Here's a somewhat definitive guide to importing the PDS MSL NAVCAM data into ArcGIS/ArcMAP by Fred Calef.

PDS images have an ascii header, followed by a raw image/data. To access the data, you need to tell ArcMAP how the image is formated and how many bytes the ascii header is. Reading either the .LBL detached ascii header file or the ascii header in the original file, you need to extract the following image information:

1) rows
2) columns
3) bands
4) bit type (8, 16, 32)
5) pixel type (UNSIGNED_INTEGER, FLOAT)
6) byte order (I or M: Intel or IEEE (little-endian, LSB) or Motorola (big-endian, MSB)
7) pixel layout (bil, bip, bsq)
8) skipbytes (ascii image header size in bytes)

and put it into an ascii file with the same file name and a 'hdr' file type. For example, for NAVCAM image
http://pds-imaging.jpl.nasa.gov/data/msl/MSLNAV_1XXX/DATA/SOL00012/NLA_398561160ILT_F0030004NCAM15000M1.IMG
the header file would look like this, named
NLA_398561160ILT_F0030004NCAM00400M1.HDR:
nrows 1024
ncols 1024
nbands 1
nbits 16
pixeltype UNSIGNEDINT
byteorder M
layout bsq
skipbytes 28672

here's another example for 'XYZ' data (i.e. elevation and location information) for file
http://pds-imaging.jpl.nasa.gov/data/msl/MSLNAV_1XXX/DATA/SOL00012/NLA_398561160XYZ_F0030004NCAM15000M1.IMG, the header file would look like this, named
NLA_398561160XYZ_F0030004NCAM00400M1.HDR:
nrows 1024
ncols 1024

nbands 3
nbits 32
pixeltype FLOAT
byteorder M
layout bsq
skipbytes 32768

Most of this information is accessible at the end of the .LBL file. Here's the label part from above with the pertinent information (~last 30 lines):

/* IMAGE DATA ELEMENTS */

```
OBJECT                      = IMAGE
  INTERCHANGE_FORMAT          = BINARY
  LINES                     = 1024
  LINE_SAMPLES               = 1024
  SAMPLE_TYPE                = MSB_INTEGER
  SAMPLE_BITS                = 16
  BANDS                    = 1
  BAND_STORAGE_TYPE           = BAND_SEQUENTIAL
END_OBJECT                  = IMAGE
```

/* VICAR IMAGE HEADER DATA ELEMENTS */

```
OBJECT                      = IMAGE_HEADER
 HEADER_TYPE               = VICAR2
 INTERCHANGE_FORMAT            = ASCII
 BYTES                   = 16384
 ^DESCRIPTION               = "VICAR2.TXT"
END_OBJECT                  = IMAGE_HEADER
```

/* ODL IMAGE HEADER DATA ELEMENTS */

```
OBJECT                      = ODL_HEADER
 HEADER_TYPE                = ODL
 INTERCHANGE_FORMAT            = ASCII
 BYTES                   = 28672
 ^DESCRIPTION                = "ODL.TXT"
END_OBJECT                  = ODL_HEADER
END
```

The appropriate metadata is fairly obvious, though it's not entirely clear whether MSB_INTEGER is signed or unsigned, though you can

check the MSL Engineering Camera SIS (software interface specification) on the PDS. You can also extract the 'skipbytes' size from multiplying 'RECORD_BYTES' (line 6) times 'LABEL_RECORDS' (line 8) and get the same number as 'BYTES' in the 'ODL IMAGE HEADER DATA ELEMENTS' section. The skipbytes number is not constant and must be calculated/extracted for each image, though appears to be consistent with image products for one NAVCAM pair with the same pixeltype. While the 'SAMPLE_TYPE' has 'MSB' in the field, it doesn't necessarily refer to the byteorder. However, MSL NAVCAM products appear to be Motorola (MSB) byteorder.

If you want the visible part of the NAVCAM, you need the file with 'ILT_' (raw), 'ILTL' (linearized), or 'RAD_' (radiometrically corrected, raw), or 'RADL' (radiometrically corrected, linearized) in the file name (letters 14-17 from the left). The corresponding location data in site frame is 'XYZ_' (raw) or 'XYZL' (linearized). 'Radiometrically corrected' means the image has been modified to enhance clarity and remove camera artifacts (see the SIS for specifics). 'Linearized' means the lens distortion has been removed and straight lines appear straight; for example, the horizon. If you choose 'ILT_' or 'RAD_', you must use the 'XYZ_' data, otherwise the image won't match the elevation data. Be careful with the bands/columns that you use as XYZ is in a right-handed coordinate system. Compared to a Cartesian Coordinate system, the NAVCAM data maps as YX(-Z); i.e. 'Y' is the X-axis, 'X' is the Y-axis and 'Z' is inverted.

Your best option is to wirte
Now you have the visible(ILT/RAD) and spatial (XYZ) data aligned and are able to view it in ArcMAP by adding it in like any other data. Since the row/column in the visible and spatial data correspond, you can extract the 'visible' image value and equivalent 'spatial' XYZ value to make this data into a mapping layer like a digital elevation model (DEM) or orthophoto. Here are the steps I used in ArcMAP to make an orthophoto and DEM from the above NAVCAM data:

*Most steps here are using ArcTools inside ArcMAP.
1) Convert the ILT or RAW data to points using "Raster to Point".
2) Add the XYZ values to the points using "Extract Multi Values to Points". Make sure to select each band in the XYZ image file.
3) Remove bad values. Use 'Select by Attributes' to remove cases where the 'Y' and 'Z' data are zero indicating no stereo correlation. There are several methods to remove bad values; this is one.
4) Map the XYZ data. One way is to convert it to an 'Event' layer using 'Make XY Event Layer'; again, several ways to do this. A cleaner way

might be 'ASCII 3D to Feature Class', but requires a 3D Analyst extension.
5) Interpolate the 'visible' data and/or 'elevation' data to a raster layer. If you have Spatial or 3D Analyst, use one of the various tools in the 'Interpolation' toolbox like 'Natural Neighbor'.

*Many of the above steps could probably be done or automated in ArcMAP using Model Builder or Python. Not to mention, some of this could be translated into GDAL commands for an open source solution.