



LMS Patient Acquisition Manual for Siemens Scanners

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1. Glossary

Term	Description
A-P	Anterior-Posterior
ARRT	The American Registry of Radiologic Technologists
B0	Main magnetic field
CE	Continuing Education
DICOM	Digital Imaging and Communications in Medicine
DOB	Date Of Birth
ECG	ElectroCardioGram
F-H	Feet-Head
FFE	Fast Field Echo
GRE	Gradient Recalled Echo
IDEAL	Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation
ID	Identifier
LMS	LiverMultiScan
LSN	Liver Surface Nodularity
MOLLI	Modified Look Locker Inversion Recovery
MOST	Magnitude Only thin-Slice T2*
MRE	Magnetic Resonance Elastography
MRI	Magnetic Resonance Imaging
MR	Magnetic Resonance
NOLLI	Non-MOLLI T1 Mapping
PACS	Picture Archiving and Communication System
PG	Peripheral Gating
PII	Personally identifiable Information
PPU	Peripheral Pulse Unit
R-L	Right-Left
RF	Radio Frequency
RIS	Radiology Information System
S-I	Superior-Inferior
SAR	Specific Absorption Rate
SNR	Signal-to-Noise Ratio
SSFP	Steady State Free Precession
WIP	Work In Progress

Term	Description
dB/dt	Time varying gradient
tantanh	tangent hyperbolic tangent

2. Introduction

2.1. Scope

This manual is intended to describe the correct procedure to perform the Perspectum set up protocol to an *MR* operator on Siemens scanners. Please use this document as a reference guide when performing the protocol acquisitions. The manual is divided in three main sections: Preparation, Acquisition and Data Export.

2.2. Continuing Education

In some territories, such as the USA, this training is eligible for continuing education (*CE*) credit. The *CE* is sponsored by Perspectum and will be presented by a member of the Imaging Applications team. The presenter's name, date, and attendees will be written on the Imaging Staff Training Checklist at the time of training; this form will be kept in Perspectum's records of site training activities and an electronic copy will also be sent to the site. In order to qualify for *CE*, the document, Multiparametric Liver MRI Applications Training – MRA1157, should also be provided along with the training. This document includes post-activity evaluations that must be completed to award credit.

2.3. Compatibility and Requirements

All sequences described in this manual require scanner hardware and software to be compliant with all manufacturer's specifications, especially gradient performance, eddy current compensation, and magnetic field (*B0*) homogeneity and stability. The protocols cannot be utilized on scanners outside of the manufacturer's service specifications and calibration schedules. Do not use phased-array coils with failed elements or without *SNR* checks passed.

2.3.1. T_2^* and Proton Density Fat Fraction Mapping Requirement

The system should also have the Multi-Echo Gradient-Echo package available. This package is offered as a product on most Siemens scanners without the need of additional license.

2.3.2. T1 Mapping Requirement

T1 mapping protocols require the manufacturer's clinically approved software product MyoMaps.

3. Preparation

3.1. Patient Registration



CAUTION

Ensure the subject is registered to a new *MR* study.

The minimum required information for registering the patient is as follows:

- Patient *ID*: <Use agreed Subject ID Naming Scheme>
- Patient Name: <Use Agreed Subject Naming Scheme>
- Date of birth (*DOB*): <Use agreed DOB Scheme>
- Operator: Enter Your Initials
- The patient's height (when available), weight and sex

Date of Birth (*DOB*) Scheme: If *PII* is allowed, the patient's date of birth *DOB* may be used. Otherwise, **please use 01-Jan, and the correct YEAR of birth.**

Please note that the MRI technician/radiographer who performs patient acquisition must have undergone training by either:

- (a) Authorised Perspectum Imaging Applications specialists
- (b) Previously trained site personnel authorised to perform internal training

A record of such internal training must be provided to Perspectum with the appropriate Imaging Staff Training Checklist.

3.2. Breath-hold Instructions

Breath-holding should be explained and practised when required because variations in the depth of a subject's breathing can markedly alter the image quality and the consistency of the abdomen position between acquisitions. End-expiration breath-hold is chosen because breathing out is a more repeatable process. This should be explained to the patient: 'The scans are better if you hold your breath after breathing out comfortably.' The following instructions should be given to the patient ahead of each scan:

- Breathe in.
- Breathe out.
- Stop and hold your breath there.
- Breathe away or Resume breathing (after data has been acquired).

3.3. Patient preparation

LMS requires end-expiration breath-hold and requires phased-array receiver coils.

LMS requires cardiac gating, end-expiration breath-hold and phased-array receiver coils.

