Lessons Learned from Collecting Data for the Reconstruction and ATR Projects

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# Synopsis

The purpose of this document is to document the lessons learned when collecting data for the reconstruction project (Task Order 3) and the ATR project (Task Order 4). The data were collected on the Imatron medical CT scanner located near the San Francisco airport at the Heartscan medical clinic. The points noted herein should be addressed when data is collected in the future.

# Lessons Learned

## Specifying what has to be done during data collection

1. A lexicon should be created for all aspects of data collection including target preparation, packing, scanning, data archiving and retrospective reconstruction.
2. A glossary of terms and acronyms should be made available to all personnel.
3. A printer should be made available to print out instructions.
4. Standard operating procedures (SOP) should be developed for making specimens (e.g., saline), containing targets, packing bags, scanning, data archiving and retrospective reconstruction.

## Data recording

1. Using a slice serial number (SSN) is a good idea for each scan. This leads to common and sequential naming convention for raw data, corrected data and images.
2. Templates for all spreadsheets should be created in advance.
3. The fields and their contents should be specified in writing.
4. The blog was a good idea; however, additional personnel are required to record sufficient detail.
5. Consider taping to the wall each day a list of objects to be scanned along with goals for packing and in particular clutter.
6. Videos should be made for all bags with the exception of bags that are rescanned without changing contents or their locations.

## Objects

1. Avoid object philosophy issues by not doing the following.
	1. Scan targets of the same type that are touching to prevent merged objects.
	2. Scan bags with objects of the same type. For example, make sure that rubber is not present in other forms (e.g., a rubber mallet).
2. Do not mix targets and pseudo targets. If pseudo targets need to be scanned, do not mix those scans with the scans of targets.

## Object spreadsheet

1. All objects (targets and non-targets) should be entered in advance of scanning. The only exceptions are materials that are made on site (e.g., saline and concealed/contained objects).
2. Separate sheets should be used for source materials (e.g., big blocks of clay, rubber sheets or containers of saline), specimens, and non-targets.
3. Agree on units (e.g., mm or cm) for all fields.

## Labels

1. Different colors should be used for different types of objects (target, non-target, pseudo target, and specimen).
2. A computerized label maker should be used instead of handwriting labels.
3. Labels with numbers should be printed in advance.
4. Consider using bar codes to label objects and a bar code reader to verify that the proper objects are packed in a bag. Software may have to be written to transfer the output of the bar code reader to spreadsheets. The bar codes should be a supplement to human-readable labels.
5. Mark the preferred axis of an object on the object.
6. The SSN should be shown in all pictures of packed bins.

## Imatron scanner itself

1. Figure out a way to eliminate on-line reconstruction, which limited the bag scanning rate to half of the predicted rate of approximately ten bags/hour.
2. A better metric than bags/hour is number of helical scans protocols/hour.
3. Determine how to connect a Windows 7 computer to the reconstruction computer so that projection data and images can be transferred from the scanner without the use of on intermediate computer.

## Scanning on the Imatron scanner

1. Investigate other scanning protocols that would allow scanning longer bags during one helical scan operation. However, changing protocols may render previously collected data useless.
2. Drop the reconstruction dependencies. The Imatron recon is a useful QC tool, but delays each scan and requires large data space. This limits the bag scanning rate and raises the changes of data transfer/management errors
3. Scanning portions of a bag/bin can be done when it is known that nothing relevant is contained in the end a bag/bin.
4. Keep the bags aligned with the table top (i.e., do not flip, twist and rotate) so that the packing locations represent where objects are in the images.

## Packing bags

1. Clear bins are useful in order to see the contents in the bin.
2. Simulate real bags with bins by adding two aluminum bars and a couple of wheels to the interior of the bins.
3. Consider the cost/benefit of real bags. Typical luggage was too long and sometimes too wide to be scanned on the Imatron CT scanner.
4. The contents and locations of objects should be specified in advance.
5. A person should check that the correct objects are placed in the bag, in the proper location and in the proper orientation. This means at least two people are responsible for packing versus the one person that was used.
6. The number of targets per bag should be an average, not absolute per bag.

## Targets

1. Consider the cost/benefit of pseudo targets; their use increases the complexity logging the scanning activity and complicates the scoring of the results of an ATR,.
2. Make sheets and one bulk the same material to eliminate the question of when does a sheet become a bulk.

## Personnel supporting the scanning

1. More people would be helpful, especially for verification of samples and data recording. The verification should include, but not limited to, the following tasks, when packing and scanning a bag.
	1. All objects are properly labeled.
	2. All objects are entered properly in the database.
	3. The locations and orientations of all objects are recorded in the database.
	4. Object philosophy issues are avoided.
	5. Pictures are available for all objects.
	6. Unpacking videos are recorded.
	7. Scan information (e.g., RCP numbers) are recorded.
2. The tool developer and at least one ATR developer should be present to witness scanning and to make sure that sufficient information about the scans is recorded.
3. Two training sessions should be conducted before most of the bags are scanned one without the scanner (i.e., a virtual dry run) and one with the scanner, but only scan approximately ten bags (i.e., a real dry run).
4. Agree on roles and responsibilities of all personnel.
5. Switch roles during the scanning to understand the needs of all personnel.

## Scanning site

1. Arrive a day in advance to:
	1. Prepare all liquids
	2. Sort out and label all objects.
	3. Perform a dry run with the scanner.
	4. Prearrange data extraction to demonstrate data can be extracted from the scanner, and rectify extraction issues ahead of the actual visit.
	5. Arrange for work surfaces (tables).
2. When departing:
	1. Make arrangements to ship all scanning items back to ALERT.
	2. Restore space to state it was in before arrival.

## Tools used as part of data collection.

1. To the degree possible, preprint labels. This avoids duplication, and permits accounting for pre-determined blocks of numbers
2. Bring multiples of the following items so that their use does not get into the critical path cameras, pens, scales and labels.
3. Bring a portable printer so that updated SOPs can be provided to personnel.
4. Bring a portable scanner or iPhone camera so that related documents can be archived before they are lost.

## Off-line reconstruction of the data

1. Make sure that sufficient people are available to perform this task.
2. Tasks also include
3. compensating for overlap between helical protocols
	1. Renaming files
	2. Writing scripts to drive xrec
	3. Finding bounding boxes of targets. The bounding boxes should be created onsite so that the locations of the objects are fresh in the minds of the people who packed the bags.
	4. Verifying the contents of databases (spreadsheets)

## Ground-truth

1. Be wary of Mevislab; it is buggy.
2. Check the literature for options for segmenting images.
3. Generate ground truth on site.
4. The rules for how to generate ground truth should be supplied in writing in advance creating the ground truth.

## FTP site

1. Its organization (layout) should be specified before scanning begins.
2. Try to upload data during the scanning session.
3. Label images should be compressed with gzip.
4. If FITS format is used, introduce a suffix for compressed FITS files (e.g., .fgz).

## Miscellaneous

1. Review best practices in other related fields. For example, review practices used for DNDO data collection.
2. Figure out a way to avoid the object philosophy issue. In TO3, N rubber sheets were stacked leading to a question of whether the stack was one object or N objects? In TO4, is a rubber mallet a target?
3. All data (projection, images and spreadsheets) should be consumed (used) earlier in the project. If possible, sample tools (ATR, reconstruction) should be available at the time that data are acquired.