



The Bones

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Chapter 1

Preliminaries

1.1 Where to find the ROVIS products

All files described herein can be found on the server `comsim`. If you have an account on this server, you can directly access the files in the directory

```
/home/rossim/html/bgrieger/BONES/.
```

In any case, you can access them via www at

```
http://comsim.esac.esa.int/rossim/bgrieger/BONES/.
```

There will also always be the latest version of this document, named `bones.pdf`.

1.2 Phases, periods, and time

The starting date of phase A is assumed to be 2014-11-15.

Phase A covers the time from completed lander delivery until no more bound orbits are possible. It is expected to last 4 month.

Phase B covers the time from the end of phase A until the nominal end of mission. It is expected to last 8 month.

An MTP period is planned to cover one month. MTP periods are named A1, A2, ..., B1, B2, ...

Trajectories have to be requested from FD in chunks of 4 month with a lead time of 4 month.

1.3 Naming convention

Orbit kernels are named as follows:

```
ORB-<Period>-<Trajectory>-V<Version>.BSP
```

Attitude kernels are named as follows:

```
ATT-<Period>-<Trajectory>-<Attitude>-V<Version>.BC
```

The placeholders are:

Period: P1, P2, ..., A1, A2, ..., B1, B2, ..., X1, X2, ...
Trajectory: A, B, C, ...
Attitude: 00, 01, 02, ...
Version: 01, 02, 03, ...

The *Attitude* 00 could by default be “VIRTIS-H pointing nadir”.

Example of an orbit kernel:

ORB-A1-A-V01.BSP

Example of an attitude kernel:

ATT-B5-C-02-V08.BC

For the orbit, there is also an ASCII file for MAPPS. It is named like the SPICE orbit kernel, just with a different extension. Example:

ORB-A1-A-V01.ASC

In this file, the spacecraft position is referenced to the Sun, as MAPPS requires a celestial body it knows to reference the position.

We provide also an orbit file in ASCII format in which the spacecraft position is referenced to the comet. It is named like the other orbit files, again just with a different extension. Example:

ORB-A1-A-V01.ORPR

As requested by the CONSERT team, we provide the orbit also in the comet body fixed frame. Example file name:

ORB-A1-A-V01.RCF

For each orbit, there is coverage table, which only depends on the orbit, not on the attitude. It has a different prefix and extension but is indexed similarly to the orbit file from which it was computed. Example:

COV-A1-A-V01.DAT

For each orbit, there may also be a file with orbit definitions (start and end of individual orbits and numbering). It also just has different prefix and extension. Example:

DEF-A1-A-V01.DAT

For each attitude, there may be a respective movie. It would have a different prefix and extension but would be indexed similarly to the attitude file from which it was computed. Example:

MOV-A1-A-01-V01.MPG

From 2012-Aug-01, for each (non-trivial) attitude file, a file comprising the title of the ongoing observation for each time step is provided, also just with different prefix and extension. Example:

OBS-A1-A-01-V03.DAT

Chapter 2

First chunk of trajectories

This chunk of trajectories covers the time from 2014-11-15 to 2015-3-15. The due date for the request to FD is 2014-7-15.

2.1 Period A1

This period lasts from 2014-11-15 to 2014-12-15.

2.1.1 Orbit A1-A

The name of the orbit kernel is

```
ORB-A1-A-V01.BSP.
```

The trajectory is a circular orbit with 10 km radius and 20° tilt from the terminator. The direction of the tilt is chosen so that the orbit becomes as polar as possible. A completely polar orbit would have required a tilt of 25°. The sense of the rotation is prograde with respect to the comet rotation.

These are the commands to copy the orbit files (SPICE kernel and ASCII files) and the coverage table from ROVIZ to the appropriate names:

```
%BEGIN FILE copy_kernels.sh
```

```
cp ../../ROVIZ/tmp/roviz_t074_p075_c021_s004_g006_r003_a4_v006.bsp \
  ../out/ORB-A1-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_ros.asc \
  ../out/ORB-A1-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_rel.asc \
  ../out/ORB-A1-A-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_fixed.asc \
  ../out/ORB-A1-A-V01.RCF
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_cov.dat \
  ../out/COV-A1-A-V01.DAT
```

```
%END FILE
```

The ROVIS file name contains (almost) all information about the parameters and boundary conditions used to generate the orbit, cf. chapter B.

We also create a command to check the actual time coverage of the copied SPICE kernel:

```
%BEGIN FILE copy_kernels.sh
```

```
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \  
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \  
../out/ORB-A1-A-V01.BSP \  
> brief1.txt
```

```
%END FILE
```

The information returned by the SPICE brief tool is:

```
BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064
```

```
Summary for: ../out/ORB-A1-A-V01.BSP
```

```
Body: ROSETTA (-226)
```

```
Start of Interval (UTC)
```

```
End of Interval (UTC)
```

```
-----
```

```
-----
```

```
2014-NOV-15 00:00:00.000
```

```
2014-DEC-14 23:59:59.999
```

2.1.1.1 The default nadir pointing attitude

The name of the attitude kernel is

```
ATT-A1-A-00-V01.BC.
```

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh
```

```
cp ../../ROVIZ/tmp/  
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u002.bc \  
../out/ATT-A1-A-00-V01.BC
```

```
%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh
```

```
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
../../ROVIZ/tmp/ros_triv.tsc \  

```

```

/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
../out/ATT-A1-A-00-V01.BC \
> brief2.txt

```

%END FILE

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A1-A-00-V01.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|------|
| ----- | ----- | ---- |
| 2014-NOV-15 00:00:00.000 | 2014-DEC-14 23:59:59.999 | N |

2.1.1.2 Remote sensing attitude profile

Version from 2012-08-01 The name of the attitude kernel is

ATT-A1-A-01-V03.BC.

This version differs from the previous version (cf. below) in that a few more bugs in the operation attitude blocks have been corrected.

Besides the SPICE attitude kernel, there is now also a file providing the title for the ongoing observation at each time step. Here are the commands to copy both files from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh
```

```

cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.bc \
  ../out/ATT-A1-A-01-V03.BC
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.dat \
  ../out/OBS-A1-A-01-V03.DAT

```

%END FILE

The ROVIS CK file name is the same as in the previous version; it was overwritten. However, the old version is preserved with the Bones file name.

Like before, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh
```

```

/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
../../ROVIZ/tmp/ros_triv.tsc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
../out/ATT-A1-A-01-V03.BC \
> brief3.txt

```

%END FILE

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A1-A-01-V03.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|----|
| 2014-NOV-15 00:00:00.000 | 2014-DEC-14 23:59:59.999 | N |

There is also a movie illustrating this attitude profile. The name of the file is

MOV-A1-A-01-V03.MPG.

This movie shows the external view all the time. With this version comes a new feature: In the lower left of the frame, the title of the ongoing observation is displayed.

Version from 2012-07-26 The name of the attitude kernel is

ATT-A1-A-01-V02.BC.

This version differs from the previous version (cf. below) in the following respects:

- A few bugs in the operation attitude blocks have been corrected.
- A bug in the slew approximation has been corrected.
- If the spacecraft $-x$ side is illuminated at the beginning or the end of a slew, the slew goes now the shortest way and is not power optimised (otherwise spurious flips may occur).

Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh
# cp ../../ROVIZ/tmp/\  
# roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.bc \  
# ../out/ATT-A1-A-01-V02.BC
```

%END FILE

The command is now commented out as the ROVIS file has been overwritten with a new version.

