PHILIPS

Computed Tomography

White paper

CT 5300

Powerful, AI-enabled CT Smart Workflow to enhance CT performance

Overview

Philips CT Smart Workflow includes AI that is deeply embedded into the tools you use every day so that you can apply your expertise to the patient, not the process. Powerful and integrated workflow tools such as AI-enabled image reconstruction, automatic patient positioning and motion-free cardiac imaging help remove common obstacles to CT performance, clearing the way for the precision in dose, speed and image quality that helps improve the patient experience from start to finish, setting your institution apart.

Current challenges in operating a CT scanner

Vacancy levels for technologists are at an all-time high[1] while the need for efficient CT throughput continues to increase. Workload is, by far, the greatest source of stress and burnout for imaging staff.[2] Given their workload pressure, imaging staff are eager for efficiency gains, and technologists believe that a quarter of their work could be automated.[2] Operational inefficiency is also associated with increased costs. The powerful, integrated tools of CT Smart Workflow are designed to help you overcome operational challenges and reduce the total cost of care.

Global staff shortages lead to inequalities in technologist experience, and this variation impacts patient positioning accuracy, exam time and image quality, producing inconsistent results from technologist to technologist. In addition, imaging staff are purpose-driven professionals. They chose their profession because they want to help and care for people.[2] Hospitals need to retain imaging staff by keeping them satisfied. Communication with the patient is important for technologists and contributes to their job satisfaction.

CT Smart Workflow is designed to address challenges in CT imaging

- Enhancing productivity despite more patients, fewer staff
- Staffing shortages can lead to greater variability in image quality
- Rising patient volumes
- Remaining competitive by enhancing the experience
- Increasing complexity of patients and the need to minimize dose

CT Smart Workflow family of AI-enabled tools

CT Smart Workflow is a family of AI-enabled tools that are designed to work together to automate, standardize and speed up CT workflow from patient preparation through scanning, reconstruction and post-processing. This includes AI that's deeply embedded into the tools used every day to deliver precision in dose, speed and image quality to offer consistent results.

Prepare

- Auto-populated patient worklist
- **Precise Position**
- Direct Results

Scan

- Bi-directional surview
- **Precise Planning**
- **Precise Intervention**

Reconstruct

- **Precise Image**
- **Precise Cardiac**
- Digital Subtraction Algorithm
- **Precise Spine**
- **Precise Brain**
- **Precise Rib***

Post-process

- Advanced Visualization Workspace Applications
- On-console Applications

*This product is not commercially available for sale in the USA.

CT Smart Workflow aids productivity from beginning to end

OnPlan patient-side gantry controls

Workflow aids are designed into Philips CT systems from the start. For example, OnPlan patient-side gantry controls support CT Smart Workflow by allowing the technologist to perform as many tasks as possible while remaining close to the patient, providing a calming influence and improving the patient experience while increasing productivity. The ability of technologists to do more from the patient's side—starting with easy access to the auto-populated patient worklist—helps lead to faster time to results and greater consistency among users.

Two OnPlan patient-side gantry controls allow the user to efficiently perform tasks such as simply moving the couch by touching the panel screen and swiping in the direction of desired movement. Advanced and easy-to-use tools for positioning and protocol selection are designed so that the majority of tasks needed to set up the scan can be completed right at the patient's side.

For interventional procedures, controls in the exam room may enable procedures to be completed in the exam room by the interventional radiologist without the need for a technologist. All of this aids in managing operational costs and optimizing patient care.

OnPlan patient-side gantry controls

91% of users in a survey agreed that OnPlan enabled more consistent results[3]

48% of users report workflow improvement of **7+** exams/day[3]

84% of users agree that OnPlan patient-side gantry controls have improved patient satisfaction[3]

Prepare → Scan → Reconstruct → Post-process

Precise Position

Precise Position also allows for a fast, efficient exam. This workflow automation tool defines patient position, vertical isocenter and surview start/stop position, and positions the patient table for the start of the scan. OnPlan patient-side gantry controls help keep the technologist close to the patient by allowing more tasks to be performed at the gantry, rather than from the control room, helping to speed up the exam.

This is important because patient positioning is associated with several known challenges: the time it takes to perform accurate positioning, intra-operator variability and the fact that vertical mis-centering can lead to unwanted consequences such as increased radiation dose and image noise.[4] Precise Position uses an AI-enabled camera that is mounted above the scanner table to visualize the patient on the table in order to automate and standardize patient positioning workflow.

