TO4 (ATR Initiative) Scan Plan   
  
Version 7

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# Introduction

The purpose of this document is to provide the details of the scanning of bags for the ATR Project.

# Scanning Session Details

## Location

Heartscan

389 Oyster Point Blvd., Suite #3

South San Francisco, CA 94080

Phone: (800) 469-4327

## Shipping Address

Ken Charles

c/o Heartscan

389 Oyster Point Blvd., Suite #3

South San Francisco, CA 94080

Phone: (800) 469-4327

## Times

1. Monday, September 30th - Thursday, October, 4th
2. Start times: 7:30 AM
3. End times: TBD

## Personnel

| **Name** | **Affiliation** | **Roles** |
| --- | --- | --- |
| Carl Crawford | Csuptwo | Technical lead, offline reconstruction, quality assurance |
| Alyssa White | ALERT | Object acquisition, pack packing, documentation |
| Rick Moore | ALERT | Object acquisition, pack packing, documentation |
| Doug Boyd | Tele-Security Sciences | Interface to Heartscan, project advisor |
| Sam Song | Tele-Security Sciences | Interface to Heartscan, project advisor |
| Ken Charles | Tele-Security Sciences | Scanner operator |
| Harry Martz | LLNL | Subject matter expert |
| Jeff Kallman | LLNL | Subject matter expert |

# Definitions

| **Term/Acronym** | **Definition** |
| --- | --- |
| Target | Something that an ATR has to detect |
| Non-target | Something that an ATR should not detect |
| Pseudo-target / PT | A target material with sub-minimum mass or a another material with density less than water. A pseudo-target is also a non-target. |
| Bag | Something to contain targets, non-targets and pseudo-targets |
| Object | The union of targets, non-targets and bags. |

# Assumptions

1. 150 – 200 bags can be scanned

# General Requirements

## Tolerances

Tolerances for making test objects listed below shall be as follows.

1. Mass: ±2%
2. Linear dimension: ±2%
3. Volume: ±2%
4. Density: ±2%

## Axes for CT scanner

The following axes shall be used for the CT-scanner

1. x: horizontal axis of axial slice
2. y: vertical axis of axial slice
3. z: parallel to direction of table movement for helical scans

## Location Code for Objects Placed in a Bag

A three-letter code is used to note where objects are placed in a bag. The code is of the form xyz, where x, y, and z are letters showing the location along the x, y and z, axes, respectively. The x- and y-axes are split into three sections denoted A, B, and C. The Z-axis is split into four sections denoted A, B, C and D. The following diagram shows some are the location codes map to a bag.



These codes correspond to the Imatron images as follows.

1. X: A refers to left side of image
2. Y: A refers to bottom of image
3. Z: A refers to slice 1

## Preferred Axes for Objects

1. Cylinders: axis of rotation
2. Sheets: Parallel to conveyor belt
3. Cuboids: Longest dimension

Notes:

1. The preferred axis for an object should be marked on an object.

## Orientation Codes for Objects

The orientation code is used to specify how the preferred axis of an object is oriented in bag. The values of the code are as follows.

1. Aligned to an axis:
   1. X: aligned to x axis
   2. Y: aligned to y axis
   3. Z: aligned to z axis
2. Not aligned to an axis but in a plane aligned with two axes:
   1. XY: in xy-plane
   2. YZ: in yz-plane
   3. XZ: in xz-plane
3. Other
   1. N: not aligned with an axis and not in plane aligned with two axes

Notes

1. A plus sign (+) sign or minus sign (-) shall be appended to all the orientation codes to show how the preferred axis of an object.

## IDs

1. IDs for targets have to be unique and numeric
2. Each packing or shape of an object has own ID. For example,
   1. Each bottle of saline has its own ID
   2. Each shape (cutting) of a rubber sheet has its own ID
3. The bulk (source) material(s) for targets should also have unique IDs. For example, the box of modeling clay should be given an ID. Each time a piece of clay is cut from the bulk or a piece is molded, it should be given a new ID.

