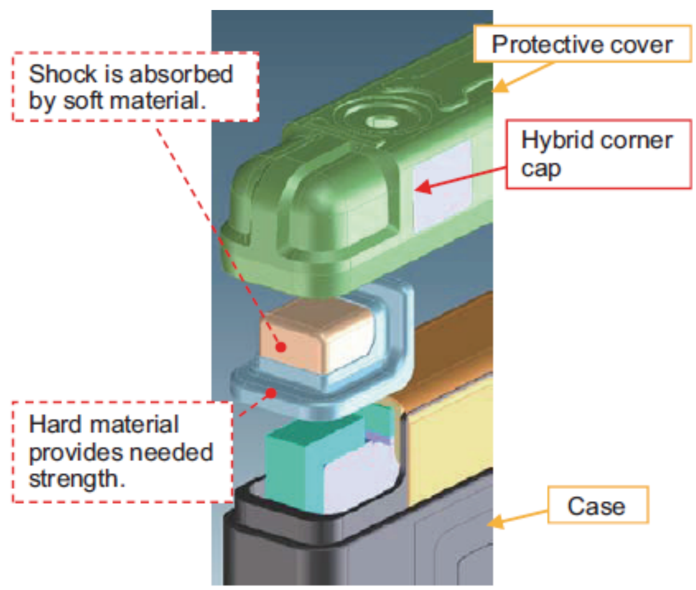

Fig. 4 Waterproof against patient incontinence or bleeding. To ensure the integrity of the corner seal, which is susceptable to shock, a combination of metal and soft materails is used.

cassette that is difficult to damage even in scenarios where the cassette is drenched in liquid. Our target performance was to ensure waterproof capabilities in normal operating scenarios.

In order to ensure the sealing of vulnerable corners, we developed a cap-shaped cover and carried out an all-inclusive study to further innovate against various shocks. For the corner, we utilized metal materials to ensure toughness and a soft material that is flexible enough to shape itself accordingly to absorb the shock.

By creating a hybrid structure formed of two different materials, we achieved a structure that provides optimal shock resistance and absorption (Fig. 4). This structure increased the degree of sealing and achieved the desired waterproof standard, IPX6.*

3. Improved Cycle Time

3.1 Parallel Processing

The AeroDR System has ensured instantaneous imaging through its quick preview technology, significantly increasing client productivity. However, in orthopedics and other fields that require multiple images, the time between the beginning of exposure and the subsequent image (cycle time) has not necessarily been optimal. Additionally, instant responsiveness is required for imaging that occurs within operating rooms and emergency department, etc., where easy-to-handle wireless cassettes and simple to operate panels are necessary for instant responsiveness. When using a wireless network where stable transfer speed is difficult to achieve, significant time-saving measures are desired.

For use in every imaging scenario, the AeroDR XE establishes six seconds as the target value after analyzing user positioning between imaging.

The imaging cycle for DR imaging: When considering imaging duration, we found that the most time was spent transferring images from the panel to the console and processing the image in order to optimize it for diagnostics. Because these processing procedures involve a large amount of disparate imaging data, it is imperative to consider where to store that data.

Regarding the high processing load and the amount of input/output data for each process, we succeeded in optimizing the process by subdividing and dispersing those loads, which permits parallel operation and the reduction of data transfer volume between units. By heavily reviewing the architecture within consoles and separating the user interface screen and the imaging control layer, we were able to develop a new pre-fetch mechanism that enables panels to be prepared for subsequent imaging during the review of current images. Such technologies have allowed us to achieve a six-second target cycle time while connected to a wireless network, divesting users from the stress of continuous imaging while providing stable performance regardless of the network environment for a worry free environment.

4. Roaming Improvement

4.1 Challenges of the Conventional System

Within the AeroDR system, panel roaming between imaging environments was achieved by connecting all the environments that share panels via a wired network as a subsystem on the same subnet and connecting them to registration devices, such as docking stations that are linked to their respective environments.

The need for a wired network connection became a restriction to adding or changing panels within patient rounds and to situate the registration docking station near the radiology department. Although it is possible to set up different independent systems on the network, systems that are separated physically and divided logically (with a different subnet), this would require network information within each system to be reconfigured. It would be necessary to export data to each system, causing user operational situations that require extra work. (Fig. 5)

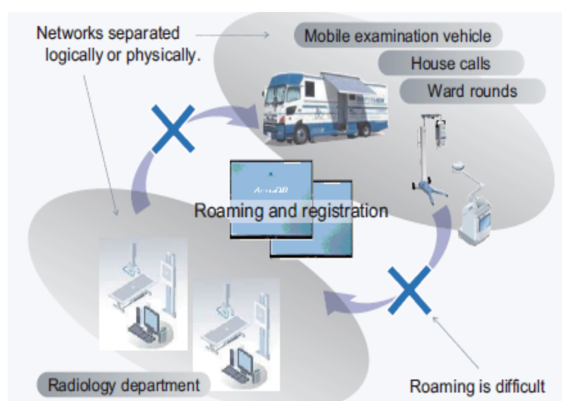

Fig. 5 Roaming is restricted when isolated from the radiology department

4.2 From a Centralized to a Decentralized Process

In order to resolve these issues, we have distributed the panel roaming central management function between subsystems (shooting environments), which only exists in conventional systems, and changed the specifications to achieve individual resolution (Fig. 6).