During the development of Precise Position, a convolutional neural network (CNN) was trained with hundreds of thousands of inputs to ensure robustness to age, gender, skin color, positioning, etc. With robustness achieved through a large volume training set, the CNN was then tested with new input and verified against the desired output of correctly identified anatomical landmarks.

In clinical usage, Precise Position performs the following functions:

- Structure, color and depth information from the camera is used by the AI-enabled Precise Position algorithm to identify 13 points of patient anatomy
- These anatomical landmarks are used to automatically detect and select patient orientation (e.g. prone/supine,head/feet first)
- Optimal table height for vertical isocentering is automatically calculated using the defined anatomical landmarks
- Surview start and stop positions are automatically calculated based on the scan type and anatomical landmarks
- Suggested start and stop positions are visually superimposed on a real-time image of the patient for operator review
- Once reviewed by the technologist, these positions initiate automatic table movement to the calculated height and surview start position

Inaccurate positioning of the anatomy of interest relative to isocenter can cause image quality degradation and/or result in higher patient dose. Precise Position has been shown to increase both the accuracy and consistency of patient positioning, which can help mitigate these issues and prevent unnecessary patient dose.[5-7]

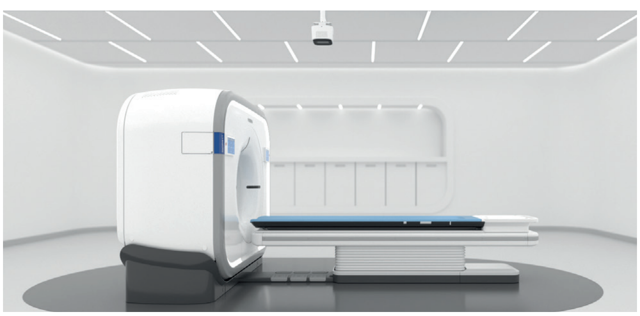
Precise Position uses innovative AI-based algorithms to deliver intelligence that adapts to the patient, resulting in more efficient workflow, an improvement in operator consistency and additional time to focus on the needs of the patient to increase the likelihood of a successful exam.

Precise Position

Decreases patient positioning time by up to **23%***

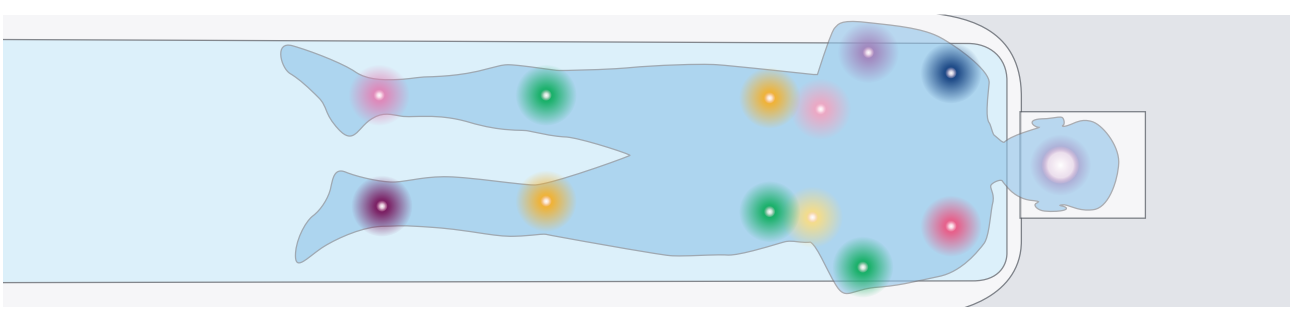
Increases use-to-user consistency by up to **70%***

Improves accuracy of vertical centering relative to manual positioning by up to **50%***



Precise Position smart camera for patient positioning.

OnPlan patient-side gantry controls enable the technologist to spend more time with the patient.



Precise Position automatically defines 13 anatomical landmarks.

