Examples of NAOJ's Engineering Tasks in International Project: Case of Telescope Structure of Thirty Meter Telescope

Sugimoto, Masahiro
NAOJ TMT Project

Contents

- ✓ Introduction of TMT Structure (STR)
  - ➢ Workshare of NAOJ in TMT, Status/history of STR, Highlight of STR design
- ✓ Challenges and Key Contributions of NAOJ staffs to STRs
  - ➢ Organization of STR and NAOJ's member roles, Challenges to proceed the project, Contribution of NAOJ

Contents

- ✓ Introduction of TMT Structure (STR)
  - ➢ Workshare of NAOJ in TMT, Status/history of STR, Highlight of STR design
- ✓ Challenges and Key Contributions of NAOJ staffs to STRs
  - ➢ Organization of STR and NAOJ's member roles, Challenges to proceed the project, Contribution of NAOJ

TMT Thirty Meter Telescope

Members' contributions

NAOJ National Astronomical Observatory of Japan

Telescope

Enclosure

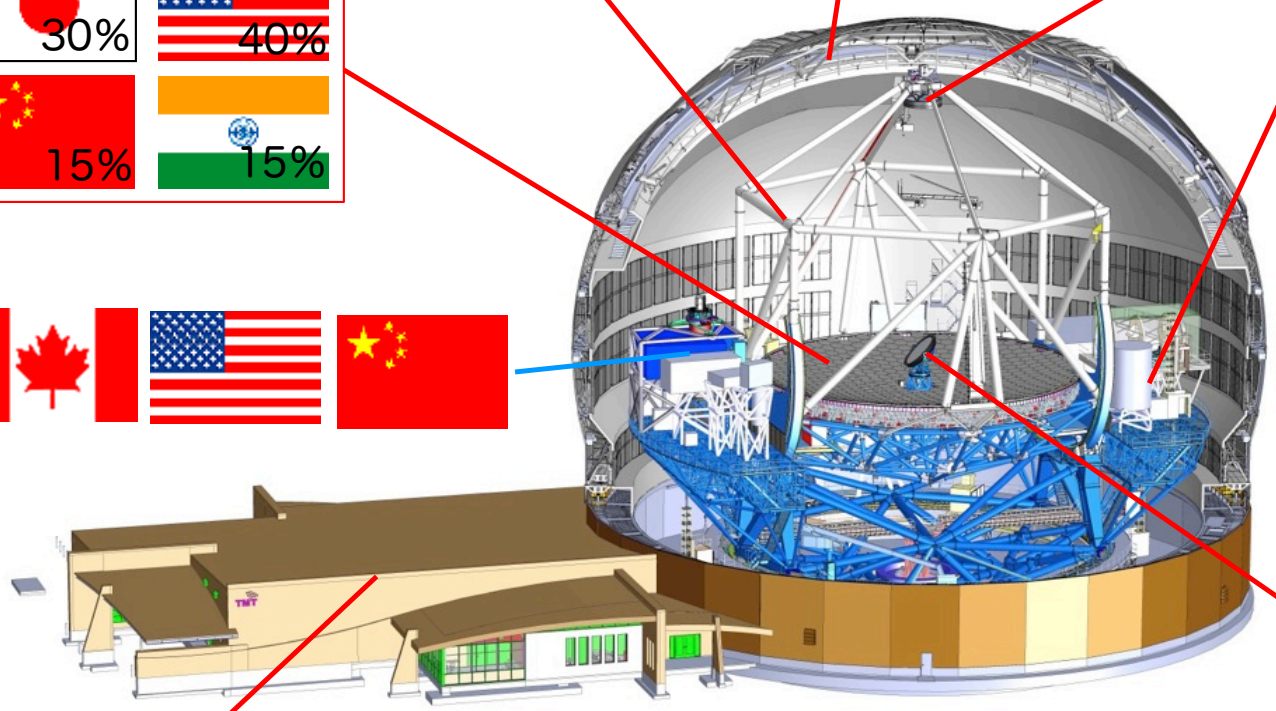
M2

M1 blank

M1 polish 30% 40% 15% 15%

Instruments

