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## 1. Introduction

In medical settings, X-ray diagnostic imaging systems are designed with support systems that provide a stable platform for heavy components such as the X-ray tube and collimator that use lead to prevent radiation leakage and provide a convenient means of moving the imaging system into the desired radiography position. These support systems must be sufficiently strong and durable to perform these tasks and have well-balanced weight that allows easy manipulation. These support systems can make X-ray diagnostic imaging systems weigh as much as several hundred kilograms. Although it is important that X-ray systems are positioned for each individual examination and patient, performing this manually would entail repeatedly moving a very heavy mass and place a tremendous burden on the operator that risks shoulder discomfort and back pain. If positioning is not performed smoothly and trouble-free, it also places a greater burden on the patient by lengthening the time required to hold a instructed posture.

To improve the examination environment with respect to these issues, Shimadzu equips its general radiography systems, mobile X-ray systems, and fluoroscopy systems with proprietary GLIDE Technologies. GLIDE Technologies ensure smooth action that mirrors operator intent even for medical systems weighing several hundred kilograms. This article describes these GLIDE Technologies.

## 2. The Elemental Technologies of GLIDE Technologies

The “GLIDE” name ascribed to GLIDE Technologies refers to gliding-like movement. GLIDE Technologies used five elemental technologies to achieve this gliding-like movement: sensing technology, torque

control technology, shock reduction technology, stability control technology, and balance technology. The development of these technologies was driven by engineers’ passion to improve the examination environment and improve the operability of medical systems.

### • Sensing Technology

One of the methods by which effortless movement is achieved is through power assistance. The challenge faced by power assist technology is, while power assist functions move the system in the direction of force applied by the operator at a given moment, the force applied by the operator is constantly changing. Sensing technology plays a vital role in accurate force detection when both the operator and medical system are in motion, and this technical expertise is integrated into control handles that have undergone repeated prototyping (Fig. 1).

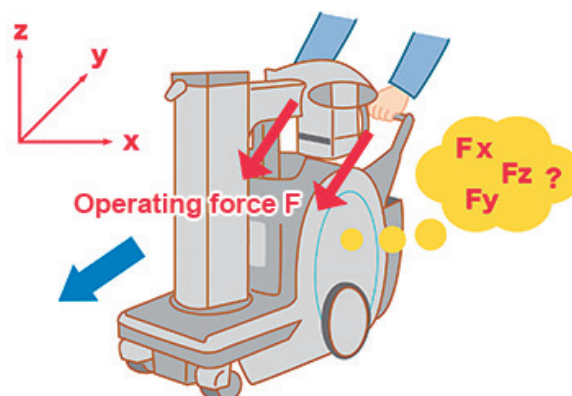


Fig.1 Sensing Technology

### • Torque Control Technology

$F = Ma$ . Effecting the operator’s intended action may appear a simple question of adjusting the speed and acceleration of the medical system based on this common physical law, but, in practice, a control scheme based purely on speed and acceleration could not eliminate “unnaturalness” from medical system movement. The root cause of this

“unnaturalness” was feedback delay and cumulative error. To resolve this problem, motor and system characteristics were revised and a compensating torque control was devised that consistently transmits accurate torque levels with no delay. This approach successfully eliminated “unnaturalness” from medical system movement (Fig. 2).

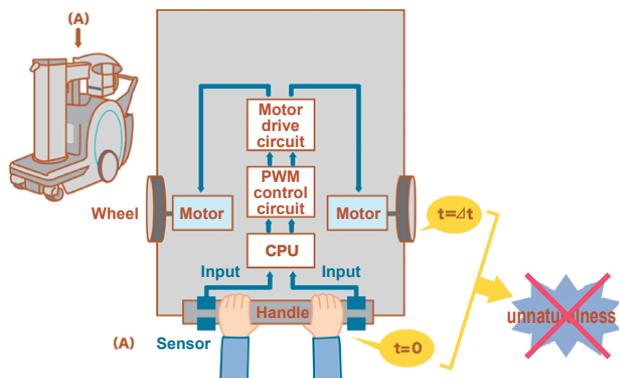


Fig.2 Torque Control Technology

### • Shock Reduction Technology

Power assist technology must be able to control medical systems so that the response of the medical system aligns with the operator’s sensations. For example, when an operator attempts to move a medical system from a standstill, the operator applies a greater force on the control handle than they expect. When this force is transmitted unmodified, the unit suddenly jerks forward with a shuddering motion. Experimentation revealed that, for the same amount of force detected by the sensor, the force applied in the operator’s estimation differed depending on the drive state of the system and the movement of the operator. A long period of trial and error was required to eliminate this shudder, or “unnaturalness,” which was eventually eliminated using speed-dependent torque control technology (shock reduction technology) (Fig. 3).