Please prepare the patient following these steps:

1. Explain and demonstrate the breath-hold instructions as above.
2. Position the patient in the supine position.
3. Set up cardiac trace input (gating or simulator) and check the signal has clear R-wave triggering.
4. Select the correct trigger source in the Gating Window.
5. Patient arms can be positioned at the sides, though above the head is acceptable if subject does not easily fit into bore.
6. Use the spine array and the torso/body phased-array coil.
7. Scanner laser should be landmarked on the xiphisternum of the patient.

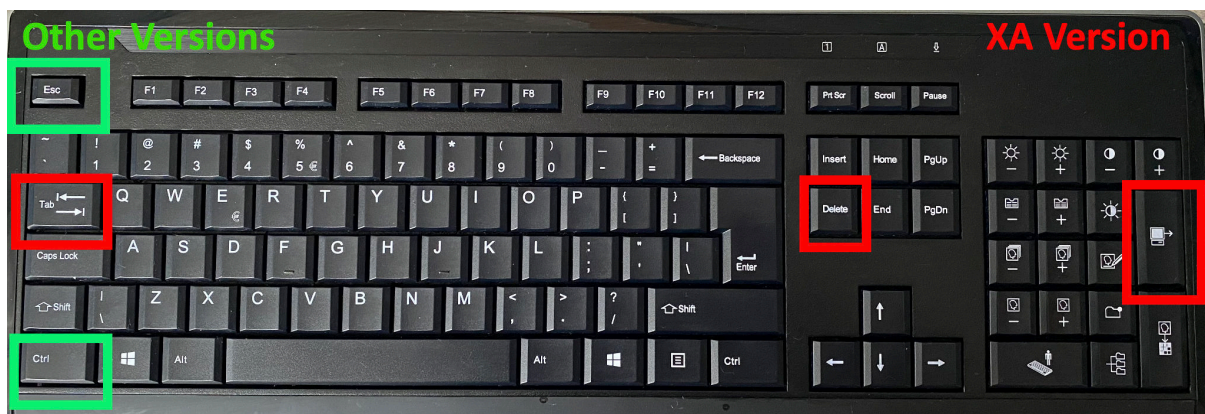
3.4. Cardiac Trace Input

Some pulse sequences require cardiac triggering/gating. This input can be from either the patient or a cardiac trace simulator. Both methods are outlined below.

3.4.1. Cardiac Trace Simulator

To set up the simulation please login as advanced user and follow these steps:

1. Open Windows menu,



- a. **On XA version:** the key combination is **Tab + Del + +**.
Note that Siemens MR keyboard is Windows modified keyboard. The **+** key on the numeric side of the Windows keyboard is the "Send to node 1" key on Siemens MR keyboard.
 - b. **On the other versions:** hold **Ctrl+esc** to have the windows menu appear.
2. Select **<Advanced User>** (or medadmin on XA versions) – this will prompt you for the password. The Siemens engineer for the site or a site staff will have access to this password.
 3. Hold **Ctrl+esc** to bring up windows start menu.
 4. Open a terminal window, either **<Command Prompt>** or **<Run>**
 5. In **<Command Prompt>** type **ideacmdtool** and press **Enter**
 6. From IDEACmdTool Menu please select the number correspondent to **<PMU Control>** option (in general it is 1) Then press **Enter**
 7. From the PMU control menu please select **<PMU Signal simulation>** option (in general it is 1) then press **Enter**.

8. From the menu please select **<startSignalSimulation>** option (in general it is **4**) Then press **Enter**.
9. To set all the ECG simulator parameters to the values below (for VE11 and XA versions, please simply press **Enter** 4 times):
 - a. ECG-period duration to 1000 ms
 - b. Respiration-period duration to 3000 ms
 - c. Pulse-period duration to 1000 ms
 - d. External signal period duration to 2000 ms

The simulated heartbeat should appear on the Exam tab as shown in [Figure 1 \(page 6\)](#).