As a side benefit, seamless operation, including roaming, within each subsystem can be performed without issue, even when a malfunction occurs within the central control system.

**The product may fail to maintain its waterproof performance (equivalent to IPX6) if it has been dropped. The waterproof performance of this product does not guarantee that produt damage or failure will not occur.*

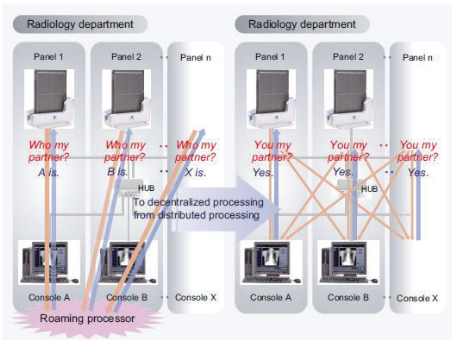

Fig. 6 Change to decentralized processing for roaming. Various roaming issues can be solved at the individual subsystems so that each subsystem can work independently. If there is a central control function failure, the independent subsystems will continue to operate.

4.3 Automatic Setup of Networks

The aforementioned decentralized process is further strengthened with the introduction of Zero Configuration Networking (hereafter referred to as Zeroconf) (Fig. 7).

As this is realized at the application level within the AeroDR XE, the roaming of aforementioned panels and the development of data portability (to be discussed later) are devised to be solved efficiently.

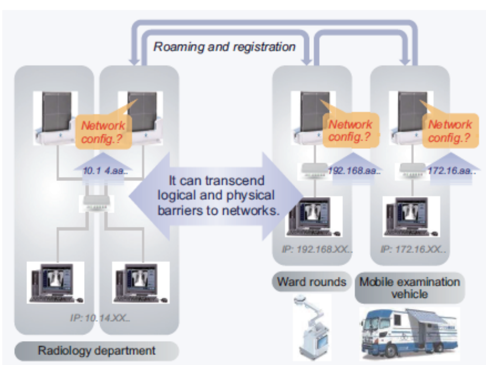

Fig. 7 The concept of Zeroconf (Zero Configuration). The sharing of panels among systems on the network that are isolated physically or logically was attained through roaming. The panels ask for their configurations, and then the consoles reply to the panels.

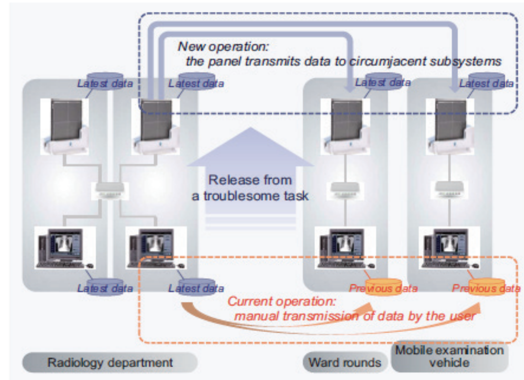

Fig. 8 Transmission by the panel of data unique to the panel. Seamless panel data sharing was realized among systems.

4.4 Realization of Data Portability

To resolve the issue of sharing data between separated systems, we have introduced a mechanism that releases data from the panel. Panel-specific data is held within a new panel. After system roaming, data from the panel itself is then released back to the roaming destination system (Fig. 8).

With this improvement, data is shared between separate systems and within the new circumstance; users are then freed from redundant procedures. This enables seamless panel operation between imaging environments.

5. Conclusion

In addition to the panel's reduced weight, robustness, and liquid resilience, the AeroDR XE reduces the burden placed upon healthcare workers while improving patient operability. By optimizing system design, we have improved cycle time to reduce the burden placed on patients; we also have enhanced our roaming system to facilitate easier use within general radiography rooms, during hospital ward rounds, and in operating rooms, making AeroDR XE a simple, reliable and robust solution for extreme environments.

In the future, not only will Konica Minolta seek to further improve the usability and universality of the AeroDR XE to improve the quality of healthcare services, but it will strive to contribute to increasing productivity at clinical sites.