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# Benefits of the DICOM Modality Performed Procedure Step

Rita Noumeir

**A few years ago, the Digital Imaging and Communications in Medicine standard introduced a network transaction that is initiated by modality equipment, mainly at the beginning and at the end of the acquisition. This transaction, the Modality Performed Procedure Step (MPPS), is sent to the Picture Archiving and Communication System and/or to the Radiology Information System. It carries information about what really has been performed by the modality equipment during acquisition. In this paper, we present MPPS and discuss its benefits. We show how MPPS enables efficient radiology workflow and how it ensures accuracy and completeness of imaging information. We think our paper helps bridge the gap between MPPS implementation and deployment. By understanding all the MPPS benefits, the end user becomes aware of the great enhancement in patient care that this transaction provides.**

**KEY WORDS: Digital Imaging and Communications in Medicine, DICOM, Modality Performed Procedure Step, MPPS, Workflow, Picture Archiving and Communication System, PACS, Radiology Information System, RIS, Integrating Healthcare Enterprise, IHE**

## INTRODUCTION

Optimal patient care requires prompt access to the patient's entire relevant clinical information to assist in healthcare decisions. Modern Electronic Patient Record (EPR) provides centralized access to different sources of data that constitute the patient medical record. Such data include patient history, diagnostic reports from different care domains, images, and other clinical data in electronic format. Because the timely availability of relevant clinical data has been proven to improve patient care, great efforts are spent to model, implement, and deploy EPR. Electronic Patient Record requires defining frameworks for information sharing that offer capabilities for communicating data, as well as for understanding information encoding and semantics. Therefore, most recent efforts have focused on defining unified data models and standards that address data access and security issues.[1]

Electronic Patient Record development is still at an early stage of development. Access to relevant clinical information as soon as possible, information accuracy, and information completeness will turn out to be much more critical with wider EPR deployment and adoption after solutions for sharing information become readily available.[2] But accuracy and completeness of information cannot be achieved with information-sharing frameworks only, as they depend on domain workflows. In fact, the care provider should be ensured access to the latest clinical information. Such information, a corrected radiology report for example, is generated by a domain process, according to a specific workflow, and is shared with others through the EPR. The domain process receives an order for a diagnostic service and shares its diagnostic result with other care providers through the EPR. Furthermore, this diagnostic process provides many notifications about the progress status of a specific service to

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enable accuracy and completeness of information. In particular, notification of the availability of corrected or erroneous information, as well as notification of the availability of new unplanned information, is very important. Indeed, this notification may be as important as the availability of the data itself. Therefore, modern EPR will require notifications from domain processes in addition to providing centralized access to domain results.

A domain workflow, in radiology for example, involves many phases and subprocesses that are chained together to fulfill the diagnostic service. In radiology, these phases include image acquisition and interpretation and may include image processing. Making clinical information available as soon as possible translates into the rapid turnaround achieved with an efficient domain workflow. Increasing efficiency is obtained mainly by reducing and eliminating dead time between phases. That is achieved by initiating the subsequent phase as soon as the results generated by the preceding phase are available and ready to be worked on. More specifically, reporting or image processing would start as soon as images are acquired and are available.[3]

Traditionally, when using a RIS workstation in addition to the modality equipment, the technologist can signal the end time of the acquisition, enabling subsequent phases to proceed.

In this paper, we will focus on the image acquisition phase, showing how the Modality Performed Procedure Step (MPPS) introduced by the Digital Imaging and Communications in Medicine (DICOM) standard enables efficient workflow in radiology, accuracy, and completeness of imaging information. Introduced a few years ago, MPPS is a network transaction initiated by modality equipment mainly at the beginning and at the end of the acquisition. The MPPS transaction is sent to the Picture Archiving and Communication System (PACS) and/or the Radiology Information System (RIS). This transaction carries information about what really has been performed by the modality equipment during acquisition. What is performed can be exactly what has been planned and scheduled, or it can be different.