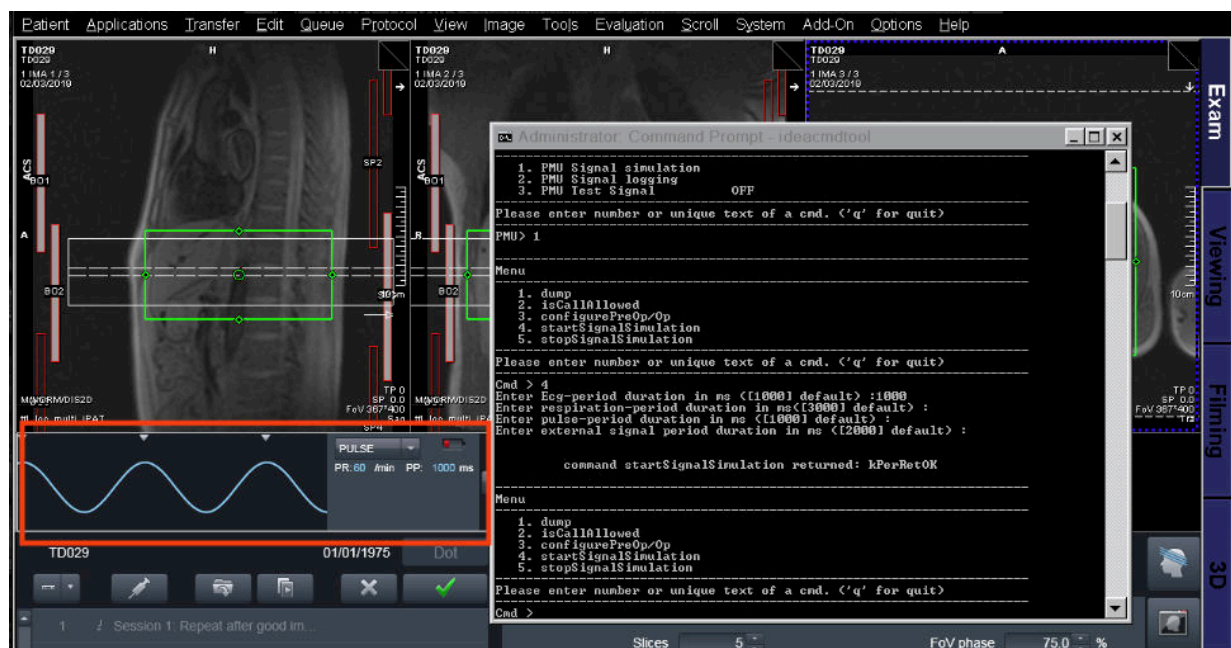


Figure 1. The simulated heartbeat is highlighted with a red box. Please note, this is a VE11 interface.

3.4.2. Cardiac Gating

1. Use *ECG* or pulse oximeter to set up the patient's cardiac gating.
2. select the correct trigger source in the gating window (physiology monitoring window) and confirm the signal has clear R-wave.

When switching the gating method from (*PPU* to *ECG* or vice versa) or when recapturing the cardiac cycle, the trigger delay is being reset to the default value of 0 ms. Make sure the trigger delay is set to 50 ms after adjusting the gating method or when recapturing the cardiac cycle.

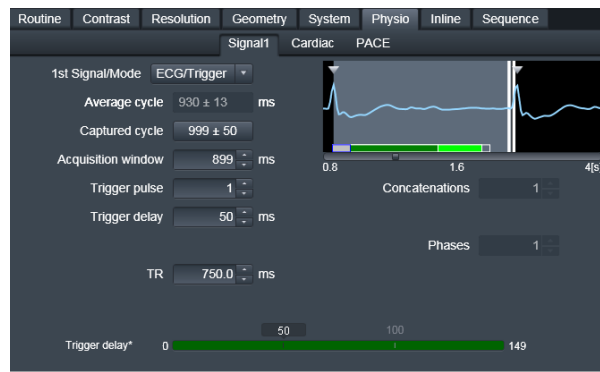


Figure 2. If use the patient's heartbeat input, please make sure to set Trigger Delay to 50ms

3.4.3. Cardiac Trace Simulator

To set up the simulation please login as advanced user and follow these steps:

1. Open Windows menu,



- a. **On XA version:** the key combination is **Tab + Del + +**.
Note that Siemens MR keyboard is Windows modified keyboard. The **+** key on the numeric side of the Windows keyboard is the "Send to node 1" key on Siemens MR keyboard.
 - b. **On the other versions:** hold **Ctrl+esc** to have the windows menu appear.
2. Select **<Advanced User>** (or medadmin on XA versions) – this will prompt you for the password. The Siemens engineer for the site or a site staff will have access to this password.
 3. Hold **Ctrl+esc** to bring up windows start menu.
 4. Open a terminal window, either **<Command Prompt>** or **<Run>**
 5. In **<Command Prompt>** type **ideacmdtool** and press **Enter**
 6. From IDEACmdTool Menu please select the number correspondent to **<PMU Control>** option (in general it is **1**) Then press **Enter**
 7. From the PMU control menu please select **<PMU Signal simulation>** option (in general it is **1**) then press **Enter**.
 8. From the menu please select **<startSignalSimulation>** option (in general it is **4**) Then press **Enter**.
 9. To set all the ECG simulator parameters to the values below (for VE11 and XA versions, please simply press **Enter** 4 times):

- ECG-period duration to 1000 ms
- Respiration-period duration to 3000 ms
- Pulse-period duration to 1000 ms
- External signal period duration to 2000 ms

The simulated heartbeat should appear on the Exam tab as shown in Figure 3 (page 8).