Like before, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh
```



```
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \  
  ../out/ATT-A1-A-01-V02.BC \  
> brief4.txt
```

%END FILE

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A1-A-01-V02.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|----|
| 2014-NOV-15 00:00:00.000 | 2014-DEC-14 23:59:59.999 | N |

Version from 2012-07-05 The name of the attitude kernel is

ATT-A1-A-01-V01.BC.

The attitude file provided contained gaps between pointings. These gaps were interpolated so that the inserted slew matches the provided attitudes at the beginning and at the end of the slew — let them be power optimized or not — while the attitude during the slew tends towards being power optimized.

Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh
```

```
cp ../../ROVIZ/tmp/  
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u004.bc \  
  ../out/ATT-A1-A-01-V01.BC
```

%END FILE

Like before, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh
```

```
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \  
  ../out/ATT-A1-A-01-V01.BC \  
> brief5.txt
```

%END FILE

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A1-A-01-V01.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|----|
| 2014-NOV-26 09:00:00.000 | 2014-NOV-26 10:59:59.999 | N |

There is also a movie illustrating this attitude profile. The name of the file is

MOV-A1-A-01-V01.MPG.

This movie shows the external view all the time.

2.2 Period A2

This period lasts from 2014-12-15 to 2015-1-15.

2.2.1 Orbit A2-A

The name of the orbit kernel is

ORB-A2-A-V01.BSP.

The trajectory is a circular orbit with 10 km radius and 20° tilt from the terminator. The direction of the tilt is chosen so that the orbit becomes as equatorial as possible. A completely equatorial orbit would have required a tilt of 68°. The sense of the rotation is prograde with respect to the comet rotation.

These are the commands to copy the orbit files (SPICE kernel and MAPPS ASCII file), the coverage table, and the orbit definition file from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh
```

```
cp ../../ROVIZ/tmp/roviz_t078_p077_c021_s005_g006_r003_a4_v006.bsp \  
  ../out/ORB-A2-A-V01.BSP  
cp ../../ROVIZ/tmp/  
roviz_t078_p077_c021_s005_g006_r003_a4_v006_ros.asc \  
  ../out/ORB-A2-A-V01.ASC  
cp ../../ROVIZ/tmp/  
roviz_t078_p077_c021_s005_g006_r003_a4_v006_rel.asc \  
  ../out/ORB-A2-A-V01.ORPR
```

```

cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_cov.dat \
  ../out/COV-A2-A-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_def.dat \
  ../out/DEF-A2-A-V01.DAT

```

%END FILE

The ROVIS file name contains (almost) all information about the parameters and boundary conditions used to generate the orbit, cf. chapter B.

In order to investigate the effect of a 1 km uncertainty in the spacecraft position, we create a set of six additional kernels which represent a position offset of 1 km in six different directions. These are the commands to copy them to the appropriate file names:

%BEGIN FILE copy_kernels.sh

```

cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_forward.bsp \
  ../out/ORB-A2-A-V01_FORWARD.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_backward.bsp \
  ../out/ORB-A2-A-V01_BACKWARD.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_left.bsp \
  ../out/ORB-A2-A-V01_LEFT.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_right.bsp \
  ../out/ORB-A2-A-V01_RIGHT.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_up.bsp \
  ../out/ORB-A2-A-V01_UP.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_down.bsp \
  ../out/ORB-A2-A-V01_DOWN.BSP

```

%END FILE

We also create a command to check the actual time coverage of the copied SPICE kernel:

%BEGIN FILE copy_kernels.sh

```

/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ORB-A2-A-V01.BSP \
> brief6.txt

```

%END FILE

The information returned by the SPICE brief tool is:

BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064

Summary for: ../out/ORB-A2-A-V01.BSP

Body: ROSETTA (-226)

| Start of Interval (UTC) | End of Interval (UTC) |
|-----------------------------------|-----------------------------------|
| ----- 2014-DEC-15 00:00:00.000 | ----- 2015-JAN-14 23:59:59.999 |

2.2.1.1 The default nadir pointing attitude

The name of the attitude kernel is

ATT-A2-A-00-V01.BC.

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh  
  
cp ../../ROVIZ/tmp/  
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u002.bc \  
  ../out/ATT-A2-A-00-V01.BC  
  
%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh  
  
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \  
  ../out/ATT-A2-A-00-V01.BC \  
> brief7.txt  
  
%END FILE
```

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A2-A-00-V01.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------|------------------|----|
|--------------------|------------------|----|

```
-----  
2014-DEC-15 00:00:00.000 2015-JAN-14 23:59:59.999 N
```

2.2.1.2 Remote sensing attitude profile

Version from 2012-08-28 The name of the attitude kernel is

```
ATT-A2-A-01-V01.BC.
```

Here are the commands to copy the SPICE attitude kernel and the file providing the title for the ongoing observation at each time step from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh
```

```
cp ../../ROVIZ/tmp/  
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u005.bc \  
  ../out/ATT-A2-A-01-V01.BC  
cp ../../ROVIZ/tmp/  
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u005.dat \  
  ../out/OBS-A2-A-01-V01.DAT
```

```
%END FILE
```

The ROVIS file name contains (almost) all information about the parameters and boundary conditions used to generate the file, cf. chapter B.

Like before, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh
```

```
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \  
  ../out/ATT-A2-A-01-V01.BC \  
> brief8.txt
```

```
%END FILE
```

The information returned by the SPICE ckbrief tool is:

```
CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064
```

```
Summary for: ../out/ATT-A2-A-01-V01.BC
```

```
Object: -226000
```

```
Interval Begin UTC          Interval End UTC          AV
```

```
-----  
2014-DEC-15 00:00:00.000 2015-JAN-14 23:59:59.999 N
```

2.3 Period A3

This period lasts from 2015-1-15 to 2015-2-15.

2.3.1 Orbit A3-A

The name of the orbit kernel is

```
ORB-A3-A-V01.BSP.
```

The trajectory is a circular orbit with 10 km radius and 20° tilt from the terminator. The direction of the tilt is chosen so that a co-rotational fly-by started directly from this orbit has the closest approach as close as possible to the subsolar point.

We have comet outgassing models for minimum and maximum comet activity at 1.3 AU, 2.0 AU, and 3.0 AU. Phase A3 is closer to 2.0 AU than to 3.0 AU, so in a first try the model for maximum activity at 2.0 AU was used. However, it turned out that the orbit would be very unstable and require active maintenance. Therefore, the model for minimum comet activity at 2.0 AU was used, which yields a fairly stable orbit.

These are the commands to copy the orbit files (SPICE kernel and MAPPS ASCII files), the coverage table, and the orbit definition file from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/roviz_t083_p078_c014_s005_g006_r003_a4_v006.bsp \
  ../out/ORB-A3-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_ros.asc \
  ../out/ORB-A3-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_rel.asc \
  ../out/ORB-A3-A-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_cov.dat \
  ../out/COV-A3-A-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_def.dat \
  ../out/DEF-A3-A-V01.DAT
```

```
%END FILE
```

The ROVIS file name contains (almost) all information about the parameters and boundary conditions used to generate the orbit, cf. chapter B.