We will present MPPS and discuss its benefits. Modality Performed Procedure Step enables efficient radiology workflow and rapid turnaround; MPPS also helps ensure the accuracy and completeness of information, as it enables the acquisition of erroneous and unplanned data to be signaled by the acquisition modality, the system that generated that data. Modality Performed Procedure Step is much more than simply replacing a RIS workstation with the acquisition modality.

This paper is organized as follows: a typical radiology workflow is depicted in Typical Radiology Workflow; the MPPS message along with its timing is described in Modality Performed Procedure Step Timing; MPPS information is presented in Modality Performed Procedure Step Information; MPPS benefits are discussed in Modality Performed Procedure Step Benefits; and Modality Performed Procedure Step and Integrating the Healthcare Enterprise presents the utilization of MPPS in the Integrating the Healthcare Enterprise (IHE) profiles.

## TYPICAL RADIOLOGY WORKFLOW

In a typical radiology service workflow (Fig 1), the patient demographics are sent from the hospital information system (HIS) to the RIS. An order is then entered at the HIS and sent to the RIS. After scheduling the radiology procedures at the RIS, the patient demographics, order, procedure, modality scheduled steps, and protocol information are made available by the modality equipment by using a DICOM modality worklist message. The images are acquired and stored in the archive. A DICOM storage commitment can be sent from the modality to the archive to transfer the image storage responsibility and relieve the modality from keeping these images. This typical imaging service workflow is depicted in Figure 1, a UML sequence diagram,[4] where time increases vertically downward and arrows indicate messages or network transactions between systems.

## MODALITY PERFORMED PROCEDURE STEP TIMING

Modality Performed Procedure Step is a network message that is initiated at the modality equipment. It is sent at the beginning and at the end of an acquisition step (Fig 2). The MPPS message usually does not require any specific

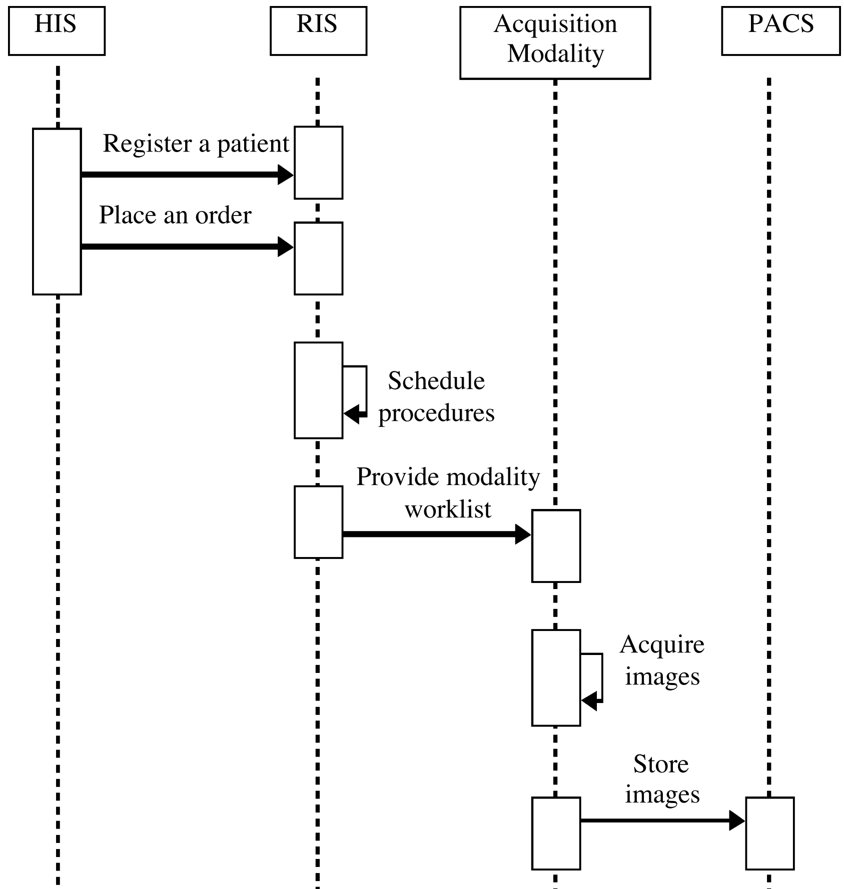


**Fig 1. Typical radiology workflow.**

action from the modality operator, as the modality equipment knows the start and the end time of acquisition. Although the MPPS message may also be sent during the acquisition, we will ignore these intermediate messages in this article to keep the discussion simple, without any loss of generality. By introducing the MPPS messages, the general workflow illustrated in Figure 1 remains unchanged, with the exception of the acquisition activity that becomes slightly more complex (Fig 2). In fact, in addition to acquiring images, the modality equipment initiates MPPS network messages.