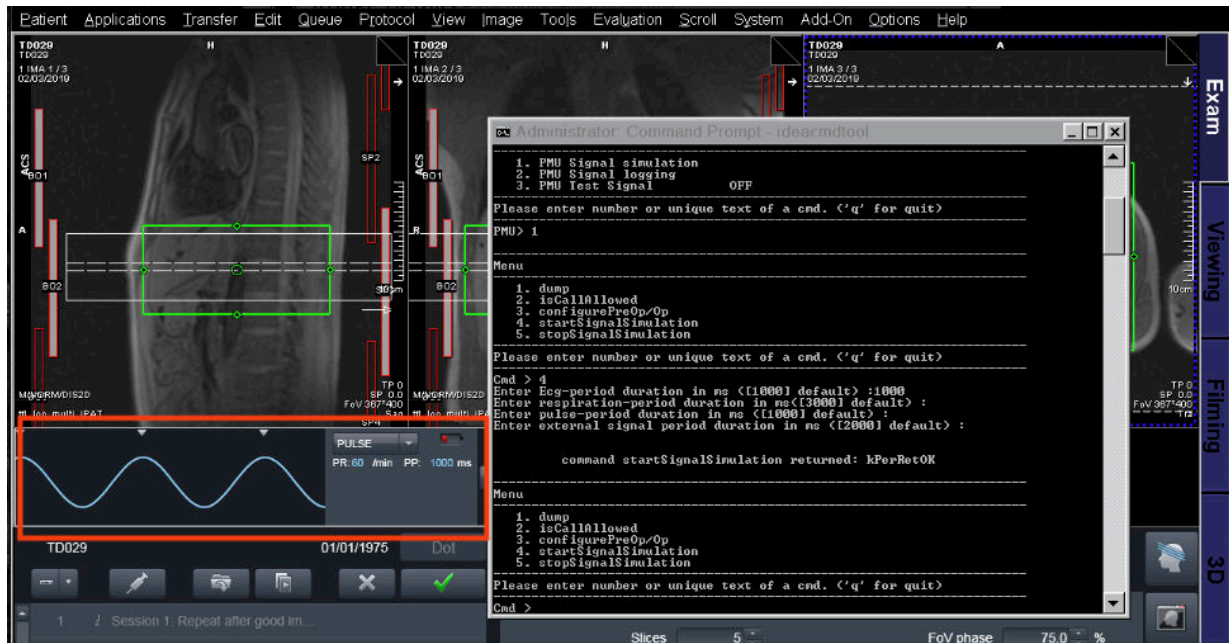


Figure 3. The simulated heartbeat is highlighted with a red box. Please note, this is a VE11 interface.

3.4.4. Cardiac Gating

- Use *ECG* or pulse oximeter to set up the patient's cardiac gating.
- select the correct trigger source in the gating window (physiology monitoring window) and confirm the signal has clear R-wave.

When switching the gating method from (*PPU* to *ECG* or vice versa) or when recapturing the cardiac cycle, the trigger delay is being reset to the default value of 0 ms. Make sure the trigger delay is set to 50 ms after adjusting the gating method or when recapturing the cardiac cycle.

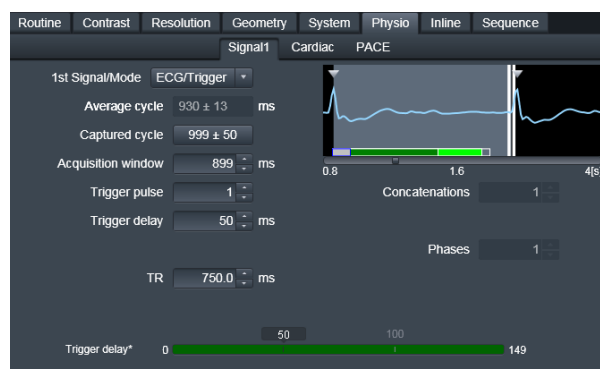


Figure 4. If use the patient's heartbeat input, please make sure to set Trigger Delay to 50ms

4. Acquisition

Please note that:

1. All protocols must be acquired before any contrast agent injection. Note that contrast agents are not necessary for any of the acquisitions.
2. All scans are performed during end-expiration breath-hold, including the Localizer scan.



CAUTION

Protocol parameters should not be changed. Any changes not specifically covered in these instructions risk corrupting the resultant parameters and cause data rejection by Perspectum Ltd.



CAUTION

Please do NOT inject any contrast agent prior to the acquisition of *LMS* protocol. This might result in erroneous parameter quantification.

4.1. Localization Protocols

4.1.1. Three-plane Localizer

A three-plane Localizer should be run at end-expiration breath-hold to produce at least one sagittal, one coronal and one transversal view of the abdomen.