### • Stability Control Technology

In order to accommodate the variable force applied by the operator and move the medical system in line with operator intent, force must be detected in multiple directions and the medical system moved in the appropriate direction. However, straight-line stability and directional responsiveness tend to work in opposition to one another. Stability control technology was developed that adjusts the balance between straight-line stability and directional responsiveness based on system installation and usage scenario (Fig. 4).

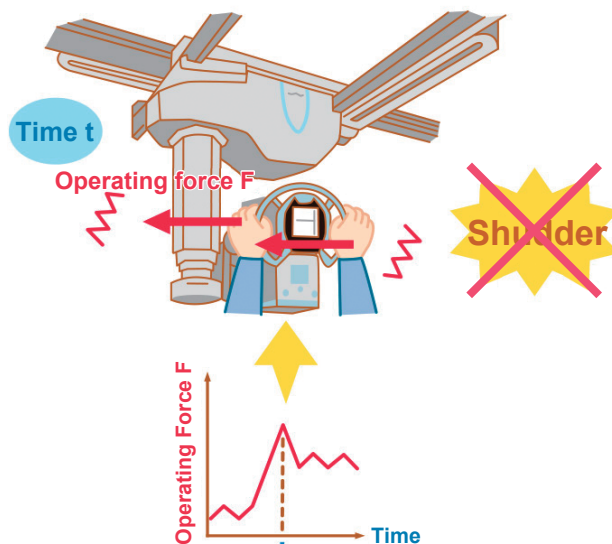


Fig.3 Shock Reduction Technology

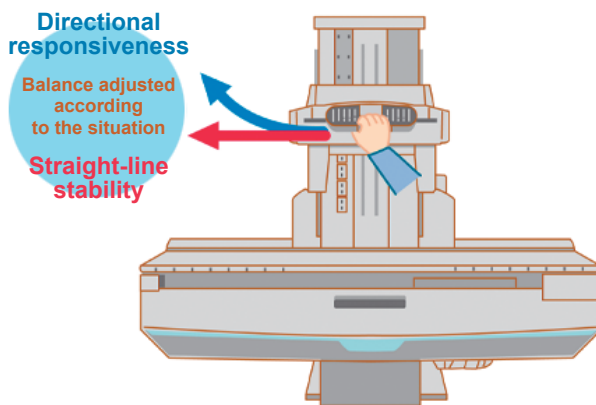


Fig.4 Stability Control Technology

### • Balance Technology

Major components, such as the X-ray tube, are attached to the support column on medical systems. Shimadzu’s mobile X-ray systems use a collapsible support column to prevent the support column from impeding the operator’s forward view during travel and to provide good visibility. A key part of the collapsible support column is a spring and wire that form a spring-balanced mechanism. This mechanism is designed to transmit power to the spring as the wire winds around a spiral-shaped pulley. This absorbs the change in elastic force generated in the spring during column extension and creates a smooth collapsible movement over the column’s entire range of extension (Fig. 5).

## 3. Shimadzu Products Featuring “GLIDE Technologies”

Shimadzu’s MobileDaRt Evolution™ MX8 Version mobile X-ray system is equipped with GLIDE

VIEW™ function, a GLIDE Technology that allows for smooth support column extension and efficient and safe travel. Shimadzu’s FLUOROSpeed™ X1 edition patient-side R/F system (for the US market) is designed for a mode of operation mainly in demand in the USA where physicians or radiological technologists operate the equipment at the table-side (fluoroscopy table) while medical care is provided to the subject. FLUOROSpeed™ X1 edition system is equipped with a GLIDE ASSIST™ function that allows for smooth manipulation of the imaging deck. A new part of Shimadzu’s product lineup is the RADspeed™ Pro style edition general radiography system, which is equipped with a POWER GLIDE™

function that allows for smooth positioning of the X-ray tube (Fig. 6).

#### 4. GLIDE Technologies in General Radiography Systems

General radiography systems are used during basic examinations in diagnostic imaging and carry out many examinations daily and acquire images of a variety of sites from the head to the chest, abdomen, arms and legs. To improve workflows in busy medical sites, Shimadzu’s RADspeed Pro style edition general radiography system (Fig. 7) has supported radiography parameters synchronizing, X-ray irradiation synchronizing, auto-positioning, and various other functions.

Despite these functions, the final deciding step in radiography is manual positioning of the X-ray tube. The operator of a general radiography system may need to alter the position of an X-ray tube located as far as 180 cm from the patient and carefully position the X-ray tube to ensure an irradiation field within several millimeters of the desired field of view. The POWER GLIDE power assist function was developed to improve the examination environment by meeting the high demands for system operability in clinical settings while reducing the burden on the operator and patient, thereby providing additional improvements in workflow.