We also create a command to check the actual time coverage of the copied SPICE kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
```

```
../out/ORB-A3-A-V01.BSP \  
> brief9.txt
```

%END FILE

The information returned by the SPICE brief tool is:

BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064

Summary for: ../out/ORB-A3-A-V01.BSP

Body: ROSETTA (-226)

| Start of Interval (UTC) | End of Interval (UTC) |
|-----------------------------------|-----------------------------------|
| ----- 2015-JAN-15 00:00:00.000 | ----- 2015-FEB-14 23:59:59.999 |

2.3.1.1 The default nadir pointing attitude

The name of the attitude kernel is

ATT-A3-A-00-V01.BC.

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh  
  
cp ../../ROVIZ/tmp/  
roviz_t083_p078_c014_s005_g006_r003_a4_v006_u002.bc \  
  ../out/ATT-A3-A-00-V01.BC  
  
%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh  
  
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
  /home/bgrieger/SUN/SPICE/lsc/naif0009.tls \  
  ../out/ATT-A3-A-00-V01.BC \  
> brief10.txt
```

%END FILE

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A3-A-00-V01.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|------|
| ----- | ----- | ---- |
| 2015-JAN-15 00:00:00.000 | 2015-FEB-14 23:59:59.999 | N |

2.3.2 Orbit A3-B

Version V02 This version covers the complete time period and comprises the return to the orbit after the flyby.

The name of the orbit kernel is

ORB-A3-B-V02.BSP.

The trajectory starts on the same orbit as A3-A. After three revolutions, when the SC is about to cross the comet equator plane ascending, it is launched into a co-rotational fly-by with closest approach distance 7.5 km (from comet center). The fly-by continues out to a distance of 75 km. Then it returns to the orbit in an arc which takes about ten days. This low-speed return arc does not go over the subsolar point (as was first envisaged), but instead is as close as possible to the terminator plane, avoiding the active day side area of the comet. Before the start of the fly-by and after return to the orbit, the trajectory is identical with A3-A.

These are the commands to copy the orbit files (SPICE kernel and MAPPs ASCII files), the coverage table, and the orbit definition file from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/roviz_2012-0817-1213.bsp \
  ../out/ORB-A3-B-V02.BSP
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_ros.asc \
  ../out/ORB-A3-B-V02.ASC
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_rel.asc \
  ../out/ORB-A3-B-V02.ORPR
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_cov.dat \
  ../out/COV-A3-B-V02.DAT
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_def.dat \
  ../out/DEF-A3-B-V02.DAT
```

%END FILE

Here the ROVIS file name gives just the creation date of the trajectory. It

does not contain references to the parameters of the trajectory because this trajectory was merged from four SPICE kernels for the segments separated by a manoeuvre. The four merged kernels were

```
roviz_t083_p078_c014_s005_g006_r003_a4_v006.bsp
roviz_t084_p079_c014_s005_g006_r003_a4_v006.bsp
roviz_t088_p080_c014_s005_g006_r003_a4_v006.bsp
roviz_t089_p081_c014_s005_g006_r003_a4_v006.bsp
```

These file names contain (almost) all information about the parameters and boundary conditions used to generate the kernels, cf. chapter B. The four kernels were loaded together and the discontinuities at the joints were smoothed assuming an acceleration of $2 \cdot 10^{-4} \text{ m/s}^2$ for the manoeuvres.

We also create a command to check the actual time coverage of the copied SPICE kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
../out/ORB-A3-B-V02.BSP \
> brief11.txt
```

```
%END FILE
```

The information returned by the SPICE brief tool is:

```
BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064
```

```
Summary for: ../out/ORB-A3-B-V02.BSP
```

```
Body: ROSETTA (-226)
```

| Start of Interval (UTC) | End of Interval (UTC) |
|--------------------------|--------------------------|
| ----- | ----- |
| 2015-JAN-15 00:00:00.000 | 2015-FEB-14 23:59:59.999 |

Version V01 The name of the orbit kernel is

```
ORB-A3-B-V01.BSP.
```

The trajectory starts on the same orbit as A3-A. After three revolutions, when the SC is about to cross the comet equator plane ascending, it is launched into a co-rotational fly-by with closest approach distance 7.5 km (from comet center). The trajectory continues without further manoeuvres out to a distance of about 100 km. This version does not comprise the return to the orbit. It covers only ten days.

These are the commands to copy the orbit files (SPICE kernel and MAPPS ASCII files), the coverage table, and the orbit definition file from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh
```

```

cp ../../ROVIZ/tmp/roviz_2012-0807-1318.bsp \
  ../out/ORB-A3-B-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_ros.asc \
  ../out/ORB-A3-B-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_rel.asc \
  ../out/ORB-A3-B-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_cov.dat \
  ../out/COV-A3-B-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_def.dat \
  ../out/DEF-A3-B-V01.DAT

```

%END FILE

Here the ROVIS file name gives just the creation date of the trajectory. It does not contain references to the parameters of the trajectory because this trajectory was merged from two SPICE kernels for the segments separated by a manoeuvre. The two merged kernels were

```

roviz_t083_p078_c014_s005_g006_r003_a4_v006.bsp
roviz_t084_p079_c014_s005_g006_r003_a4_v006.bsp

```

These file names contain (almost) all information about the parameters and boundary conditions used to generate the kernels, cf. chapter B. The two kernels were loaded together and the discontinuity at the joint was smoothed assuming an acceleration of $2 \cdot 10^{-4} \text{ m/s}^2$ for the manoeuvre.

We also create a command to check the actual time coverage of the copied SPICE kernel:

```

%BEGIN FILE copy_kernels.sh
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
../out/ORB-A3-B-V01.BSP \
> brief12.txt

```

%END FILE

The information returned by the SPICE brief tool is:

BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064

Summary for: ../out/ORB-A3-B-V01.BSP

Body: ROSETTA (-226)

Start of Interval (UTC)

End of Interval (UTC)

2015-JAN-15 00:00:00.000

2015-JAN-24 23:59:59.999

2.3.2.1 The default nadir pointing attitude

Version V02 This version belongs to the orbit file

```
ORB-A3-B-V02.BSP.
```

The name of the attitude kernel is

```
ATT-A3-B-00-V02.BC.
```

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_u002.bc \
  ../out/ATT-A3-B-00-V02.BC

%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A3-B-00-V02.BC \
  > brief13.txt

%END FILE
```

The information returned by the SPICE ckbrief tool is:

```
CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064
```

```
Summary for: ../out/ATT-A3-B-00-V02.BC
```

```
Object: -226000
```

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|----|
| 2015-JAN-15 00:00:00.000 | 2015-FEB-14 23:59:59.999 | N |

Version V01 This version belongs to the orbit file

```
ORB-A3-B-V01.BSP.
```

The name of the attitude kernel is

ATT-A3-B-00-V01.BC.