CAUTION

Check that the phased-array coil is positioned to give good *SNR* over the entire liver. Reposition the coil on the patient if necessary. Low image *SNR* adversely impacts the quality of the resulting parameter estimates.

4.1.2. Additional Localizers (optional)

Additional localizers may be run to acquire axial/transversal slices to find the right view for subsequent *LMS* slice positioning.

4.2. Liver LMS Imaging Location

4.2.1. Base Slice Positioning

The positioning mode for *LMS* scans should be "ISO". The patient table will move to bring the imaging slice to the isocentre. The base slice should be positioned such that it intersects the porta hepatis, and it should display the liver, spleen, and may also contain the stomach. If the lungs are visible in the transverse slice, please shift the image lower on the patient's abdomen as the lungs will cause susceptibility artefacts.

This slice location will be used as a reference for most of the sequences. It is imperative to position correctly. Please refer to the localizer images in [Figure 5 \(page 10\)](#) for positioning of the transverse slice.

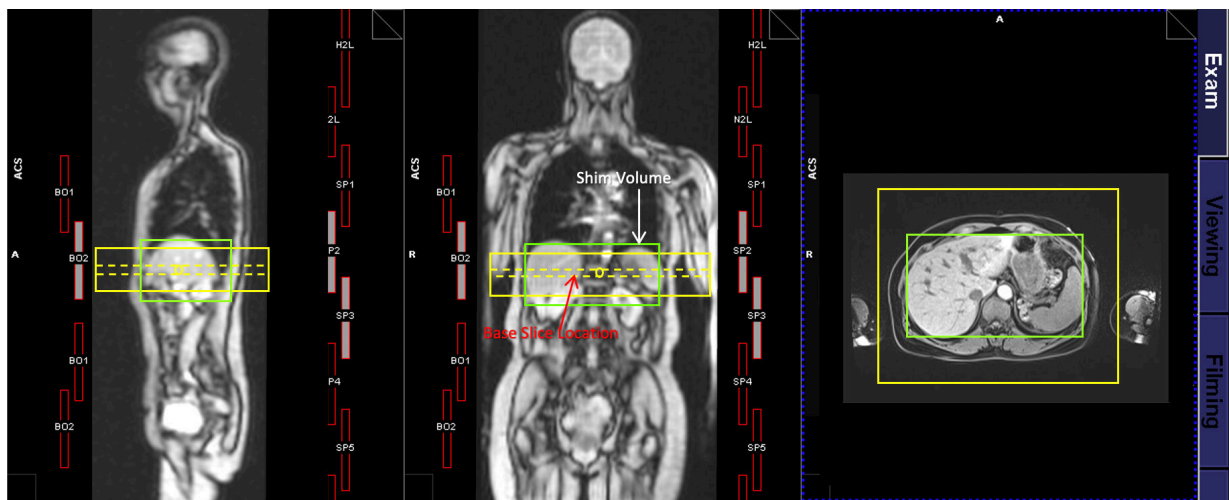


Figure 5. Three-plane Localizer view of the abdomen in coronal, sagittal, and transversal (axial) plane. The base slice location for LMS protocol is indicated in yellow and the shim volume in green.

4.2.2. Shimming

The shim volume should be centred as shown in [Figure 5 \(page 10\)](#). The *F-H* direction should cover the entire stack of slices and should be remained as in the protocol. In the *R-L* and *A-P* directions, the shim volume can be adapted until the liver is fully covered, excluding as much air as possible. Please also exclude the subcutaneous fat in obese patients.

To display the adjustment volume as an additional graphic object in the reference image, click on the



button at the Position Toolbar.



CAUTION

Each time you open an *LMS* protocol the 'Scan Assistant' will prompt to check the adjust volume. Please select 'Manual'. If this 'Manual' adjustment is not done, the system will switch back to the original manufacturer settings.



CAUTION

Shim adjustments other than those described in this manual may corrupt the parameter mapping.



CAUTION

Susceptibility Artefacts

Magnetic susceptibility artefacts appear due to: poor shim, proximity to the lungs, bowel gas or metallic implants. Susceptibility artefacts in the liver will preclude accurate parameter estimation in the areas affected as shown in [Figure 6 \(page 11\)](#).