The receiver of the message can be any system interested in having modality feedback and in tracking acquisition status and time. In a common radiology department, many systems beside the RIS may be interested in tracking the acquisition process in order either to manage different radiology subprocesses, such as postprocessing or interpretation, or to inform other systems outside of the radiology department about the status of the order. These systems include the PACS or a reporting manager, for example. The acquisition modality usually issues an MPPS message to a receiver that can forward the message to one or multiple systems. In this article, we do not focus on the network architecture that allows the MPPS message to get to all the systems concerned. We suppose, without loss of generality, that the message will arrive to all systems involved in the radiology workflow.

## MODALITY PERFORMED PROCEDURE STEP INFORMATION

Each MPPS message carries a date and time stamp (see Table 1). The message sent at the beginning carries information about the patient, the order, and the procedure information. More-

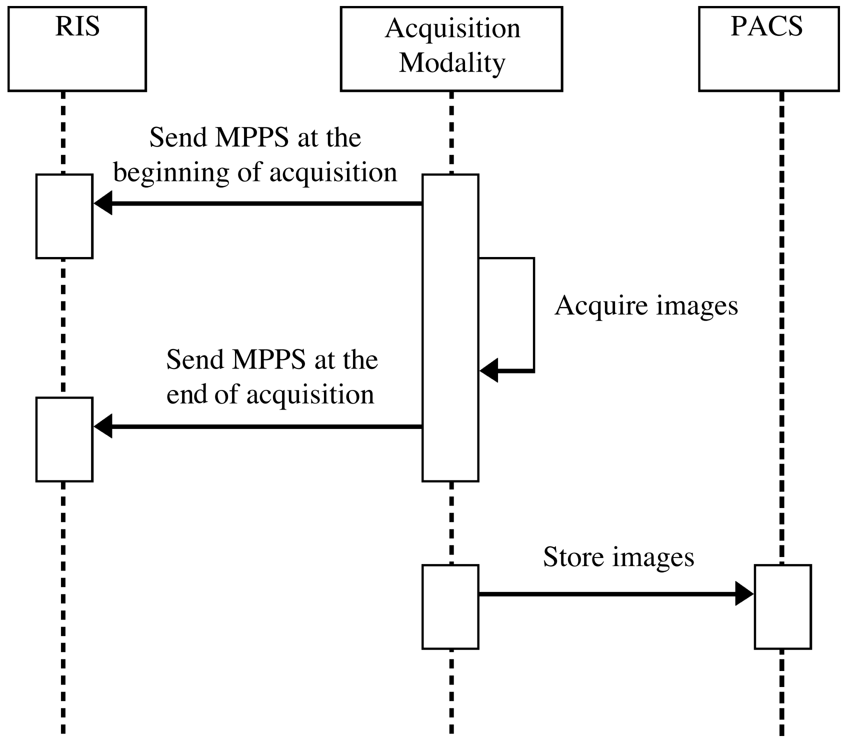


Fig 2. Modality Performed Procedure Step timing.

over, this message carries information about the equipment, the operator, and the actual acquisition being performed. The message sent at the end carries information about the images or other result objects that are generated, such as presentation states; it may also update the information sent previously about what is performed. The MPPS message may also include information known at the modality, such as radiation dose and material consumption.

In most cases, patient, order, and procedure information in MPPS messages is copied from the modality worklist (see Table 1). Exceptions exist in trauma situations, for example. In such a situation, the MPPS patient, order, and procedure information may be generated at the modality when the acquisition is not scheduled; therefore, no worklist entry is available, and the patient's demographics may not be known accurately at the time of acquisition.