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_u002.bc \
  ../out/ATT-A3-B-00-V01.BC

%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A3-B-00-V01.BC \
  > brief14.txt

%END FILE
```

The information returned by the SPICE ckbrief tool is:

CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064

Summary for: ../out/ATT-A3-B-00-V01.BC

Object: -226000

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|----|
| 2015-JAN-15 00:00:00.000 | 2015-JAN-24 23:59:59.999 | N |

There is also a movie illustrating the co-rotational fly-by with this attitude profile. The movie starts just a few hours before the launch into the fly-by, not at the beginning of A3-B. The name of the moovie file is

MOV-A3-B-00-V01.MPG.

This movie shows the external view and the WAC view side by side. The points of interest as introduced by Eberhard Gruen are marked on the comet surface.

Chapter 3

Second chunk of trajectories

This chunk of trajectories covers the time from 2015-3-15 to 2015-7-15. The due date for the request to FD is 2014-11-15.

3.1 Period B1

This period lasts from 2015-3-15 to 2015-4-15.

3.1.1 Orbit B1-A

The name of the orbit kernel is

```
ORB-B1-A-V01.BSP.
```

The trajectory is a fly-by with a closet approach of 7.5 km (from comet centre) starting from 350 km distance with a velocity of 1 m/s. The trajectory is first targeted to a fly-by distance of 20 km. At 12 hours before CAP, a manoeuvre retargets to the actual fly-by distance of 7.5 km. After the fly-by, when a distance of 350 km is reached, a second manoeuvre stops the SC and lets it slowly drift toward the terminator plane.

These are the commands to copy the orbit files (SPICE kernel and MAPPS ASCII file) from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/roviz_2011-1028-1315.bsp \
  ../out/ORB-B1-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_ros.asc \
  ../out/ORB-B1-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_rel.asc \
  ../out/ORB-B1-A-V01.ORPR
```

```
%END FILE
```

Here the ROVIS file name gives just the creation date of the trajectory. It does not contain references to the parameters of the trajectory because this

trajectory was merged from three SPICE kernels for the segments separated by the manoeuvres. The three merged kernels were

```
roviz_t057_p068_c015_s001_g006_r001_a6_v006.bsp
roviz_t060_p069_c015_s001_g006_r001_a5_v006.bsp
roviz_t061_p070_c015_s001_g006_r001_a6_v006.bsp
```

These file names contains (almost) all information about the parameters and boundary conditions used to generate the kernels, cf. chapter B.

We also create a command to check the actual time coverage of the copied SPICE kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
../out/ORB-B1-A-V01.BSP \
> brief15.txt

%END FILE
```

The information returned by the SPICE brief tool is:

```
BRIEF -- Version 3.0.0, January 14, 2008 -- Toolkit Version N0064
```

```
Summary for: ../out/ORB-B1-A-V01.BSP
```

```
Body: ROSETTA (-226)
```

| Start of Interval (UTC) | End of Interval (UTC) |
|--------------------------|--------------------------|
| ----- | ----- |
| 2015-MAR-27 22:30:00.000 | 2015-APR-11 23:55:00.000 |

These are the commands to copy the coverage table from ROVIS to the appropriate names:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_cov.dat \
../out/COV-B1-A-V01.DAT
cp ../../ROVIZ/out/\
coverage_table_flyby1.dat \
../out/COV-B1-A-V02.DAT

%END FILE
```

There are two versions of the coverage table. Version V01 was computed using the comet shape model and rotation axis of the reference model described in RO-ESC-TN-5566 as of 2012-Mar-30. Version V02 was based on the older shape model and rotation axis and corresponds to the version that had previously been distributed by e-mail, before this BONES directory was available and the current naming convention was in place.

3.1.1.1 The default nadir pointing attitude

The name of the attitude kernel is

```
ATT-B1-A-00-V01.BC.
```

This attitude is defined by VIRTIS-H pointing nadir and power optimized roll angle. Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_u002.bc \
  ../out/ATT-B1-A-00-V01.BC

%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-B1-A-00-V01.BC \
  > brief16.txt

%END FILE
```

The information returned by the SPICE ckbrief tool is:

```
CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064
```

```
Summary for: ../out/ATT-B1-A-00-V01.BC
```

```
Object: -226000
  Interval Begin UTC      Interval End UTC      AV
  -----
  2015-MAR-27 22:30:00.000 2015-APR-11 23:55:00.000 N
```

3.1.1.2 Attitude profile as provided by MK on 2012-01-25

The name of the attitude kernel is

```
ATT-B1-A-01-V01.BC.
```

This is referred to as the “best compromise” attitude profile.

The attitude file provided contained gaps between pointings. The file was interpolated by using only the pointing directions implied by the attitudes,

interpolating these directions, and then applying a power optimised roll angle. In this way, soft slews with power optimised attitude were obtained.

Here is the command to copy the SPICE attitude kernel from ROVIS to the appropriate name:

```
%BEGIN FILE copy_kernels.sh

cp ../../ROVIZ/tmp/\  
roviz_2011-1028-1315_u000_DEBUGGED.bc \  
  ../out/ATT-B1-A-01-V01.BC

%END FILE
```

Like for the orbit kernel, we create a command to check the actual time coverage of the copied attitude kernel:

```
%BEGIN FILE copy_kernels.sh

/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \  
  ../../ROVIZ/tmp/ros_triv.tsc \  
  /home/bgrieger/SUN/SPICE/lsc/naif0009.tls \  
  ../out/ATT-B1-A-01-V01.BC \  
  > brief17.txt

%END FILE
```

The information returned by the SPICE ckbrief tool is:

```
CKBRIEF -- Version 5.0.0, February 11, 2009 -- Toolkit Version N0064
```

```
Summary for: ../out/ATT-B1-A-01-V01.BC
```

```
Object: -226000
```

| Interval Begin UTC | Interval End UTC | AV |
|--------------------------|--------------------------|-------|
| ----- | ----- | ----- |
| 2015-MAR-27 23:00:00.000 | 2015-APR-11 23:49:00.000 | N |

Appendix A

Script used to copy the files

Here we list the actual script with all commands to copy files from ROVIS and to get kernel information. This script is created from this document and is just a collection of all the copy, brief, and ckbrief commands defined above:

```
cp ../../ROVIZ/tmp/roviz_t074_p075_c021_s004_g006_r003_a4_v006.bsp \
  ../out/ORB-A1-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_ros.asc \
  ../out/ORB-A1-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_rel.asc \
  ../out/ORB-A1-A-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_fixed.asc \
  ../out/ORB-A1-A-V01.RCF
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_cov.dat \
  ../out/COV-A1-A-V01.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ORB-A1-A-V01.BSP \
> brief1.txt
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u002.bc \
  ../out/ATT-A1-A-00-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
/home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A1-A-00-V01.BC \
> brief2.txt
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.bc \
  ../out/ATT-A1-A-01-V03.BC
cp ../../ROVIZ/tmp/\
```

```

roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.dat \
  ../out/OBS-A1-A-01-V03.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A1-A-01-V03.BC \
  > brief3.txt
# cp ../../ROVIZ/tmp/\
# roviz_t074_p075_c021_s004_g006_r003_a4_v006_u005.bc \
#   ../out/ATT-A1-A-01-V02.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A1-A-01-V02.BC \
  > brief4.txt
cp ../../ROVIZ/tmp/\
roviz_t074_p075_c021_s004_g006_r003_a4_v006_u004.bc \
  ../out/ATT-A1-A-01-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A1-A-01-V01.BC \
  > brief5.txt
cp ../../ROVIZ/tmp/roviz_t078_p077_c021_s005_g006_r003_a4_v006.bsp \
  ../out/ORB-A2-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_ros.asc \
  ../out/ORB-A2-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_rel.asc \
  ../out/ORB-A2-A-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_cov.dat \
  ../out/COV-A2-A-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_def.dat \
  ../out/DEF-A2-A-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_forward.bsp \
  ../out/ORB-A2-A-V01_FORWARD.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_backward.bsp \
  ../out/ORB-A2-A-V01_BACKWARD.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_left.bsp \
  ../out/ORB-A2-A-V01_LEFT.BSP
cp ../../ROVIZ/tmp/\

```

```

roviz_t078_p077_c021_s005_g006_r003_a4_v006_right.bsp \
  ../out/ORB-A2-A-V01_RIGHT.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_up.bsp \
  ../out/ORB-A2-A-V01_UP.BSP
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_down.bsp \
  ../out/ORB-A2-A-V01_DOWN.BSP
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
  ../out/ORB-A2-A-V01.BSP \
> brief6.txt
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u002.bc \
  ../out/ATT-A2-A-00-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
  ../out/ATT-A2-A-00-V01.BC \
> brief7.txt
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u005.bc \
  ../out/ATT-A2-A-01-V01.BC
cp ../../ROVIZ/tmp/\
roviz_t078_p077_c021_s005_g006_r003_a4_v006_u005.dat \
  ../out/OBS-A2-A-01-V01.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
  ../out/ATT-A2-A-01-V01.BC \
> brief8.txt
cp ../../ROVIZ/tmp/roviz_t083_p078_c014_s005_g006_r003_a4_v006.bsp \
  ../out/ORB-A3-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_ros.asc \
  ../out/ORB-A3-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_rel.asc \
  ../out/ORB-A3-A-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_cov.dat \
  ../out/COV-A3-A-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_def.dat \
  ../out/DEF-A3-A-V01.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \

```

```

    ../out/ORB-A3-A-V01.BSP \
> brief9.txt
cp ../../ROVIZ/tmp/\
roviz_t083_p078_c014_s005_g006_r003_a4_v006_u002.bc \
    ../out/ATT-A3-A-00-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
    ../../ROVIZ/tmp/ros_triv.tsc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
    ../out/ATT-A3-A-00-V01.BC \
> brief10.txt
cp ../../ROVIZ/tmp/roviz_2012-0817-1213.bsp \
    ../out/ORB-A3-B-V02.BSP
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_ros.asc \
    ../out/ORB-A3-B-V02.ASC
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_rel.asc \
    ../out/ORB-A3-B-V02.ORPR
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_cov.dat \
    ../out/COV-A3-B-V02.DAT
cp ../../ROVIZ/tmp/\
roviz_2012-0817-1213_def.dat \
    ../out/DEF-A3-B-V02.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
    ../out/ORB-A3-B-V02.BSP \
> brief11.txt
cp ../../ROVIZ/tmp/roviz_2012-0807-1318.bsp \
    ../out/ORB-A3-B-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_ros.asc \
    ../out/ORB-A3-B-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_rel.asc \
    ../out/ORB-A3-B-V01.ORPR
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_cov.dat \
    ../out/COV-A3-B-V01.DAT
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_def.dat \
    ../out/DEF-A3-B-V01.DAT
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
/home/bgrieger/SUN/SPICE/lisk/naif0009.tls \
    ../out/ORB-A3-B-V01.BSP \
> brief12.txt
cp ../../ROVIZ/tmp/\

```

```

roviz_2012-0817-1213_u002.bc \
  ../out/ATT-A3-B-00-V02.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A3-B-00-V02.BC \
  > brief13.txt
cp ../../ROVIZ/tmp/\
roviz_2012-0807-1318_u002.bc \
  ../out/ATT-A3-B-00-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-A3-B-00-V01.BC \
  > brief14.txt
cp ../../ROVIZ/tmp/roviz_2011-1028-1315.bsp \
  ../out/ORB-B1-A-V01.BSP
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_ros.asc \
  ../out/ORB-B1-A-V01.ASC
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_rel.asc \
  ../out/ORB-B1-A-V01.ORPR
/home/bgrieger/SUN/FORTRAN/toolkit/exe/brief -utc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ORB-B1-A-V01.BSP \
  > brief15.txt
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_cov.dat \
  ../out/COV-B1-A-V01.DAT
cp ../../ROVIZ/out/\
coverage_table_flyby1.dat \
  ../out/COV-B1-A-V02.DAT
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_u002.bc \
  ../out/ATT-B1-A-00-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \
  ../out/ATT-B1-A-00-V01.BC \
  > brief16.txt
cp ../../ROVIZ/tmp/\
roviz_2011-1028-1315_u000_DEBUGGED.bc \
  ../out/ATT-B1-A-01-V01.BC
/home/bgrieger/SUN/FORTRAN/toolkit/exe/ckbrief -utc \
  ../../ROVIZ/tmp/ros_triv.tsc \
  /home/bgrieger/SUN/SPICE/lsk/naif0009.tls \

```

```
../out/ATT-B1-A-01-V01.BC \  
> brief17.txt
```

Appendix B

Legend to ROVIS file names

The filenames of SPICE kernels created by ROVIZ contain fields separated by underscores. The fields made up of one letter followed by one or more digits reference the indices of the settings in effect. Below is a listing of the meaning of these indices which has automatically been extracted from the source code on Wed Oct 17 09:52:25 CEST 2012.

set_time_range:

```
t = 0 ! Use OEM file
t = 1 ! 10km flyby for testing impact of effects
t = 2 ! 1st 10km orbit
t = 3 ! 2nd 10km orbit
t = 4 ! 1st and 2nd together
t = 5 ! 1st month of phase B
t = 6 ! At ~1.3 AU
t = 7 ! Two weeks from 2014-11-15T00:00:00
t = 8 ! 12 day mapping orbit in 2014-Oct
t = 9 ! Orbit A1
t = 10 ! Orbit A2
t = 11 ! Orbit A3
t = 12 ! Orbit A4
t = 13 ! Orbit A5
t = 14 ! Orbit A6
t = 15 ! Orbit A7
t = 16 ! Orbit A8
t = 17 ! Orbit A9
t = 18 ! Orbit A10
t = 19 ! Orbit A11
t = 20 ! Orbit A12
t = 21 ! Orbit A13
t = 22 ! Orbit A14
t = 23 ! Orbit A15
t = 24 ! Orbit A16
t = 25 ! All orbits Ax
```

t = 26 ! Six weeks from 2014-Dec-01
t = 27 ! Lutetia
t = 28 ! Two weeks from 2014-Dec-01
t = 29 ! Three weeks from 2014-Dec-22
t = 30 ! Compare comet rotation axis with Nico
t = 31 ! Ideal cage Mk II from 2014-Dec-01
t = 32 ! Ideal cage Mk II from 2014-Nov-15
t = 33 ! Free drift after ideal cage
t = 34 ! Ideal cage Mk II from 2014-Nov-15, reverse direction
t = 35 ! Free drift after ideal reverse cage
t = 36 ! Terminator orbits after free drift
t = 37 ! Terminator orbits after 1st expansion
t = 38 ! Terminator orbits after 2nd expansion
t = 39 ! Last two orbits of 35 for movie
t = 40 ! Horse shoe orbit
t = 41 ! Flyby
t = 42 ! 2 month from 2015-Apr-01 (for solar gravitation)
t = 43 ! 1 month from 2015-Apr-01
t = 44 ! 2 weeks from 2015-Apr-01
t = 46 ! Flyby ref. point p051, coma model c014
t = 47 ! Flyby ref. point p052, coma model c015
t = 48 ! Flyby ref. point p052, coma model c014
t = 49 ! Quasi-geostationary flyby ref. point p053, coma model c014
t = 50 ! Like t=49, with smaller time range and step for movie
t = 51 ! Flyby at 1.3 AU, ref. point p054, coma model c016
t = 52 ! Flyby at 1.3 AU, ref. point p055, coma model c016
t = 53 ! 2015-Jul-15 +/- 1 week
t = 54 ! 2015-Apr-01 +/- 1 week
t = 55 ! Two weeks around perihel
t = 56 ! From 2015-Mar-15
t = 58 ! CAP at 2015-Apr-01, from -12 hours to +4 days
t = 61 ! CAP at 2015-Apr-01, from ~ +4 days to +11 days
t = 62 ! t=57, t=60, and t=61
t = 63 ! CAP at 2015-Apr-01, +- 2 days
t = 64 ! CAP at 2015-Apr-01, +- 12 h, slow motion
t = 65 ! Attitude file by MK
t = 66 ! Two month around perihel (icosahedra without flybys)
t = 67 ! Coverage of comet SPK
t = 68 ! Two month around perihel (icosahedra with flybys)
t = 69 ! Cut out of 62, for comparison with Bernhard
t = 70 ! Time range of example dust computation
t = 71 ! Time of Alice great circle scan
t = 72 ! Two month from 2014-Dec-01 for Phase A orbit preview
t = 73 ! Close approach trajectory, no nutation case
t = 74 ! One month from 2014-Nov-15 for Phase A orbit
t = 75 ! Flyby 6 hours around CAP for compatison with DF server
t = 76 ! Part of A1-A orbit for testing MAPPS attitude file

t = 77 ! Attitude file by MK, tail cut off to fit in sequencer
t = 78 ! One month from 2014-Dec-15 for Phase A2 orbit
t = 79 ! Like t = 74, but smaller (1 min) time step
t = 80 ! Like t = 79, but even smaller time step and cut out
t = 81 ! Like t = 74, but 30 sec time step
t = 82 ! Like t = 78, but 30 sec time step
t = 83 ! One month from 2015-Jan-01 for Phase A3 orbit
t = 84 ! Flyby starting from A3-A orbit over equator
t = 85 ! From start of t=83 to end of t=84
t = 86 ! For 11nov kernels from FD
t = 87 ! Like t=86, but later start when already close to comet
t = 88 ! From end of fly-by to end of leg 2 of return to orbit
t = 89 ! Leg 1 of return to orbit
t = 90 ! Wake-up and SC Commissioning
t = 91 ! PL Commissioning
t = 92 ! NCD (Near Comet Drift)
t = 93 ! FAT (Far Approach Trajectory)
t = 94 ! CAT (Close Approach Trajectory), Comet Characterisation and TG
t = 95 ! GMP (Global Mapping Phase)
t = 96 ! COP (Close Observation Phase)
t = 97 ! Lander Delivery and FSS (First Science Sequence)
t = 98 ! A1, A2, A3
t = 99 ! CAP at 2015-Apr-01, from ~ -4 days to +5 days
t = 100 ! Like t=68 but only ~2nd month, 1 fly-by
t = 101 ! For nadir attitude file from Albrecht
t = 102 ! For scan PTR from Albrecht
t = 103 ! Like t=86, but just end of GMP and beginning of COP
t = 104 ! Complete Phase A (preliminarily shorter)

set_trajectory_ref_point:

p = 0 ! From OEM file or analytical trajectory
p = 1 ! Sub solar point, 10 km, escape velocity in orbit plane
p = 2 ! Start point of t001_p001_s1_r1_c1_v001
p = 3 ! Start point of 1st 10km orbit
p = 4 ! Start point of 2nd 10km orbit
p = 5 ! Sub solar point, 10 km, escape velocity normal to orbit plane
p = 6 ! Anti solar point, 10 km, escape velocity normal to orbit plane