AO



M3

Facility

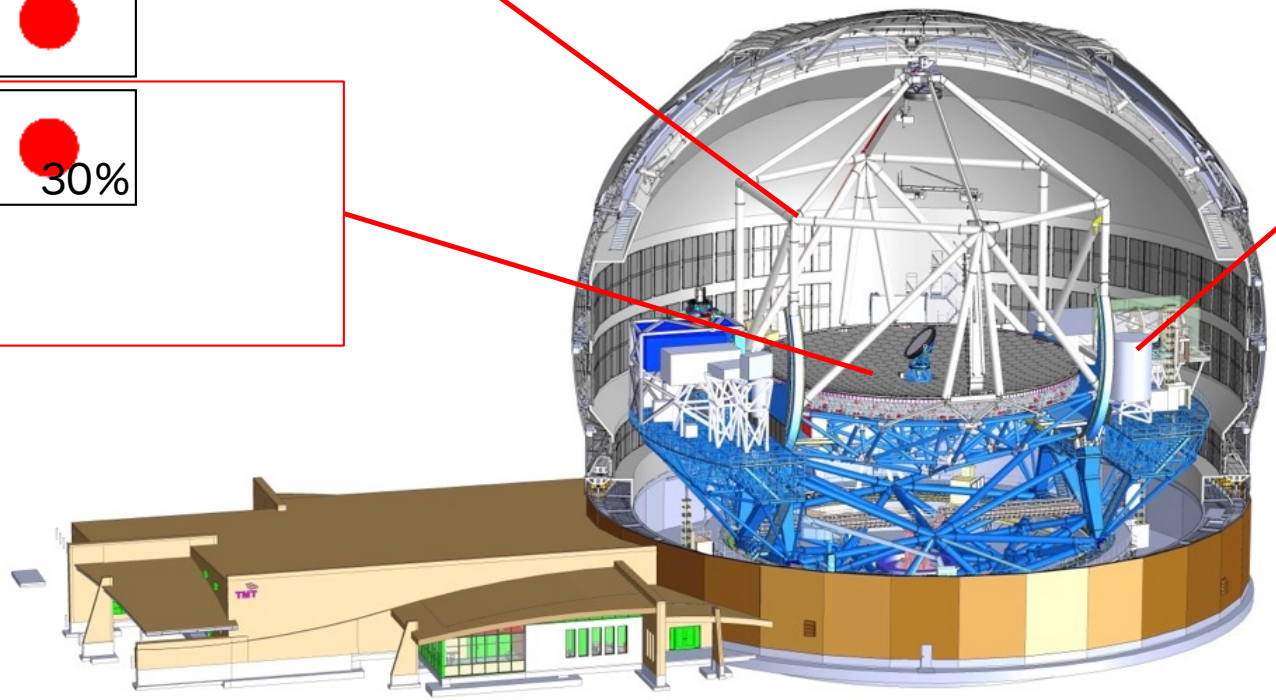
Control Systems & Software

Japan's Contributions

Telescope

M1 blank

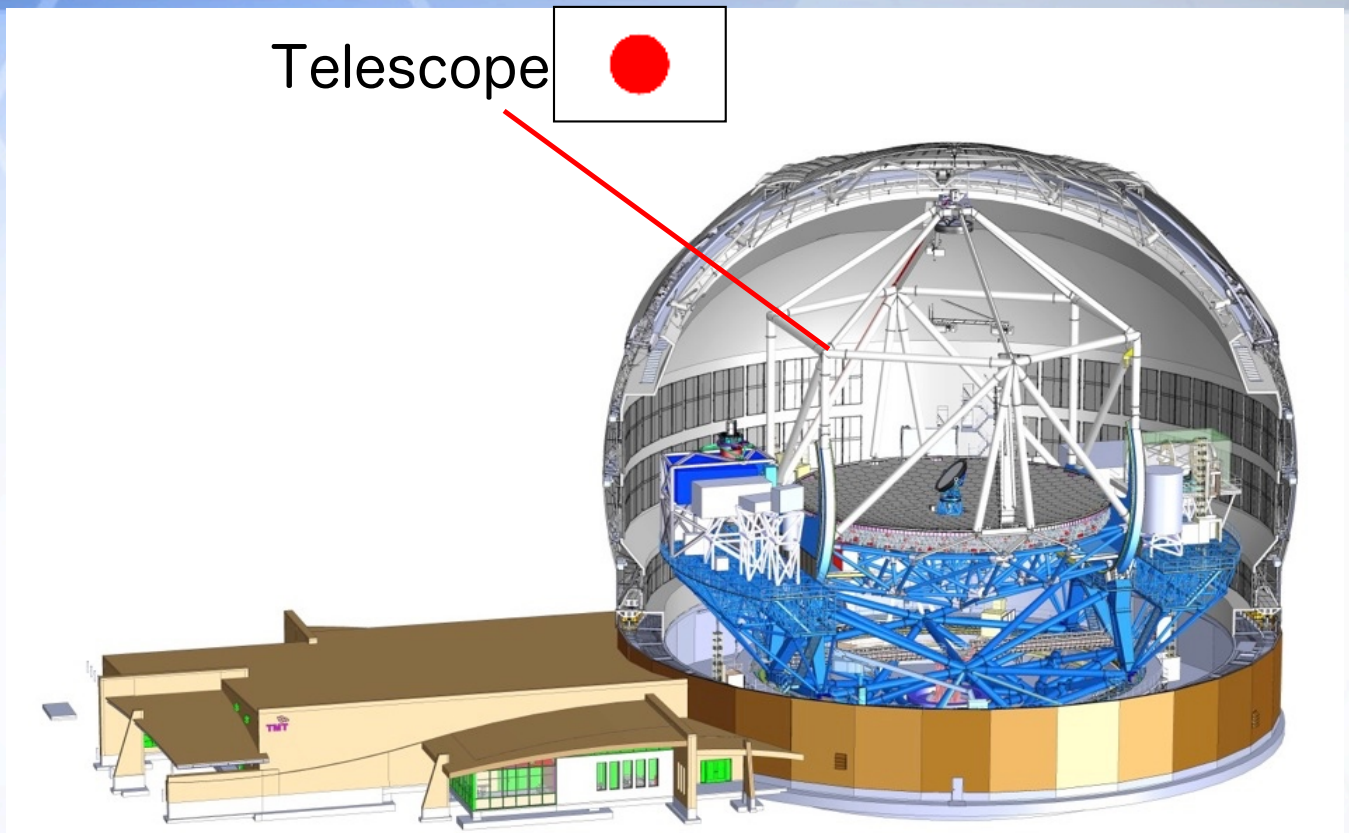
M1 polish 30%



Instruments

1) Design fabrication / installation of the telescope structure,
2) Providing all the primary mirror segment blanks,
3) Polishing 30% of the primary mirror blanks,
4) Developing part of the First Generation Instruments, and
5) Cash contributions to cover common expenses etc.