Information about the actual acquisition may be different from what was scheduled. For example, the modality operator may choose to perform the acquisition according to a different protocol. More-

**Table 1. Modality Performed Procedure Step (MPPS) information**

| MPPS Information Content | Source of Information |
|---|---|
| Patient demographics, such as:<br>• patient's name<br>• birth date<br>• sex | Copied from the modality worklist in the case of a scheduled procedure step |
| Order information, such as:<br>• accession number<br>• study instance UID | |
| MPPS information, such as:<br>• performed station<br>• performed start date and time<br>• performed end date and time<br>• performed procedure<br>• status<br>• discontinuation reason | Generated at the modality |
| Acquisition results, such as:<br>• operator's name<br>• references to the results | |
| Radiation dose, such as:<br>• anatomic region<br>• time of exposure<br>• dose of exposure | |
| Billing and material management:<br>• film consumption<br>• billing supplies and devices | |

over, the modality operator may decide to acquire additional sets of images that were not scheduled. Furthermore, the actual equipment performing the acquisition may be different from the scheduled one. Modality Performed Procedure Step carries information about the performed acquisition that may be different from the scheduled information available through the modality worklist. The correct and up-to-date acquisition parameters are known at the modality equipment. When the acquisition data are generated at the modality equipment, they are accurate and constitute the modality feedback to other systems involved in the radiology workflow.

## MODALITY PERFORMED PROCEDURE STEP BENEFITS

### Efficiency, Rapid Turnaround, and High Throughput

To fulfill a radiology order, images are acquired and interpreted to generate the radiology report. Reporting starts after the acquisition is complete (Fig 3). To optimize the total turnaround, the waiting time between acquisition and reporting should be minimized or, optimally, eliminated. The MPPS message is an automatic message that informs the RIS, the PACS, or the reporting manager about the acquisition steps that have been completed. This can immediately trigger reporting. In the absence of MPPS, the technologist must manually signal the completion of acquisition on a RIS terminal.[5]

As the RIS and PACS are informed about the completion of modality acquisition steps, subsequent phases such as reporting or postprocessing can be triggered as soon as possible, resulting in an efficient radiology workflow. Consequently, the MPPS message increases turnaround time. Moreover, MPPS enables trauma case interpretation to start as soon as one acquisition step has been completed.

On the other hand, in the presence of MPPS, the technologist does not need to signal the beginning and the end of an acquisition step at a RIS terminal. The time saving resulting from the elimination of this task does not appear to be measured in the literature,[6] whereas the time a technologist may take to interact with a quality control workstation has been reported to be between 1 and 5 min.[7] We believe that the total time saving from using MPPS increases the technologist's productivity and may result in a throughput increase.

### Radiology Information System Terminal in Addition to Modality Equipment No Longer Needed

With an automatic network transaction from the modality equipment to the RIS about the start time and end time of acquisition, a RIS terminal is no longer needed near the modality. Therefore, MPPS obviates the need for such a terminal and its associated costs in dollars, space, and efficiency.

### Automatic Technical Billing Trigger

In radiology, the procedure can be billed as two separate components: the technical component that covers the acquisition and the professional component that covers the interpretation. When billing is carried out separately for acquisition and reporting, technical billing can be triggered as soon as acquisition is completed. Modality Performed Procedure Step is thus important to automatically triggering billing.

### Quality Assurance Trigger

As the MPPS message is sent at the beginning of an acquisition, a radiologist tracking a difficult patient may trigger a quality assurance procedure while the patient is still in the department or on the modality acquisition table.

### Duration Tuning for Optimized Scheduling

The duration of acquisition steps can be calculated as the difference in time between the start acquisition MPPS message and the completed acquisition MPPS message. This duration can be calculated by the system, such as the RIS, receiving the MPPS messages. The duration time is important to adjust the scheduling duration and achieve efficient planning. Duration is also important for management reporting to identify and analyze inefficiencies in acquisition.

