THERMAL-INFRARED IMAGER TIR ON HAYABUSA-2: THEMAL PROPERTIES OF C-CLASS ASTEROID 1999JU3. T. Okada[1], T. Fukuhara[2], S. Tanaka[1], M. Taguchi[3], R. Nakamura[4], T. Sekiguchi[5], S. Hasegawa[1], Y. Ogawa[6], K. Kitazato[6], T. Matsunaga[7], T. Imamura[1], T. Wada[1], T. Arai[8], Y. Yamamoto[1], R. Takaki[1], S. Tachikawa[1], J. Helbert[9], T. Mueller[10], A. Hagermann[11], and Hayabusa2 Thermal-Infrared Imager (TIR) Team, [1]Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Sagamihara, Chuo-Ku, Kanagawa 252-5210, Japan, okada@planeta.sci.isas.jaxa.jp), [2]Hokkaido University, Japan, [3]Rikkyo University, Tokyo, [4]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, [5]Hokkaido University of Education, Asahikawa, Japan, [6]CAIST, University of Aizu, Aizu-Wakamatsu, Japan, [7]National Institute of Environmental Studies (NIES), Tsukuba, Japan, [8]National Astronomical Observatory of Japan (NAOJ), Mitaka, Tokyo, [9]Institute of Planetary Research, DLR, Berlin, [10]Max-Planck Institute for Extraterrestrial Physics, Garching, Germany, [11]The Open University, Milton Keynes, UK.

Introduction: Thermal-infrared imager TIR is a remote seising instrument on Hayabusa2 for thermal emission mapping of a C-class NEA 1999JU3. TIR observation is not only for scientific investigation of asteroid physical properties, but also for assessment of landing site selection and safety descent operation.

Hayabusa2 Mission: Hayabusa2 is the follow-on mission after Hayabusa that conducted the first asteroid sample-return in 2010. Returned samples have been investigated as initial analysis and now open to any scientists interested via international announce of opportunity. Hayabusa2 is designed after Hayabusa with some repairments and redesigns to achieve more exciting, optimizing mission. Hayabusa2 is primarily a sample-return mission, but remote sensing near-by the asteroid also has strong significance to understand the nature of asteroid, complementary to returned samples. Active impact experiment using SCI (Small Carry-on Impactor) is added to form a small crater to investigate asteroid physical properties and composition of the uppermost layer through optical and thermal imagery.

TIR Imager: In Hayabusa2, a mid-infrared thermal emission imager is to image the surface temperature profile and its temporal variation by asteroid rotation. Thermal mapper called LIR (Long-wavelength Infrared Camera) is carried on Akatsuki, renamed from Planet-C Venus climate orbiter, which was originally a commertial base but applied for mapping the moving clouds of Venus at the temperature range of 220-250K. LIR is expected to be used for thermal emission off the surface of asteroid in the mid-infrared wavelength. We have decided to use this helitage of LIR because of short-term development for Hayabusa2.

TIR adopts a non-cooled bolometer array NEC 320A with 320 x 240 effective pixels. Function of digital electronics is basically the same as that of LIR with some updates. Onboard analysis such as summation of multiple images, substraction of dark images, treatment of dead pixels, and data compression can be done in the DE (Digital Electronics). Characteric performace of TIR is shown in Table 1.

Science Objectives of TIR: We know little about asteroid 1999JU3 but it is possibly something like C-class asteroid 253 Mathilde with low density and huge craters, or like a small asteroid 25143 Itokawa with rubble-pile structure and huge boulders on its surface.

To investigate the nature of asteroid and its formation processes, physical properties of boulders or materials inside huge crates are most important to observe by TIR. Yarkovsky or YORP effects are hot topics in asteroid science and possibly evidenced by TIR observation and the future change of asteroid trajectory and rotation. If the orbiting satellites exist, asteroid mass is presicely determined. The surface and subsurface conditions will be measured at the active impact experiments by SCI and by impact sampling. Other kinds of geology and geophysical measurements will be conducted through thermal imagery with TIR.

Other Objectives of TIR: We should know the surface conditions in advance for sampling site selection. Thermal intertia is an essential data to determine sampling sites. Areas covered with pebbles are recommended due to potential importance for petrologic study and for materials gathered throughout the asteroid. Areas with potentially harzardous rocks should be avoided. Safety assessment for descent operation is much important. Thermal model of asteroid will be reconstructed using TIR data and reanalysis of descent sequence will be done prior to touchdown operation.

Table 1: Characteric Performance of TIR

Mass	3.3 kg
Power	22W (nominal)
Detector	non-cooled bolometer
Pixels (effective)	320 x 240
FOV	±8° x ±6°
IFOV	0.877 mrad
MTF(@nyquist freq.)	> 0.3
Temp. range	250 – 400 K
NETD	< 0.5K (@350K)
Absolute T resolution	< 5K (@350K)
ADC	12 Bit
Data Size	0.15MB/image
Temperature Calibration	Shutter Open/Close