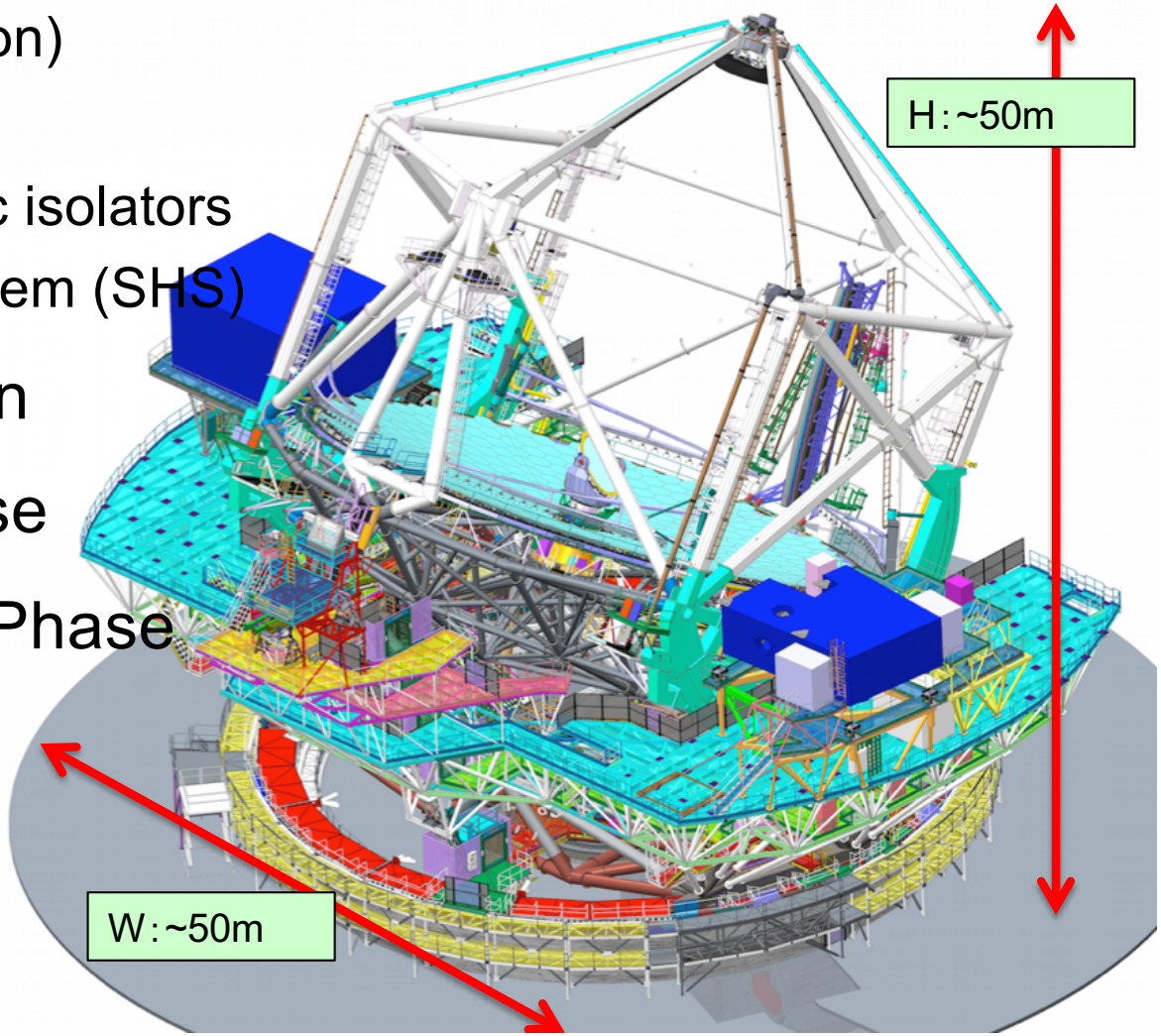
TMT-J activities: Telescope Structure (STR)



1) Design fabrication / installation of the telescope structure,
2) Providing all the primary mirror segment blanks,
3) Polishing 30% of the primary mirror blanks,
4) Developing part of the First Generation Instruments, and
5) Cash contributions to cover common expenses etc.

TMT-J activities: Telescope Structure (STR)

- Key Design Features
  - 2,600 ton (cf. Subaru 555 ton)
  - Tracking: 0.2 milli-asec
  - Seismic analysis w/ seismic isolators
  - M1 Segment Handling System (SHS)
- 2013~ Preliminary Design
- 2014~ Final Design Phase
- 2018/2019~ Fabrication Phase



Telescope Structure (STR) FDP

- STR Review:
  - ✓ 12-14th Nov 2013: PDR1 (Mechanical) PASS
  - ✓ 15-16th Apr 2014: PDR2 (Control) PASS
  - ✓ 18-20th Nov 2014: PDR3 (SHS) PASS
  - ✓ 17-20th Feb 15: FDRP1 (Mechanical)
  - ✓ 8-9th Oct 15: Long-Lead Procurement Review PASS
  - ✓ 27-29th Jul 15: FDRP2 (Control)
  - ✓ 24-26th Feb 16: dFDRP2 (Control)
  - ✓ 7-9th Dec 16: FDRP3 (SHS, ASP, Elevator)
  - ✓ Safety Review, SIS peer review, FDR Completion PASS