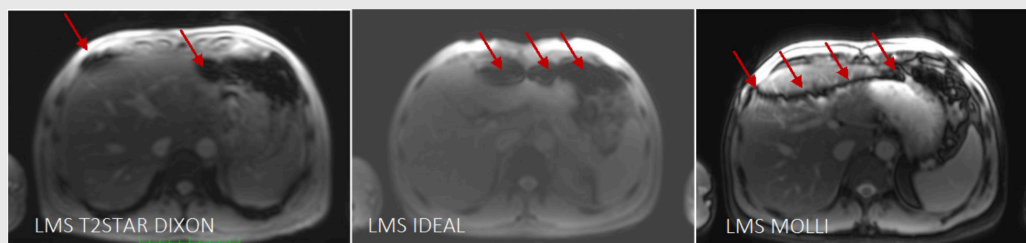


Figure 6. Susceptibility artefacts will appear as dark, distorted areas, in LMS MOLLI it also can appear as a banding artefact.

To mitigate susceptibility artefacts:

1. Ensure the centre of the single-slice is at isocentre and make sure the adjust volume is positioned as shown in Figure 5 (page 10).
2. Force a re-shim by :

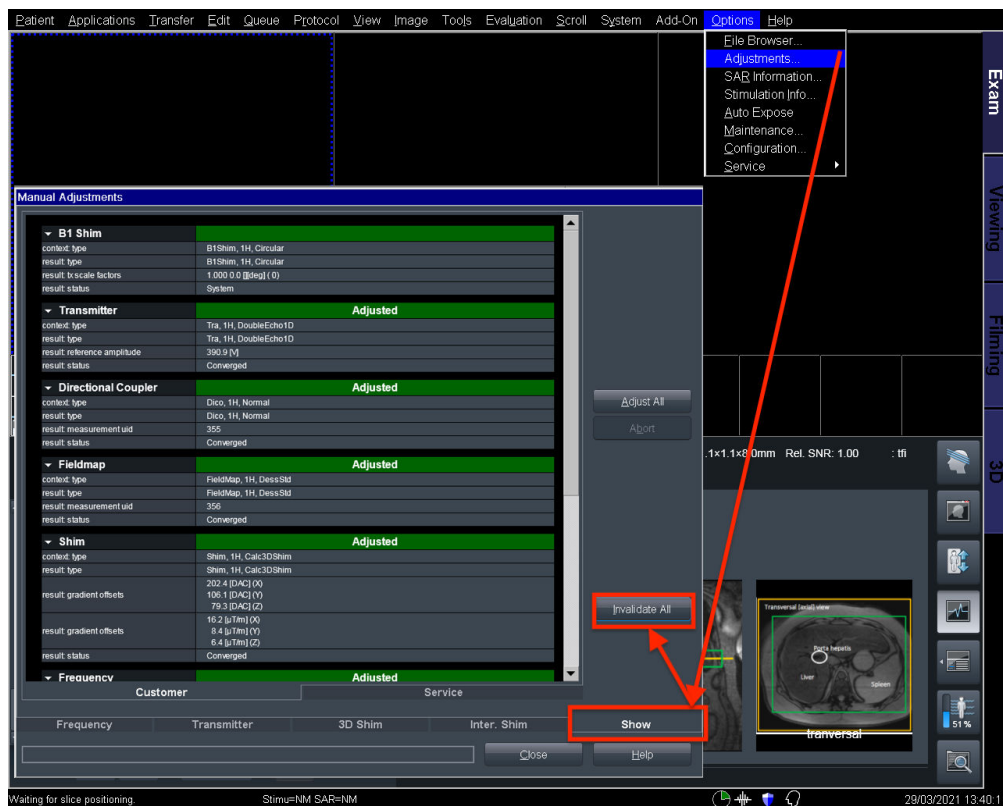


Figure 7. Options > Adjustments > Show tab > Invalidate All > Run the sequence again.

A re-shim will also occur if the slice positioning changes, even modestly.

3. Re-acquire the data.

4.3. Liver LMS IDEAL

This is a 5-slice multi-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 9 seconds. This sequence will be used to generate a PDFF map of the liver.

1. Prescribe the slice stack so that the 3rd slice (middle slice) intersects the porta hepatis.
2. The shim volume should be centered as the slice stack and the R-L and A-P directions can be adapted to ensure the entire abdomen is included in the transverse view and the liver and the spleen are completely covered as shown in Figure 5 (page 10).
3. The (F>>H) shim volume thickness should be manually adjusted to '90mm' (this can be found under System → Adjust volume) so that the shim volume is thicker than the slice stack.

4.4. Liver LMS MOST

This is a single-slice multi-echo gradient-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 11 seconds. This sequence will be used to generate a T2* map of the liver.

1. Double click on the LMS *MOST* protocol and select 'Manual' when prompt by the 'Scanning Assistant'.
2. Right click on the LMS *IDEAL* protocol → select 'Copy Parameters'. In the pop-up window select 'Center of slice groups and saturation regions' → click 'OK'.
3. Repeat **step 2** a second time and select 'Adjustment volume'.
4. Manually change the shim volume thickness (F>>H) to 20mm (can be found under System → Adjust volume). Repositioning of the shim volume may be required.