p = 7 ! Sub solar point, 10 km, kepler velocity normal, 2015-Jul-01
p = 8 ! Sub solar point, 10 km, kepler velocity normal, 2014-Nov-15
p = 9 ! Sub solar point, 5 km, kepler velocity normal, 2014-Nov-15
p = 10 ! Anti solar point, 7.5 km, elliptical, velocity normal
p = 11 ! Like p=10, but tilted by 30 deg (60 deg from terminator)
p = 12 ! Like p=11, but circular
p = 13 ! Like p=9, but reverse direction
p = 14 ! 12 day mapping orbit around 2014-Oct-15
p = 15 ! Terminator orbit for comparison with p=14
p = 16 ! Test of coma model grid

p = 17 ! Orbit A1
p = 18 ! Orbit A2
p = 19 ! Orbit A3
p = 20 ! Orbit A4
p = 21 ! Orbit A5
p = 22 ! Orbit A6
p = 23 ! Orbit A7
p = 24 ! Orbit A8
p = 25 ! Orbit A9
p = 26 ! Orbit A10
p = 27 ! Orbit A11
p = 28 ! Orbit A12
p = 29 ! Orbit A13
p = 30 ! Orbit A14
p = 31 ! Orbit A15
p = 32 ! Orbit A16
p = 33 ! 6 weeks blind flight, 20 x 7.5 km, no maneuvers
p = 34 ! 6 weeks blind flight, 20 x 20 km, no maneuvers
p = 35 ! 6 weeks blind flight, 10 x 10 km, no maneuvers (CRASH!!!)
p = 36 ! Lutetia 1
p = 37 ! Lutetia 2
p = 38 ! Start 2014-Dec-01, polar orbit 7.5 x 7.5
p = 39 ! Start 2014-Dec-22, something with maximum drift
p = 40 ! Free drift after ideal cate
p = 41 ! Free drift after ideal reverse cate
p = 42 ! Terminator orbits after free drift
p = 43 ! 25 km Terminator orbits after 1st expansion
p = 44 ! 40 km Terminator orbits after 2nd expansion
p = 45 ! Horse shoe orbit
p = 46 ! Fly by
p = 47 ! Very elliptical for solar force
p = 48 ! Free drift at 2 AU
p = 49 ! 7.5 km terminator orbit
p = 50 ! 7.5 km tilted orbit
p = 51 ! Fly by at 7.5 km with 1 m/s
p = 52 ! Fly by at 80 km with 1 m/s
p = 53 ! Quasi-geostationary flyby at 7.5 km
p = 54 ! 1.3 AU, fly by at 7.5 km with 1 m/s
p = 55 ! 1.3 AU, fly by at 80 km with 1 m/s
p = 56 ! 1.3 AU, fly by at 20 km with 1 m/s
p = 57 ! 1.3 AU, fly by at 30 km with 1 m/s
p = 58 ! 1.3 AU, fly by at 50 km with 1 m/s
p = 59 ! 1.3 AU, fly by at 7.5 km with 2 m/s
p = 60 ! 2.0 AU, fly by at 20 km with 1 m/s
p = 61 ! 2.0 AU, fly by at 30 km with 1 m/s
p = 62 ! 2.0 AU, fly by at 50 km with 1 m/s
p = 63 ! Perihel, fly by at 7.5 km with 1 m/s

p = 64 ! Chunk on the surface
p = 65 ! 2.0 AU, Fly by at 100 km with 1 m/s
p = 66 ! 1.3 AU, Fly by at 100 km with 1 m/s
p = 67 ! 2.0 AU, Fly by at 7.5 km with navigation, 1st part, backward
p = 68 ! 2.0 AU, Fly by at 7.5 km with navigation, 1st part, forward
p = 69 ! 2.0 AU, Fly by at 7.5 km with navigation, 2nd part
p = 70 ! 2.0 AU, Fly by at 7.5 km with navigation, 3rd part
p = 71 ! Preliminary version of 72 with interpretation error
p = 72 ! 2.0 AU, Fly by at 7.5 km with navigation, 2nd part with nav err
p = 73 ! Like p=68, but with zero velocity for solar pressure study
p = 74 ! Start with circular terminator orbit at 13 km
p = 75 ! Circular orbit at 10 km with 20 deg tilt as polar as possible
p = 76 ! Equatorial orbit at 10 km for PCK test
p = 77 ! 10 km orbit with 20 deg tilt as equatorial as possible
p = 78 ! 10 km orbit with 20 deg tilt for corotational flyby
p = 79 ! Corotational flyby from orbit
p = 80 ! Return to orbit after flyby, 2nd part
p = 81 ! Return to orbit after flyby, 1st part

set_dsmc_file:

c = 1 ! 3.0 AU, H2O driven, cartesian grid
c = 2 ! 3.0 AU, CO/CO2 driven, cartesian grid
c = 3 ! 2.7 AU, original ISSI case, cartesian grid
c = 4 ! 2.0 AU, original ISSI case, cartesian grid
c = 5 ! 1.3 AU, original ISSI case, cartesian grid
c = 6 ! 3.0 AU, CO/CO2 driven, polar grid
c = 7 ! 3.0 AU, CO/CO2 driven, coarse exponential grid
c = 8 ! 3.3 AU, original ISSI case, cartesian grid
c = 9 ! 3.0 AU, CO/CO2 driven, extra fine cartesian grid
c = 10 ! 3.0 AU, CO/CO2 driven, fine exponential grid
c = 11 ! 2.7 AU, original ISSI case, fine exponential grid
c = 12 ! 2.0 AU, original ISSI case, fine exponential grid
c = 13 ! 2.7 AU, CO/CO2 driven, cartesian grid
c = 14 ! 2.0 AU, minimum activity, fine exponential grid
c = 15 ! 2.0 AU, maximum activity, fine exponential grid
c = 16 ! 1.3 AU, original ISSI case, fine exponential grid
c = 17 ! 2.7 AU, CO/CO2 driven/Jet, fine exponential grid
c = 18 ! 2.7 AU, CO/CO2 driven/Jet, cartesian grid
c = 19 ! 1.3 AU, minimum activity, fine exponential grid
c = 20 ! 1.3 AU, maximum activity, fine exponential grid
c = 21 ! 3.0 AU, maximum activity, fine exponential grid

set_comet_shape_mod:

s = 1
comet mass 1d13 kg
largest axis 5 km
100 grid points along largest axis