Direct results

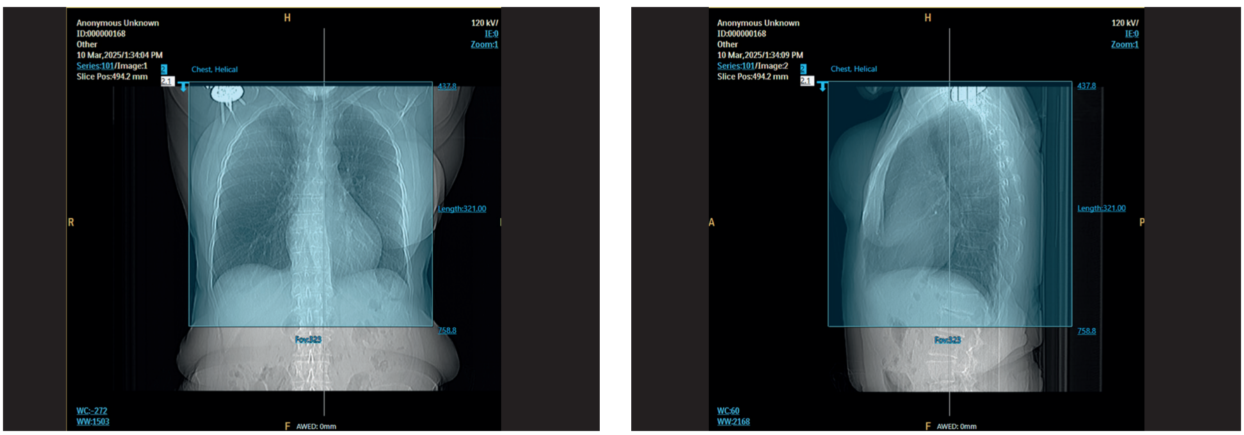
Direct results can be specified in the Exam Card during scan prep for auto-processing in the reconstruction phase. These smart algorithm tools for visualization and processing automatically create different views for the ribs, spine, brain or volume images that can be saved as a series. This saves precious time, as technicians do not have to create these images manually.

*Based on Philips in-house assessment by five clinical experts, comparing manual positioning versus Precise Position in 40 clinical cases using a human body phantom.

Precise Planning

The Precise Planning automation tool selects the start and end points on the surview for diagnostic scans. The Precise Planning algorithm was created with a learned regression model. Inputs to the model are the scanner coordinates of the detected body landmarks with the desired output of a scan range specified by a clinical expert.

In clinical practice, the algorithm will use the scanner coordinates of the detected anatomical landmarks to determine the start and end position of the diagnostic scan. The suggested diagnostic scan range is shown visually to the operator for acceptance and/or modification. Eliminating the need to manually position the "scan box" results in potential time-savings for the operator and greater consistency from operator to operator.



Precise Planning automatically creates the scan box.

Bi-directional surview

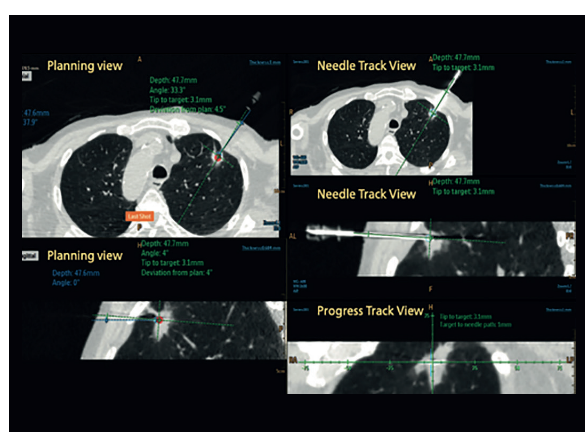
Surview in two directions creates frontal and lateral images which can be used to increase the accuracy of scan planning, reducing the need for rescans and saving time.

Precise Intervention

The Precise Intervention planning tool streamlines workflow by allowing users to plan needle trajectories and save multiple needle and scan positions for quick access during procedures. It also offers easy integration of multimodality images as references for planning and execution.

Precise Intervention needle guidance not only reduces the number of exposures needed to reach the target but also reduces total procedure time by up to 16%[8], helping minimize risk to the patient.