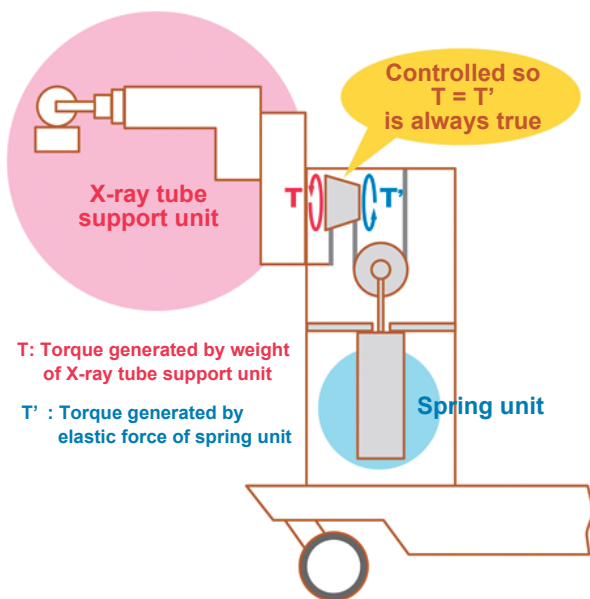


Fig.5 Balance Technology

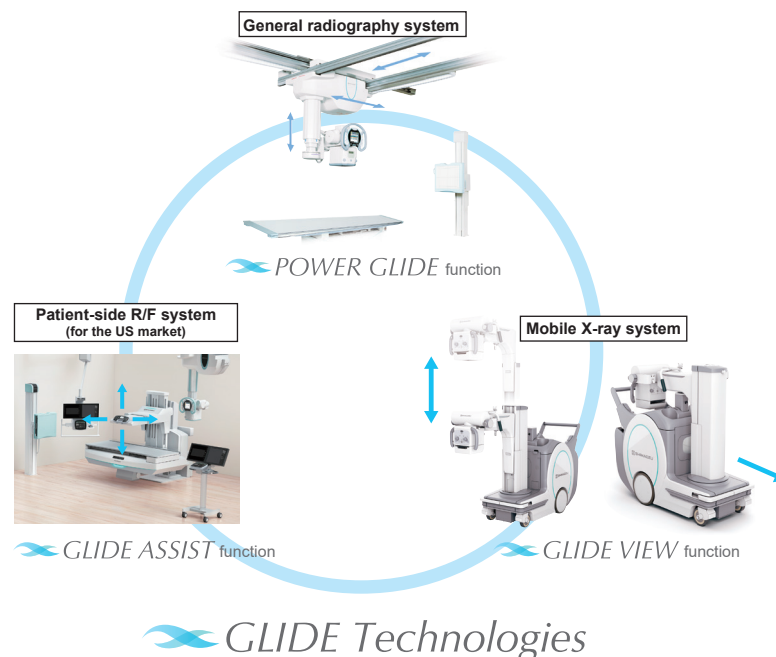


Fig.6 Shimadzu Products Featuring “GLIDE Technologies”



Fig.7 RADspeed Pro style edition General Radiography System

### (1) Smooth Operation Even with One-Handed Control

Shimadzu expanded the use of its well-regarded power assist technology, normally found in Shimadzu's MobileDaRt Evolution MX8 Version mobile X-ray system, and integrated it into the RADspeed Pro general radiography system for smooth operation even with one-handed control of systems weighing as much as 300 kg. Without POWER GLIDE, over 3 kg of force was needed to start moving the unit from a standstill, but with POWER GLIDE, just 1 kg of force or less is needed to start moving the unit. It reduces the burden on the operator by two-thirds enabling a substantial reduction in manual labor.

Force sensors can also detect very small forces on the X-ray tube support handle and allow constant control of system motors via optimum output signals in three axes (longitudinal, transversal, and vertical axes). The angle of handle rotation is also transformed into coordinates in real-time, providing system operability with no awkwardness even during rotation-controlled movement.

### (2) Adjustable Power Assist Level Based on Usage

Along with excellent operability, three power assist levels can be selected via the touch-screen control panel on the X-ray tube support (Fig. 8). The power assist level is adjustable to accommodate various scenarios, such as reducing the assist level for radiography that requires fine positioning, and increasing the assist level when rapid system movement is required, such as moving between standing and supine radiography. Turning the collimator lamp on also automatically reduces the assist level, assisting with fine positioning. Furthermore, the acceleration (Acc), deceleration (Dec), and maximum speed (Speed) of each assist level can be adjusted at any time (Fig. 9). During configuration at installation, password protection can also be applied so only a manager can change the settings.