```

s = 2
  comet mass 1d13 kg
  largest axis 5 km
  200 grid points along largest axis
s = 3
  comet mass 1.07487142E+13 kg
  largest axis 5.03671074 km
  100 grid points along largest axis
s = 4
  agreed reference model
  comet mass 1.2084E+13 kg
  effective radius 1.907 km
  100 grid points along largest axis
s = 5
  agreed reference model
  comet mass 1.2088E+13 kg to agree with FD
  effective radius 1.907 km
  100 grid points along largest axis
s = 6
  New Lowry shape model

set_gravity_field_dim:
g = 1 ! nlat = 37, nr = 100
g = 2 ! nlat = 73, nr = 200
g = 3 ! nlat = 37, nr = 20
g = 4 ! nlat = 37, nr = 25, half inner radius (for Lutetia)
g = 5 ! nlat = 73, nr = 50, half inner radius (for Lutetia)
g = 6 ! nlat = 73, nr = 200, half inner radius (for chunks)

set_comet_pck:
r = 0 ! V00, wrong.
r = 1 ! V01
r = 2 ! kernel created by ROVIZ based on CNES values
r = 3 ! kernel created by BG based on reference model
r = 4 ! kernel created by BG for bone A1-A-00 to align with ellipsoid

propagate_trajectory:
v = 1
  Version v001 is from 2011-02-15.
v = 2
  Version v002 (2011-02-25):
    + solar radiation pressure also on SC bus (6 m^2)
    + backradiation taken into account by a factor of 1.5
    + gas drag on solar panels completely inelastic
    + gas drag also on SC bus (6 m^2)
    + SC mass now 1500 kg
    + Solar panel area now 64 m^2

```

+ Non-spherical shape of comet taken into account

v = 3
 Version v003 (2011-03-07):
 - SC bus surface area for solar radiation pressure now
 8.95 m⁵ (instead of 6 m²)

v = 4
 Corrected radial interpolation weighting factor error and
 rad/deg error in array index computation for non-spherical
 disturbance.

v = 5
 Version v005 (2011-06-08):
 Now the force contribution of the non-spherical shape is rotated
 back to the reference frame, which had been forgotten erroneously.

v = 6
 Version v006 (2011-08-23):
 If the initial state is provided in a body fixed
 frame, the velocity vector is now transformed to the reference
 frame taking into account the rotation rate of the frame; this
 was commented out for some chunk experiments.
 Solar radiation pressure is switched off when (approximately) in
 shadow.
 Corrected error in impulse flux from coma on backside of comet.

v = 7
 Version v007 (2011-08-23):
 Same as v006, but parameters set for chunks instead of SC.

v = 8
 Version v008 (2011-09-21):
 Same as v006, but non-spherical shape switched off.

v = 9
 Version v009 (2011-10-20):
 Same as v006, but non-spherical shape and coma switched off.

v = 10
 Version v010 (2011-11-17):
 Same as v006, but reduced SC mass for solar pressure study.

v = 11
 Version v011 (2012-05-17):
 Same as v009, but solar gravity and radiation pressure also
 switched off.

v = 0
 No propagation, just pass on input, which may come from
 analytical computation

a (accuracy):
 ve = 10d0*(-a) ! Error growth rate [m/s]

interpol_att:
 u = 0 ! Use interpolated pointings from file (power optimized)

u = 1 ! OSIRIS_NAC pointing nadir
u = 2 ! VIRTIS-H pointing nadir
u = 3 ! Use fully interpolated attitudes from file
u = 4 ! Interpolate blocks directly, but slews power optimized
u = 5 ! Like u=4, but slews only power optimized if no -X illum

Appendix C

Document change record

RCS file: /home/bgrieger/cvs/BONES/src/bones.tex,v

Working file: bones.tex

head: 1.22

branch:

locks: strict

access list:

symbolic names:

keyword substitution: kv

total revisions: 22; selected revisions: 22

description:

revision 1.22

date: 2012/10/17 08:27:35; author: bgrieger; state: Exp; lines: +25 -0
Added in the section on Orbit A2-A a paragraph and the copy commands
for the SPICE orbit kernels with 1 km offset in different directions.

revision 1.21

date: 2012/08/30 11:50:12; author: bgrieger; state: Exp; lines: +10 -1
Copied a recomputed CK (now with 30 seconds time step) to the server
and implemented also copying of the file with the observation titles
for A2-A-01.

revision 1.20

date: 2012/08/30 10:09:26; author: bgrieger; state: Exp; lines: +34 -0
Added the section on the attitude profile A2-A-01.

revision 1.19

date: 2012/08/20 12:59:54; author: bgrieger; state: Exp; lines: +9 -0
Added naming convention for orbit file in body fixed frame and copying
of such file for A1-A.

revision 1.18

date: 2012/08/20 08:48:41; author: bgrieger; state: Exp; lines: +126 -0
Added version V02 of the orbit files and the default attitude file

for A3-B.

revision 1.17

date: 2012/08/13 09:47:23; author: bgrieger; state: Exp; lines: +20 -1
Added a note on the movie MOV-A3-B-00-V01.MPG.

revision 1.16

date: 2012/08/09 15:43:03; author: bgrieger; state: Exp; lines: +110 -0
Added section on A3-B.

revision 1.15

date: 2012/08/08 10:51:47; author: bgrieger; state: Exp; lines: +93 -0
Added section on orbit A3-A.

revision 1.14

date: 2012/08/03 13:40:14; author: bgrieger; state: Exp; lines: +18 -1
Added the naming convention for the orbit definition file and the copying
of the one for Bone A2-A.

revision 1.13

date: 2012/08/01 15:50:32; author: bgrieger; state: Exp; lines: +88 -5
Added another new (bug fixed) version attitude profile, A1-A-01-V03,
including a file with observation titles and a movie. Commented out
the automated copying of the older version to preserve it (avoid
overwriting). Added the naming convention for movies and files with
observation titles.

revision 1.12

date: 2012/07/26 08:59:02; author: bgrieger; state: Exp; lines: +43 -1
Added the new version (bug fixed) attitude profile A1-A-01-V02.

revision 1.11

date: 2012/07/06 08:11:48; author: bgrieger; state: Exp; lines: +26 -1
Added a note on the movie MOV-A1-A-01-V01.MPG.

revision 1.10

date: 2012/07/05 15:36:06; author: bgrieger; state: Exp; lines: +38 -1
Added the section on the attitude profile A1-A-01.

revision 1.9

date: 2012/07/03 10:48:27; author: bgrieger; state: Exp; lines: +21 -3
Added description of comet referenced ASCII orbit file to the naming
convention. Added copying of the comet referenced ASCII orbit file to
the sections on A1-A, A2-A, and B1-A.

revision 1.8

date: 2012/06/04 11:44:06; author: bgrieger; state: Exp; lines: +90 -1

Added section on orbit A2-A.

revision 1.7

date: 2012/05/31 09:28:12; author: bgrieger; state: Exp; lines: +19 -5
Copied the original version of the coverage table for B1-A as version
V02 to the server and documented this.

revision 1.6

date: 2012/05/31 08:00:17; author: bgrieger; state: Exp; lines: +36 -14
Erroneously opened TeX file directly (here prefer to work in src, not
in tmp).

revision 1.5

date: 2012/05/25 12:09:20; author: bgrieger; state: Exp; lines: +151 -6
Added trajectory B1-A.

revision 1.4

date: 2012/05/11 12:57:20; author: bgrieger; state: Exp; lines:
+143 -20
Added to the copy script also the ASCII orbit file for MAPPS. Added
section for the default nadir pointing attitude. Added section on where
to find the ROVIS products. Added copying also the coverage table from
ROVIS. Gave also naming examples for MAPPS orbit files and coverage files.

revision 1.3

date: 2012/05/10 17:07:31; author: bgrieger; state: Exp; lines:
+168 -12
Slightly revised naming convention. Adjusted spacing on title
page. Changed documentclass to report. Moved change record to end of
document. Added section on phases, period, and time. Created chapter
for first chunk of trajectories and implemented automated generation
of names and dates. Wrote section on Bone A1-A. Implemented automated
creation of script to copy kernels. Incorporated a listing of the
resultant script. Incorporated the legend to ROVIS file names. Wrote in
the script also command to get orbit kernel information with brief and
incorporated it in the document.

revision 1.2

date: 2012/05/09 16:50:31; author: bgrieger; state: Exp; lines: +40 -3
Put Jolly Roger on title page and wrote down kernel naming convention.

revision 1.1

date: 2012/05/09 16:02:13; author: bgrieger; state: Exp;
Created CVS project and incorporated automated change record generation
from CVS.

=====