Reduce procedure time by up to **16%[8]**

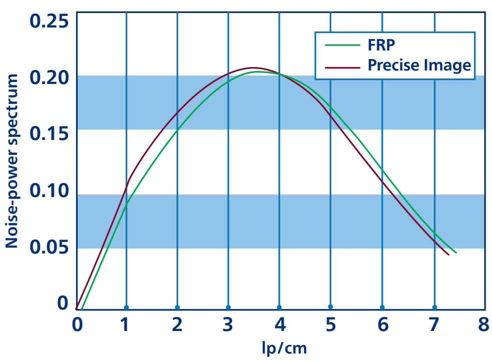


Precise Intervention

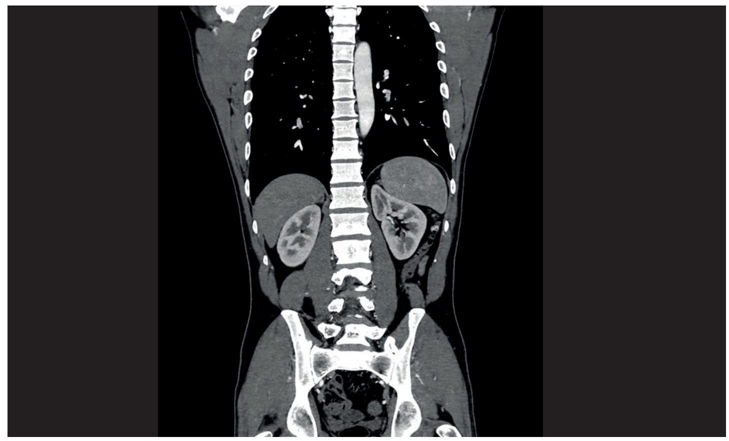
Precise Image

Precise Image is a novel reconstruction approach that uses AI to improve image quality while reducing dose with an appearance that more closely resembles that of typical filtered back projection (FBP). This provides high-quality images with a familiar appearance and at low dose. Precise Image can now also be used in cardiac exams. Philips deep learning-based reconstruction has shown a significantly higher detectability index than others across multiple clinical scenarios.[9] See the Philips “Precise Image: a multivendor task-based image quality comparison” white paper for more information.

NPS vurve



Normalized noise-power spectrum measurements from a 30 cm water phantom



Precise Image provides fast AI reconstruction that preserves the traditional FBP look and feel and improves diagnostic confidence at half the dose.

Precise Image improves diagnostic confidence at half the dose

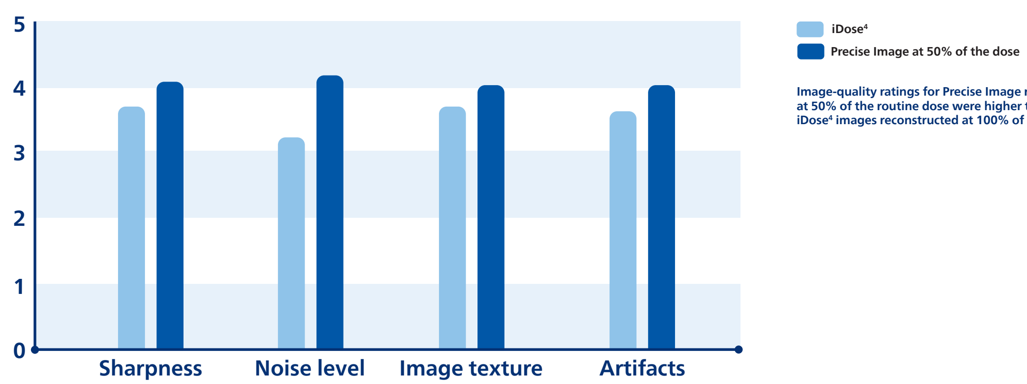


Image-quality ratings for Precise Image reconstructed at 50% of the routine dose were higher than those for iDose4 images reconstructed at 100% of the routine dose.

Simultaneously provides

80% lower radiation dose*

85% lower noise*

60% improved low-contrast detectability*

*In clinical practice, the use of Precise Image may reduce CT patient dose depending on the clinical task, patient size, and anatomical location. A consultation with a radiologist and a medical physicist should be made to determine the appropriate dose to obtain diagnostic image quality for the particular clinical task. Dose reduction assessments were performed using reference body protocols with 1.0 mm slices at the “Smoother” setting, and tested on the MITA CT IQ Phantom (CCT189, The Phantom Laboratory) assessing the 10mm pin and compared to filtered-back projection. A range is seen across the 4 pins, using a channelized hoteling observer tool, that includes lower image noise by 85% and improved low-contrast detectability from 0% to 60% at 50% to 80% dose reduction. NPS curve shift is used to evaluate image appearance, as measured on a 20 cm water phantom in the center 50 mm x 50 mm region of interest, with an average shift of 6% or less.