## File Naming Conventions

1. Filenames:
   1. Compatible with Linux and Windows
   2. No spaces
   3. Less than 10 characters
2. Scans should have a unique serial number
3. Filenames should have a specified prefix.
   1. R – raw projection data in DAS counts
   2. S – sinogram (corrected) data
   3. C –CT image data
   4. G – ground truth labels
   5. A – ATR label images

## FTP Site Contents

1. Raw data
2. Image data
   1. DICOM
   2. FITS
3. Ground truth labels
4. Sinograms
5. Documentation
   1. Spread sheets
      1. Objects
      2. Packing
   2. Scanning narrative
6. Tools
   1. Franco’s code and documentation including
      1. Gregor’s FITS’s code
      2. Crawford’s parse library

Notes:

1. CT images and label images may be compressed with gzip or zip

# Objects for Scanning

## General

1. Types
   1. Targets (objects of interest for ATR)
   2. Non-targets
      1. Common items found in checked and carry-on baggage
         1. Produce
         2. Perishables
         3. Fragile items
      2. Items to contain/conceal targets
   3. Bags
      1. Hard shell
      2. Soft shell (e.g., duffle bags)
      3. Plastic bins
2. Sources
   1. Task Order 1 – Segmentation Initiative
      1. Sourced by ALERT
      2. Presently at Heartscan
   2. Task Order 3 – Reconstruction Initiative

## Targets

### Materials

1. Saline doped to have a densities overlapping with other liquids commonly found in bags.
   1. Range: 1050 MHU – 1150 MHU in steps of 20 MHU
   2. Add 5 g of salt tablet for every 100 mL, which should increase the density by 5%.
   3. The saline should be mixed at a high concentration and then diluted to the appropriate concentration. If you want to get 10 grams of salt per 100 grams of solution, try to dissolve the 10 grams of salt in 70 ml of water and then dilute to get to 100 grams of solution.
2. Modeling clay (polymer) doped with TBD material to vary its linear attenuation coefficient. See following sites for additional information.
   1. <http://en.wikipedia.org/wiki/Polymer_clay>
   2. [www.sculpey.com/products/clays/original-sculpey](http://www.sculpey.com/products/clays/original-sculpey)
3. Rubber sheets and rubber blocks

### Requirements

1. Minimum mass: 250 g
2. Maximum mass: None
3. Minimum thickness for sheets: 0.25 inch
4. Maximum thickness for sheets: 1.5 inch
5. Sheet shape:
   1. Not all rectangular
   2. Some with holes cut in the middle

## Pseudo-Targets

1. Pseudo-targets (PT) are one of the following two types
   1. Target materials listed in Section 5.2 with masses ≥ 125 g and < 250 g
   2. Powders with masses greater ≥ 125 g and density < 1 g/cc
2. ATRs are not required to detect PTs. A detection on a PT will be considered to be a false alarm.
3. If possible, ground truth should be created for PTs in the future for future ATR development
4. ≤ 5 PTs may be placed in each bag

## Non-Targets

1. Common objects found in checked and carry-on luggage
   1. Food
   2. Clothing
   3. Cosmetics
   4. Electronics
      1. iPad or equivalent
2. Containment items
   1. Bags
   2. Bins
3. Clutter items
   1. Electronics
   2. Metal
   3. Large fluid

## Notes

1. All objects have to fit into scan FOV (475 mm)
2. Objects should be less than 840 mm (33 inches)
3. Containers are not part of targets. For example, the bottle containing is not part of the target; only the saline is the target.
4. Targets are contiguous, where the definition of contiguity is TBD

# Packing

1. Three targets on average per bag
2. Three pseudo-targets on average per bag
3. Targets
   1. Different shapes
      1. Clay: via molding
      2. Saline: via different containers
      3. Sheets:
         1. via cutting and bending
         2. Thickness controlled by procurement
   2. Different masses:
      1. x1 – x2 minimum mass
   3. Orientations
      1. Easy
      2. Medium
      3. Difficult
   4. Locations
      1. Center
      2. Periphery
   5. Clutter
      1. Low
      2. Medium
      3. Heavy
   6. Emulate some items (e.g., iPad) divested at the check-point
4. Notes
   1. Targets should be shaped differently than non-targets in a bag so that the targets can be visually identified in the CT images. For example, a liquid target should be placed in a round bottle and all non-targets liquids should be placed in rectangular bottles.
   2. TBD if targets can be touching
   3. Non-targets may be repacked. For example:
      1. Coke poured in 250 ml bottle
      2. Honey put into a plastic bag
      3. Water
   4. Bags shall be set off at least 5 cm from the scanning table with foam
   5. Empty spaces in bags may be filled with foam or clothing
   6. Object may be held into position using masking tape
   7. Containers should not always be completely filled.
   8. Simulated detonators, timing devices, power supplies and wires not required
   9. All items packed in the bag shall be labeled with an ID. The exception is that clothing and foam does not have to be labeled.