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Fig.8 Assist Level Switching Screen

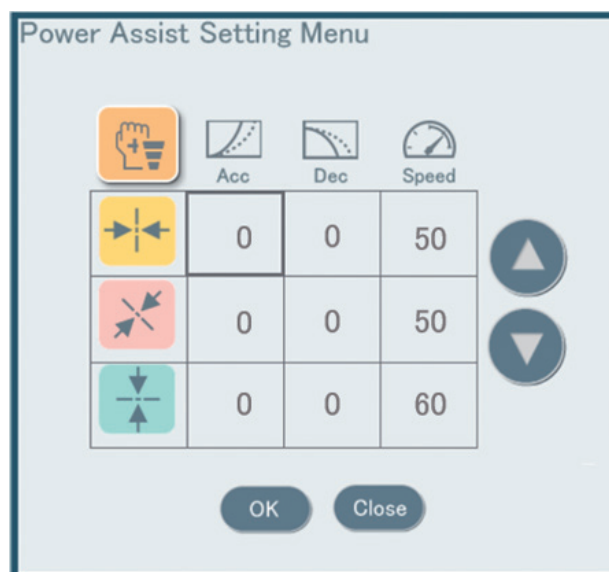
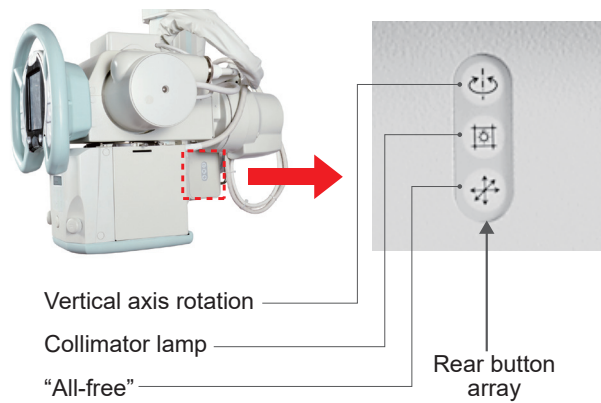


Fig.9 Assist Level Configuration Screen

### (3) Improved Operation of Rear Button Array

A vertical axis rotation button, "all-free" button, and collimator lamp button are found on the column of the X-ray tube support on the past Shimadzu systems (Fig. 10a). When the front control panel is not accessible during positioning, these operations can be performed via a rear button array found on the rear of the system. The placement of this button array has been evaluated that it has detailed



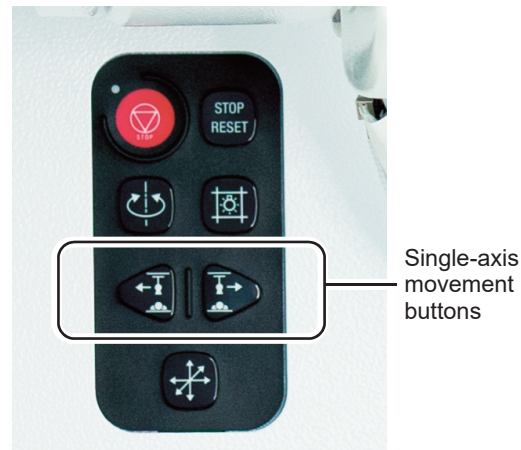


a)

**Fig.10** Rear Button Array on X-Ray Tube Support

a) Without POWER GLIDE

b) With POWER GLIDE



b)

consideration from the viewpoint of the medical site. When POWER GLIDE is added, a new single-axis movement buttons are also included (**Fig. 10b**). Pressing these buttons move the system at a constant velocity in a pre-configured direction. When multiple operators are engaged in positioning, this allows the X-ray tube support to be operated stress-free from the rear and delivered to another operator in front of the system, or the X-ray tube support can be operated stress-free from the rear while the patient aligns from the Bucky table.

## 5. Summary

This article described GLIDE Technologies that aim to improve the examination environment in medical sites by enabling smooth, stress-free system movement that mirrors operator intent.

POWER GLIDE is a newly introduced GLIDE Technology that ensures smoother and more effortless positioning of X-ray tubes on general radiography systems. POWER GLIDE reduces the physical burden on the shoulder and back of operators, reducing the risk of shoulder discomfort and back pain. POWER GLIDE promises to substantially reduce the burden on the operator and improve the examination environment. By providing additional improvements in workflow, it also shortens the duration of time patients must maintain a instructed posture and helps with efficient examinations.

Shimadzu will continue to refine GLIDE Technologies and various other technologies to improve the quality of medical care.

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