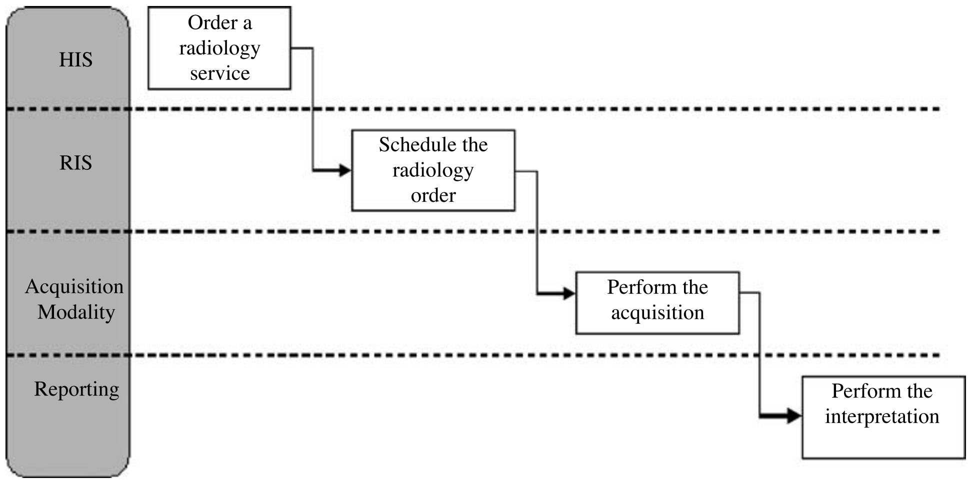


**Fig 3. Radiology workflow.**

### Accurate Information About What Procedure Was Really Performed

The performed work can be different from what was scheduled. The technologist may decide to change the scheduled protocol, for example, or acquire additional images. The MPPS messages report about what has been actually performed at the modality and link the performed steps to the scheduled steps. Therefore, MPPS can be used to increase the accuracy of the technical billing by identifying precisely the work performed at the modality.

### Accurate Information About Who Did the Acquisition

The MPPS message carries information about the actual human performer and the actual equipment involved in the acquisition. This information may be different from the scheduled information. In fact, an acquisition modality can query the worklist per modality type and perform an acquisition that was originally scheduled for other equipment. With the MPPS message, the RIS can record the actual acquisition human performer and equipment.

### Append Acquisition Management

At the modality, extra images may be acquired in addition to what was initially scheduled. In fact, the modality operator can select the same worklist entry several times to acquire different sets of images. The MPPS message is used to tell the RIS or PACS that additional unscheduled series of images are appended to a just-acquired study.

### Discontinuation of Acquisition Management

A modality operator can decide to discontinue an acquisition for any reason, if the patient is pregnant or allergic to contrast, for example. The reason is usually entered at the modality equipment and communicated with the MPPS message to the RIS or PACS. Many common discontinuation reasons have been identified and standardized by DICOM. Acquisition discontinuation has an important impact on the workflow. In fact, when an acquisition is discontinued, reporting is not triggered and the RIS usually sends an order cancellation or an order modification to the HIS.

### Erroneous Acquisition Management

An exception situation may occur, where the incorrect worklist entry is selected and the wrong patient demographics are attached to images that may already have been stored in the archiving system. The MPPS message can be used to inform other systems, such as the PACS, about the situation; this transaction will be given discontinued status and a reason that indicates the wrong worklist entry was selected. Furthermore, the same MPPS transaction references the images with wrong demographics that may have been sent to other systems. Consequently, the MPPS transaction clearly indicates which images are wrong, enabling adequate management of such a serious exception situation.

Another exception situation may occur when an order is to be cancelled or modified at the RIS.[8] Modality Performed Procedure Step allows the RIS to know whether the acquisition has been already performed so that the appropriate action may be taken.

### Accurate Information About the Actual Acquisition Protocol

The RIS can tell the modality not only what is scheduled, but also how to perform it. For example, a chest X-ray procedure can be scheduled as one step and includes two acquisition views, one posterior/anterior and one lateral. Both views can be transmitted within the worklist message from the RIS to the modality. This example is simple, but the same mechanism can be applied to more complex acquisition protocols. The modality operator can choose to perform the acquisition differently from what is indicated in the modality worklist. Consequently, the MPPS message generated at the modality contains a sequence of protocol codes that define the acquisition protocol. It automatically informs the RIS and PACS about the actual acquisition protocol performed.