# Scanning

## Overview

1. Same scanning protocol as TO3 with the exception that only high energy (130 kV) data will be acquired
2. Save raw data
3. Images reconstructed offline

## Scanning Protocol

1. Collimator: 1.5 mm
2. Slice thickness: 1.5 mm
3. kV: 130
4. mA: 630
5. Exposure: 0.1 s for 130 kV
6. Pitch: 1
7. Scan time: 0.100 s
8. Recon Method: Offline
9. Reconstruction kernel: Highest resolution
10. Field of View: 475 mm
11. Tilt: 0.0 deg
12. Slew: 0.0 deg
13. Maximum number of slices: 280

Notes:

1. The maximum number of slices that can be collected with the above protocol is 280 slices, which corresponds to 420 mm or 16.54”. Therefore, bags longer than this length will have to be scanned multiple times at different table locations.
2. Bags should be marked with a leading edge and always scanned in the same orientation.

# Reconstruction

1. Images created with xrec offline
2. Limor Martin’s protocols
3. DICOM images created
4. Corrected projection data (sinograms) created
5. The center of gravity of each target (in slice) coordinates determined

# Documentation

## Object Database

1. Per object (target, non-target, bag)
   1. Name
   2. Description (text)
   3. Mass
   4. Dimensions
   5. Photos
      1. Object shown with ruler
      2. At least one photo shall show the object’s ID
   6. ID
2. Notes
   1. Each instantiation of a target (e.g., saline) shall have its own ID

## Packing Database

1. Per bag
   1. ID of bag
   2. Raw data filename(s)
   3. Image file name(s)
   4. Textual description of bag
   5. IDs of non-targets, targets, and pseudo-targets
   6. Orientation of bag when scanned – not required if the bag is aligned with the patient table and the top-leading edge is scanned first and at the top.
   7. Per each target
      1. ID
      2. Type: saline, sheet,
      3. Location code of target in the bag; see Section 5.3.
      4. Orientation code; see Section 5.5.
      5. Description of objects and IDs into which target is inserted
      6. Code for clutter: light, medium, heavy (code TB(
      7. Description of clutter
         1. L: low
         2. M: medium
         3. H: heavy
      8. Bounding box for target (in slice) coordinates
   8. Unpacking video (TBD)
   9. Unpacking photos
2. A log (i.e., Word or blog) file shall be maintained to describe the events of packing, scanning, etc. See the sample log file located at: ./eng\_research\_TO3/Imatron/C300-Data%2006-Aug-2013/\_DataSets/High\_Clutter/Contents%20of%20Bag%200032/DETAILS%20OF%20BAG%200032.docx

# Tasks before Arrival at Heartscan

1. Revise/iterate this document
2. Procure objects and tools (as listed throughout this document)
   1. Before departure for CA
   2. After arrival in CA
3. Access databases used for TO1 and TO3
4. Develop new databases for TO4

# Initial Tasks upon Arrival at Heartscan

## Object Sorting and Cataloging

1. Find work space (tables)
2. Sort out objects
3. Assure all objects labeled and labels do not duplicate
4. Catalog all objects
5. Pack and document test bag

## Scanning

1. Agree on scanning and reconstruction protocols
2. Scan test bag
3. Transfer raw data
4. Perform off-line reconstruction
5. Estimate time per bag
6. Agree on total number of bags to scan during the week

## Other Initial tasks

1. Agree on roles and responsibilities
2. Agree on schedule
3. Discuss need for breaks and food
4. Determine saline concentration
5. Discuss file naming conventions
6. Measure physical mass, density, volume and density of (tolerances TBD):
   1. Containers
   2. Targets
   3. Non-targets