4.5. Liver LMS T2STAR DIXON

This is a single-slice multi-echo gradient-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 10 seconds. This sequence will be used to generate a T2* map of the liver.

1. Double click on the LMS T2STAR *DIXON* protocol → select 'Manual' from the 'Scanning Assistant'.
2. Right click on the LMS *MOST* protocol → select 'Copy Parameters'. In the pop-up window select 'Center of slice groups and saturation regions' → click 'OK'.
3. Repeat **step 2** a second time and select 'Adjustment volume'. Ensure that the shim volume is still covering the slice. Repositioning of the shim volume may be required.

4.6. Liver LMS MOLLI

This is a multi-slice, multi-breath-hold, cardiac-gated acquisition performed at end-expiration breath-hold. This scan acquires 5 transverse slices, one slice per breath-hold. Each breath-hold lasts approximately 9-12 seconds. This sequence will be used to generate a T1 map of the liver.

After each slice has been acquired the operator will be prompted to give breathing instruction for the next slice. During the scan, it is imperative to monitor the physiological recording trace to check **no heartbeats are missed** by the system's triggering algorithm.

Before running each of the MOLLI acquisitions, allow at least 10 seconds of waiting time for T1 recovery. This scan will run 5 times to collect 5 slice locations.

Slice 1

Double click on the LMS MOLLI protocol and select 'Manual' from the 'Scanning Assistant'. Right click on the LMS *MOST* protocol that just ran, select 'Copy Parameters'. In the pop-up window select 'Center of slice/slab groups and saturation regions', then click 'OK'. Repeat this procedure a second time selecting 'Adjustment volume'. Ensure that the shim volume is still covering the slice similar to [Figure 5 \(page 10\)](#). Repositioning of the shim volume may be required. Scan using the breath-hold instructions.

Slice 2

Copy and paste the previous LMS MOLLI scanned (slice 1), click on the coronal or sagittal image of localizer and press **Ctrl+4** to move it up towards the top of the liver by the amount dictated by the LMS protocol. Ensure the shim volume covers the slice similar to [Figure 5 \(page 10\)](#) and reposition the shim volume as needed. Scan using the breath-hold instructions.

Slice 3

Copy and paste the second LMS MOLLI scanned (slice 2), click on the coronal or sagittal image of localizer and press **Ctrl+4** to move it up toward the top of the liver by the amount dictated by the LMS protocol. Ensure the shim volume covers the slice and reposition the shim volume as needed. Scan using the breath-holding instructions.

Slice 4

Copy and paste the first LMS MOLLI scanned (slice 1), click on the coronal or sagittal image of localizer and press **Ctrl+3** to move it down. Ensure the shim volume covers the slice, reposition the shim volume as needed. Scan using the breath-holding instructions.

Slice 5

Copy and paste the fourth LMS MOLLI scanned (slice 4), click on the coronal or sagittal image of localizer and press **Ctrl+3** to move it down. Ensure the shim volume covers the slice, reposition the shim volume as needed. Scan using the breath-holding instructions.

5. Data export

If the patient registration contains personally identifiable information (*PII*), please refer to the Patient de-Identification Manual for help removing the PII but preserving the private DICOM tags necessary for describing the image acquisition.

Private DICOM tags are special tags added by the manufacturer to describe the MRI sequence. They do NOT refer to private information, nor PII. Many DICOM anonymization tools have an option to remove all Private Tags. Do not remove Private Tags when exporting data.



CAUTION

Private DICOM tags must be preserved in any data export. Private DICOM tags are not PII tags. PII must be removed if this scan is for research purposes.

These instructions cover exporting data from the scanner for transfer. If your site is unable to export from the scanner directly and transfers data via a PACS system please use the PACS export to save the DICOM images.

5.1. Saving *DICOM* Images for Transfer

To export data from the Siemens MRI Scanner directly, save the data from the <Patient browser> to a location where it can be uploaded to Perspectum portal. Select the data you want to export.

5.1.1. Export data to a CD or DVD

1. In <Patient Browser> select the appropriate subject folder.
2. Select <Transfer> and then <Export to CD-R>
3. In the <Enter Label> enter a unique name.

For XA software version ensure the *properties* is selected as "Create *DICOM* file System" and *Image Conversion* is selected as "Interoperability".

5.1.2. Export data with a USB stick or external hard drive

1. In <Patient Browser> select the appropriate subject folder.
2. Select <Transfer> and then <Export to off-line>
3. Select the path and folder from the path selection list (this could be a USB stick, external hard drive or CD).
4. Select *DICOM* in <Select format>.
For XA software version, select " Create *DICOM* file System" and select "Interoperability" for the image conversion option.
5. **DO NOT** select <Anonymously>. For XA software **DO NOT** select " anonymize as...".
6. Confirm with OK. For XA software version click on "Export".