Precise Cardiac

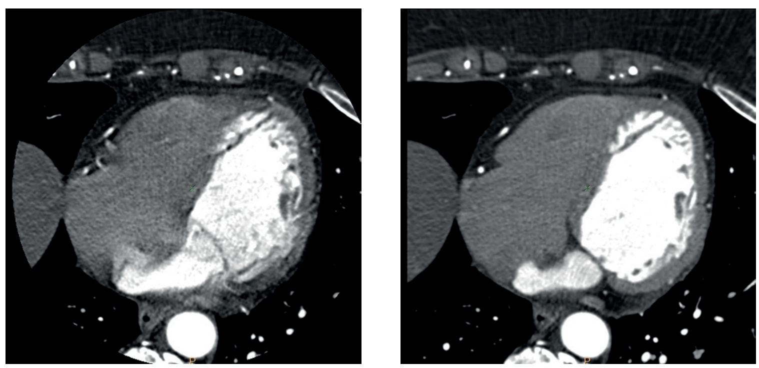
Precise Cardiac is a reconstruction algorithm that compensates for cardiac motion in CT imaging. Precise Cardiac employs efficient filtering techniques in a predefined region around the targeted cardiac phase to identify relevant objects and dynamically track their motion behavior in the localized portion of the cardiac cycle.

Motion-corrected images are generated by taking into account the displacement of structures and performing the relevant corrections as part of the back-projection process. Precise Cardiac is built into the CT console workflow, avoiding the need for any manual intervention, data transfer or additional workstations.

Removes motion artifacts for rapidly moving coronaries, producing an image that is not significantly different than one with **zero motion**[10]

Offers **6x** gain in effective temporal resolution, which is 29 ms* for CT 5300[10]

Significantly improves subjective image quality, interpretability and objective image quality of CCTA studies in clinical practice, particularly in patients with higher heart rates[11]



Without Precise Cardiac | With Precise Cardiac

Digital subtraction algorithm (DSA)

DSA uses an arterial phase and a non-contrast image of the head and neck to create an image with bone removed in order to improve visualization of the vessels.

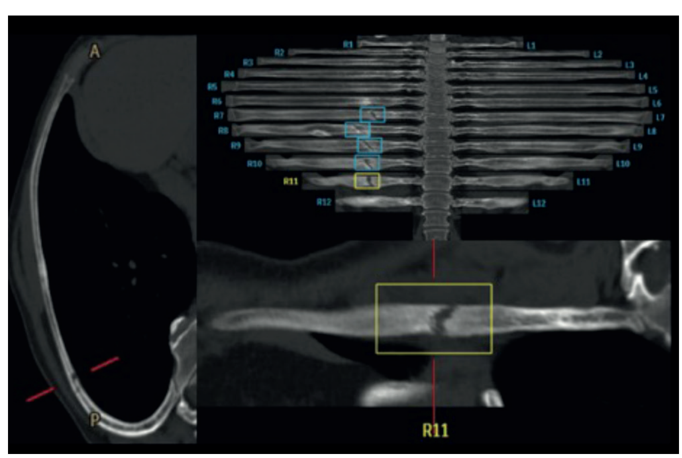
Automated visualization and processing tools

These smart algorithm tools automatically create various views of the ribs, spine, brain or volume images that can be saved as a series. This saves precious time, as technicians do not have to manually create these images.

Precise Spine automatically labels the vertebrae and creates an axial series of images, based on the spinal cord, easing workflow.

Precise Brain automatically generates a symmetrical brain batch parallel to the orbitomeatal line (OML) to speed image preparation time with fast AI reconstruction.

Precise Rib* offers fast results for assessing rib fractures in critical patients to help speed time to diagnosis with a segmentation and labeling algorithm to enable automatic extraction of the rib cage, rib centerline extraction and rib labelling. This tool for emergency departments or trauma scans provides automatic comprehensive results that reduce reading time and support faster report generation for critical trauma patients.



Precise Rib visualization to quickly assess rib fracture.

*This product is not commercially available for sale in the USA.