# Item Responsibility

| **What** | **Who** | **Notes** |
| --- | --- | --- |
| Scale | CC | < 1 g accuracy |
| 250 ml containers | CC | McMaster |
| Perishable items. Fruit, vegetables, etc. | CC | Purchase upon arrival in CA |
| Stream of commerce containers, > 125 ml for saline | AW | Soda cans, bottles plastic bins, metal, thermos. Most 250 ml or larger |
| Modeling clay. Sculpey. [www.sculpey.com/products/clays/original-sculpey](http://www.sculpey.com/products/clays/original-sculpey) | CC |  |
| Rubber sheets | CC |  |
| Salt (w/o iodine) | AW | For doping water 1050-1150 MHU |
| Tape for IDs | AW |  |
| Marker (permanent) | AW |  |
| Laptop for documentation | AW |  |
| Digital camera | AW |  |
| Video camera | AW |  |
| Plastic bags (sandwich, quart, gallon) | CC | For containing saline and storing modeling clay |
| Plastic wrap | AW | For wrapping modeling clay and |
| Knife | AW | For cutting modeling clay |
| Rubber hammer | AW | For shaping modeling clay |
| Ruler (metric, >30 cm) | AW |  |
| Tape measure (metric, > 1 m) | AW |  |
| Measuring cup | AW | For saline |
| Plastic storage bins < 30” long | CC | To scan instead of suitcases |
| Ethernet switch and cables | CC |  |
| Saw | CC | For cutting rubber and pipes |
| Powder | HM |  |
| Clothing for packing | AW |  |
| Displacement gradients | RH | Used in TO1 |
| Old laptop computer | RM |  |
| Picture frames | RM |  |
| Masking and duct tape | AW |  |
| Ceramic mugs | AW |  |
| Pipes (metal, plastic) | CC |  |
| Rubber bands | AW |  |
| Oil | CC |  |
| Honey | CC |  |
| Peanut butter | CC |  |

Abbreviations:

1. CC: Carl Crawford
2. AW: Alyssa White
3. HM: Harry Martz
4. RH: Rick Moore

# Local Shopping

1. Costco/Safeway
   1. Peanut butter
   2. Coke
   3. Oil
   4. Fruit
   5. Honey
   6. Salt
   7. Pepper
   8. Rice
   9. Batteries
   10. Sugar (power)
   11. flour
2. Lowes
   1. Bins
   2. Masking tape
   3. Pipes, metal and pvc
   4. Saws
   5. Powder
   6. Misc. tools for scanning
   7. Large bottles for mixing saline
3. Goodwill
   1. Clothes
   2. Shoes/boots
   3. Concealment items
   4. Clutter items

# Local Resources

Home Depot

2 Colma Blvd

Colma, CA

(650) 755-9600 ‎

Target

1150 El Camino Real

San Bruno, CA

Walmart

600 Showers Dr

Mountain View, CA 94040

Phone: (650) 917-0795

Lowes (closest to Heatscan)

720 Dubuque Ave

South San Francisco

(650) 452-1040

Costco

451 S Airport Blvd

S San Francisco, CA

Safeway

30 Chestnut Ave.

South San Francisco, CA

Goodwill

225 Kenwood Way

S San Francisco, CA

(650) 737-9827

<http://sfgoodwill.org/>

Trader Joes

765 Broadway

Millbrae, CA

(650) 259-9142

# Additional Notes

1. This plan was written, in part, based on the lessons learned during collecting data for the Segmentation Initiative (Task Order 1) and the Reconstruction Initiative (Task Order 3). See the final reports for those projects for additional information.
2. Spares should be brought for critical equipment such as scales, cameras, digital cameras, archive material and computers.

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Version** | **Date** | **Author** | **Revisions** |
| 1 | 9/12/2013 | Crawford | Initial release. |
| 2 | 9/18/2013 | Crawford | Numerous changes mainly based on phone conference on 9/130/2013. |
| 3 | 9/23/2013 | Crawford | Miscellaneous changes |
| 4 | 9/23/2013 | Crawford | Changes due to feedback from vendor, LLNL and Franco |
| 5 | 9/25/2013 | Crawford | Misc. last-minute changes |
| 6 | 10/8/2013 | Crawford | Revised after scanning took place |
| 7 | 10/6/2014 | Crawford | Removed revision history. Added correspondence to Imatron images. |