### Radiation Information Tracking

Modality Performed Procedure Step may include radiation information intended to enable the RIS to store information on patient exposure to ionizing radiation. Such information includes the anatomic region and the exposure time. With MPPS, the RIS is able to track and record radiation information for legal or quality-control purposes.

### Material Information for Billing and Inventory Management

Modality Performed Procedure Step may include information about material consumption, such as the number and size of films, chemicals, supplies, or devices. This information can be used by the RIS to calculate the charges for billing. This information can also be used for inventory management.

### References to Acquisition Results, Such as Images

The MMPS message includes a sequence of unique identifiers that identify all DICOM objects generated during the acquisition, such as images. Modality Performed Procedure Step informs other systems about all the images and other objects that have been generated. As these objects usually comprise the input for the subsequent steps, such as reporting, a reporting manager can use these references to determine the input for its reporting worklist entries. In fact, the MPPS message links the images generated to the procedure required. While interpreting this procedure, the image references can be used to automatically determine the proper images to display.

### Procedure or Modality Steps Grouping

The operator at the modality equipment can decide to perform multiple steps that were scheduled separately in one acquisition step. For example, on a spiral CT scanner, the operator can decide to perform only one acquisition step by grouping the requested chest, abdomen, and pelvis procedures. In this example, one series of images is generated to fulfill three procedures. The MPPS message will reference all scheduled procedures. Consequently, the RIS and PACS are automatically informed about the grouping.

In the previous example, there are typically three billable procedures that may be reported separately. Because the display workstation should be able to determine the subset of images specific to each procedure, the composition of the subsets—the split—is decided at the modality. The modality operator selects a subset of the acquired images, such as the chest images, chooses the appropriate window width/window level for the chest images, and produces a chest presentation state that references the subset of images that belongs to the chest procedure. An MPPS message that references the chest presentation state, object, and the scheduled chest procedure is then sent to the RIS or PACS. Consequently, the interpretation of the chest procedure is carried out by visualizing the chest images and applying the appropriate window width/window level.

The management of modality step grouping and subset splitting is made possible by using MPPS. This sophisticated workflow is fully described as the Presentation of Grouped Procedures profile in the IHE Technical Framework[9] as well as in Ref. 10.

## MODALITY PERFORMED PROCEDURE STEP AND INTEGRATING THE HEALTHCARE ENTERPRISE

Modality Performed Procedure Step is a required transaction for many IHE integration profiles. Integrating the Healthcare Enterprise is an initiative sponsored jointly by the Radiological Society of North America and the Healthcare Information and Management Systems Society to stimulate integration of healthcare information resources. Integrating the Healthcare Enterprise has defined many integration profiles that specify how to implement integration capabilities between different equipment from different vendors.[9,11] The foundation of almost all integration profiles is the scheduled workflow (SWF) integration profile. It establishes a seamless flow of information that supports efficient patient care workflow in a typical imaging encounter by specifying transactions that maintain the consistency of patient information, from registration through ordering, scheduling, imaging acquisition, storage, and viewing. In SWF, MPPS is used to maintain consistency between what is performed at the modality and the other systems in radiology.

The patient information reconciliation integration profile extends SWF by providing the means to match images acquired for an unidentified patient, during a trauma case for example, with the patient's registration and order history. Modality Performed Procedure Step is used to inform the PACS and RIS about any unscheduled image acquisition.

The presentation of grouped procedures (PGP) integration profile addresses the complex information management problems that arise when information for multiple procedures is obtained in a single acquisition step, such as single CT acquisition of the chest, abdomen, and pelvis. Presentation of grouped procedures integration profile provides the ability to view image subsets resulting from a single acquisition and relate each image subset to a different requested procedure. In PGP, MPPS is used to inform the RIS and PACS about the grouping and to allow the splitting into subsets.