Prepare | Scan | Reconstruct | Post-process

On-console applications

A rich set of visualization tools and clinical applications are offered on the Philips Advanced Visualization Workspace. Additionally, the following applications are offered on the console, allowing for fast workflow in time- critical applications (e.g. brain perfusion) and providing an alternative to a full advanced visualization workstation.

- Lung Nodule Analysis
- CT Colonoscopy
- Brain Perfusion
- Vessel Analysis
- Dental Planning
- Cardiac Calcium Scoring
- Cardiac Function Analysis
- Cardiac artery analysis
- Dual Energy CT

How CT Smart Workflow elements work together – a look at three clinical scenarios

CT Smart Workflow elements work together to improve technologist efficiency, reduce workflow variation and improve image quality. Three common non-contrast CT examination types demonstrate this: abdomen, head and lumbar spine.

Each of these three examination types would benefit from the following CT Smart Workflow elements working together:

- **Patient demographic information is auto-populated via OnPlan patient-side gantry controls.** While the patient is in the scan room, the technologist is able to select the patient from the HIS/RIS worklist and automatically populate the patient demographics for the scan. This avoids time spent walking to and from the control room.
- **Precise Position:** After the patient is placed on the scanner table, Precise Position automates planning of the surview scan and positions the table for the start of the surview. This speeds up workflow, results in more accurate table height relative to isocenter, and reduces variation across technologists.
- **Precise Planning:** Automatic planning of the diagnostic scan can be faster and with less variation across technologists.
- **Precise Image:** Deep learning-based reconstruction simultaneously lowers noise, improves image quality and enables lower dose, with all reconstruction times of under one minute for factory scan protocols.

For a non-contrast head exam, if the patient's head is not positioned ideally, Precise Brain would additionally save the time required for a technologist to manually reconstruct a corrected image series by automatically generating a symmetrical brain batch parallel to the orbitomeatal line (OML).

For a lumbar spine exam, Precise Spine would automatically label the vertebrae and create an axial series of images based on the spinal cord and discs, additionally eliminating this manual work for the technologist.

Time study results

To illustrate the potential time savings, Philips conducted a simple time study using two internal clinical experts who individually performed the three types of examinations with and without CT Smart Workflow capabilities. The desired examination outputs were as follows:

- **Non-contrast head:** corrected angulated axial 1 mm reconstruction of the brain
- **Non-contrast spine:** angulated axial 1 mm reconstruction of the five lumbar discs + S1 relative to the spinal cord with labeled disc spaces
- **Non-contrast abdomen:** basic axial reconstruction of the abdomen

	Time study comparing with and without CT Smartworkflow (average time in seconds)					
	Head		Spine		Abdomen	
	Without	With	Without	With	Without	With
Input data	19.75	7.21	19.60	5.84	16.07	5.64
Position patient on table	26.98	26.02	23.92	23.67	18.39	16.53
Move patient to start position for surview	21.30	18.53	20.58	11.70	17.48	12.84
Plan and scan the surviews	13.74	13.74	11.79	11.27	14.52	14.64
Plan the acquisition	19.01	8.91	9.79	8.82	7.06	5.47
Scan	7.00	7.00	6.80	6.80	8.60	8.60
Reconstruction time (manual batch vs CT Smart Workflow)	90.12	32.90	153.14	22.71	31.36	29.39
Total average time	**197.90**	**114.29**	**245.60**	**90.80**	**113.47**	**93.10**
Time savings (seconds)	**83.61**		**154.81**		**20.37**	

Table 1 summarizes the average time for the two operators to perform the stages of each examination. This study demonstrates that CT Smart Workflow elements saved a total of 83.61 seconds for the non-contrast head exam, 154.81 seconds for the non-contrast spine exam, and 20.37 seconds for the non-contrast abdomen exam.*

Conclusion

CT Smart Workflow is a family of AI-enabled tools that work together to bring precision in dose, speed and image quality for faster time to results, increased operation efficiency and an enhanced experience for users and patients.
At Philips we believe in working together to break down boundaries, remove complexity and deliver a seamless approach to healthcare. The powerful CT Smart Workflow tools bring you advances that matter in your day-to-day imaging, such as AI reconstruction, automatic patient positioning and motion-free cardiac imaging. CT Smart Workflow helps you deliver better care to more people.

* Internal study results are not predictive of results in all usage environments. Results in other cases may vary.

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Results from case studies are not predictive of results in other cases. Results in other cases may vary.

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