5.1.3. Check the data is transferred completely

1. Select <Transfer> → <Local job status>.
2. A window will pop up to show the data transfer status

It is preferable to compress the folder of exported DICOMs and submit the single compressed file to the Portal.

- **On a Windows:** right click on the folder in Windows Explorer and select <Send To> and <Compress (zipped) folder>. If the folder resides on a CD or DVD, you will need to copy the folder to a location that can be saved to.
- **On a Mac:** hold Ctrl and click on the folder, then select <Compress>.

Upload the compressed file to the Portal.

For additional instruction on using the Portal, please see the QAS Portal Customer Instruction - PDM077 on the Portal website.

6. Acquisition Checklist

Step	Task
Patient information	<input type="checkbox"/> Patient name: Use agreed patient naming scheme <input type="checkbox"/> Registration ID: Use agreed patient ID naming scheme <input type="checkbox"/> Date of birth: Use agreed scheme <input type="checkbox"/> Correct sex, height, weight and exam date <input type="checkbox"/> Operator: Input the initials of the operator performing the examination. <input type="checkbox"/> Patient Position: Select the appropriate position. <input type="checkbox"/> Leave the rest of the fields empty.
Localiser (one breath-hold)	<input type="checkbox"/> Run localiser on expiration
LMS IDEAL (one breath-hold)	<input type="checkbox"/> Place the slice stack (5 slices) so that the middle slice (third slice) will intersect the porta hepatis. <input type="checkbox"/> Position the shim volume centred on the slice stack. <input type="checkbox"/> Adjust the shim volume only in R-L and A-P directions to the patient's dimensions so all of the abdomen is included in the transverse view. <input type="checkbox"/> Scan the sequence at end of expiration. <input type="checkbox"/> Check image quality, if there is motion artefacts please re-acquire the sequence.
LMS MOST (one breath-hold)	<input type="checkbox"/> Position the single with the same centre of LMS IDEAL, intersecting the porta hepatis. <input type="checkbox"/> Position the shim volume centred on the slice; shim volume is thicker than the slice. <input type="checkbox"/> Adjust the shim volume only in R-L and A-P direction to the patient's dimensions so all of the abdomen is included in the transverse view. <input type="checkbox"/> Scan the sequence at end of expiration. <input type="checkbox"/> Check image quality, if there is motion artefacts please re-acquire the sequence.
LMS T2STAR DIXON (one breath-hold)	<input type="checkbox"/> Position the slice with with the same centre of LMS MOST, intersecting the porta hepatis. <input type="checkbox"/> Position the shim volume centred on the slice. shim volume is thicker than the slice thickness. <input type="checkbox"/> Adjust the shim volume only in R-L and A-P direction on the patient's dimensions so all of the abdomen is included in the transverse view. <input type="checkbox"/> Scan the sequence at end of expiration. <input type="checkbox"/> Check image quality, if there is motion artefacts please re-acquire the sequence.

Step	Task
LMS MOLLI (5 breath-holds)	<ul style="list-style-type: none"> <input type="checkbox"/> Slice 1: Double click on the LMS MOLLI and select 'Manual' if prompted to; Right click on the LMS T2STAR DIXON scanned above; select 'Copy Parameters'; In the pop-up window select 'Center of slice groups and saturation regions'; click OK. Repeat 'Copy Parameter' steps for 'Adjustment Volume'. <input type="checkbox"/> Slice 2: Copy and paste the previous LMS MOLLI series; prescribe slice 2 cranial to slice 1 by pressing [Ctrl]+[4] once. <input type="checkbox"/> Slice 3: Copy and paste the previous LMS MOLLI series; prescribe slice 3 cranial to slice 2 by pressing [Ctrl]+[4] once. <input type="checkbox"/> Slice 4: Copy and paste the first slice (porta hepatis); prescribe slice 4 inferior to slice 1 by pressing [Ctrl]+[3] once. <input type="checkbox"/> Slice 5: Copy and paste slice 4; prescribe slice 5 inferior to slice 4 by pressing [Ctrl]+[3] once. <input type="checkbox"/> Make sure the shim volume is centred on the slice and adjust the shim volume only in R-L and A-P direction so all of the abdomen is included in the transverse view. Exclude subcutaneous fat as much as possible. <input type="checkbox"/> Check image quality for each slice; are there artefacts? If so, please re-acquire the sequence.

7. Issue Control

Issue	Details	Date	Initial
6.0	Conversion to Paligo; Sign-off	April 2019	FSN
7.0	Updated the acquisition sequences and added cardiac trace simulator	July 2020	FSN

8. Approvals

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