The charge posting integration profile specifies information about charges associated with particular procedures, as well as information about patient demographics, accounts, insurance, and guarantors, to enable the generation of claims. Although MPPS is not a required transaction for this profile, it is used to determine the time when technical charges are eligible.

**Table 2. MPPS benefits**

| Benefits | Source of information |
|---|---|
| Efficiency in turnaround and throughput | Transaction point in time |
| Radiology Information System terminal eliminated at modality | Transaction point in time |
| Technical billing trigger | Transaction point in time |
| Quality assurance trigger | Transaction point in time |
| Duration tuning for optimized scheduling | Date and time |
| Accurate information about what procedure is really performed and accurate billing | Performed procedure |
| Accurate information about who did the acquisition | Performed station and operator's name |
| Append acquisition management | Reference to a scheduled procedure that is already performed |
| Acquisition discontinuation management | Discontinuation reason |
| Accurate information about the actual acquisition protocol | Performed acquisition protocol |
| Radiation information tracking | Radiation dose |
| Material information for billing and inventory management | Billing and material |
| References to acquisition results, such as images | Reference to images or results |
| Procedure or modality steps grouping | Reference to multiple scheduled procedures or modality steps |

The postprocessing workflow (PFW) integration profile addresses the need to schedule and track the status of a postprocessing step, such as computer-aided detection or image processing. The reporting workflow (RWF) integration profile addresses the need to schedule and track the status of the reporting workflow tasks, such as interpretation, transcription, and verification. Although MPPS is not a required transaction for these profiles, it is used to determine when PFW and RWF can proceed.

## CONCLUSION

We have shown that DICOM MPPS enables efficient workflow, increases throughput, eliminates redundant data entry, propagates accurate acquisition parameters, facilitates acquisition quality assurance, and allows uncommon workflow management. A summary of MPPS benefits is given in Table 2, where each benefit is linked to the MPPS information source. These benefits can be classified into two groups: workflow enhancement and data accuracy. The benefit source resides either in the transaction point in time or in the transaction data. Workflow management, such as initiating reporting or billing, is made possible by knowing the time the subsequent steps can be carried out and also by knowing what exactly has been performed at the modality. Data accuracy requires a single point of data entry, at the modality equipment where the acquisition information is known. Modality Performed Procedure Step is thus a modality feedback that propagates the acquisition information to other systems involved in the radiology process, such as the PACS and RIS.

Modality Performed Procedure Step involves interactions with other information systems, such as the PACS and/or RIS. To fully benefit from its deployment, the RIS and PACS should be able to use the MPPS information to automate workflow and ensure information accuracy.

Integrating the Healthcare Enterprise played a major role in accelerating MPPS implementation in modality equipment, PACS, and RIS systems. In fact, the most basic IHE profile, the scheduled workflow profile, requires MPPS. Therefore, all vendors that have implemented this basic integration profile have already implemented MPPS. Consequently, IHE has a great impact on the standard implementation by bridging the gap between the standard development and its interpretation and by accelerating the standard implementation. Moreover, IHE enables integrated work and information flows between heterogeneous systems by organizing a yearly testing phase where vendors test their implementation with a common testing tool in addition to a face-to-face testing event that allows for broad and live interoperability testing among many vendors and systems.

However, there is still a gap between implementation and deployment. Unfortunately, the deployment of MPPS has been much slower than expected, although most modality equipment and many PACS and RIS systems have implemented it. We believe our paper helps bridge this gap. By understanding all MPPS benefits, the end user becomes aware of the great enhancement in patient care that this transaction provides.

One last barrier to MPPS deployment may still exist. In fact, in almost all institutions, legacy and new modality equipment operate side by side within a single radiology department with a single workflow management system. Modality Performed Procedure Step is the most economical and accurate solution for achieving efficient workflow. Legacy modality equipment that do not support MPPS can be integrated within this workflow by delegating the MPPS creation to either a RIS terminal or a modality relay station.[12] This "nonnative" transaction enables other systems involved in the workflow to operate at their best efficiency level.

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## BIOGRAPHY

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