11 reviews / 6 years ~ 1.8 review per year

Contents

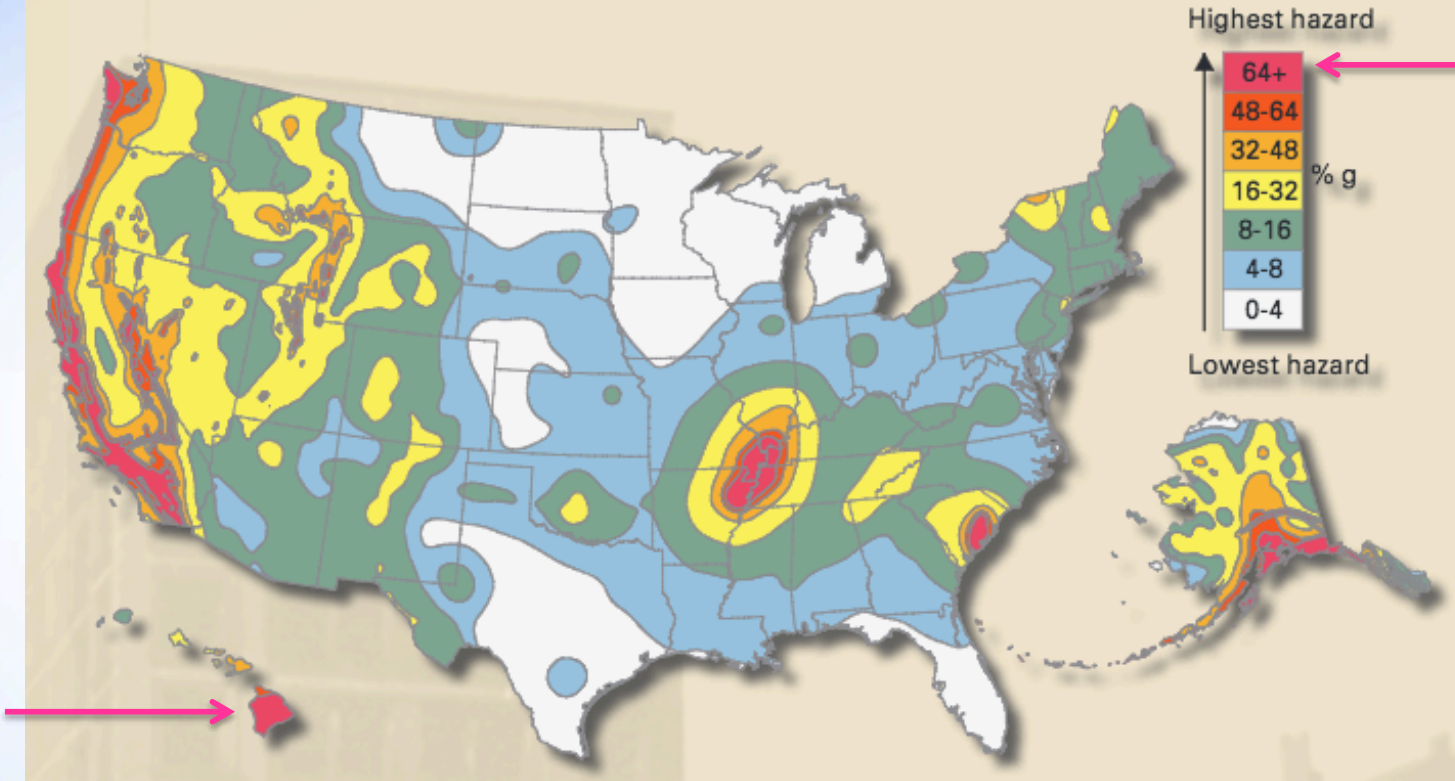
- ✓ Introduction of TMT Structure (STR)
  - ➢ Workshare of NAOJ in TMT, Status/history of STR, Highlight of STR design (Drive, Seismic, SHS)
- ✓ Challenges and Key Contributions of NAOJ staffs to STRs
  - ➢ Organization of STR and NAOJ's member roles, Challenges to proceed the project, Contribution of NAOJ

Seismic Isolation System
How big EQ could happen?

TMT Thirty Meter Telescope

NAOJ National Astronomical Observatory of Japan

✓ Hazard Map



*The 2008 U.S. Geological Survey National Seismic Hazard Maps for the United States are based on current information about the rate at which earthquakes occur in different areas and on how far strong shaking extends from earthquake sources. Colors on this particular map show the levels of horizontal shaking that have a 2-in-100 chance of being exceeded in a 50-year period. Shaking is expressed as a percentage of **g** (**g** is the acceleration of a falling object due to gravity).*

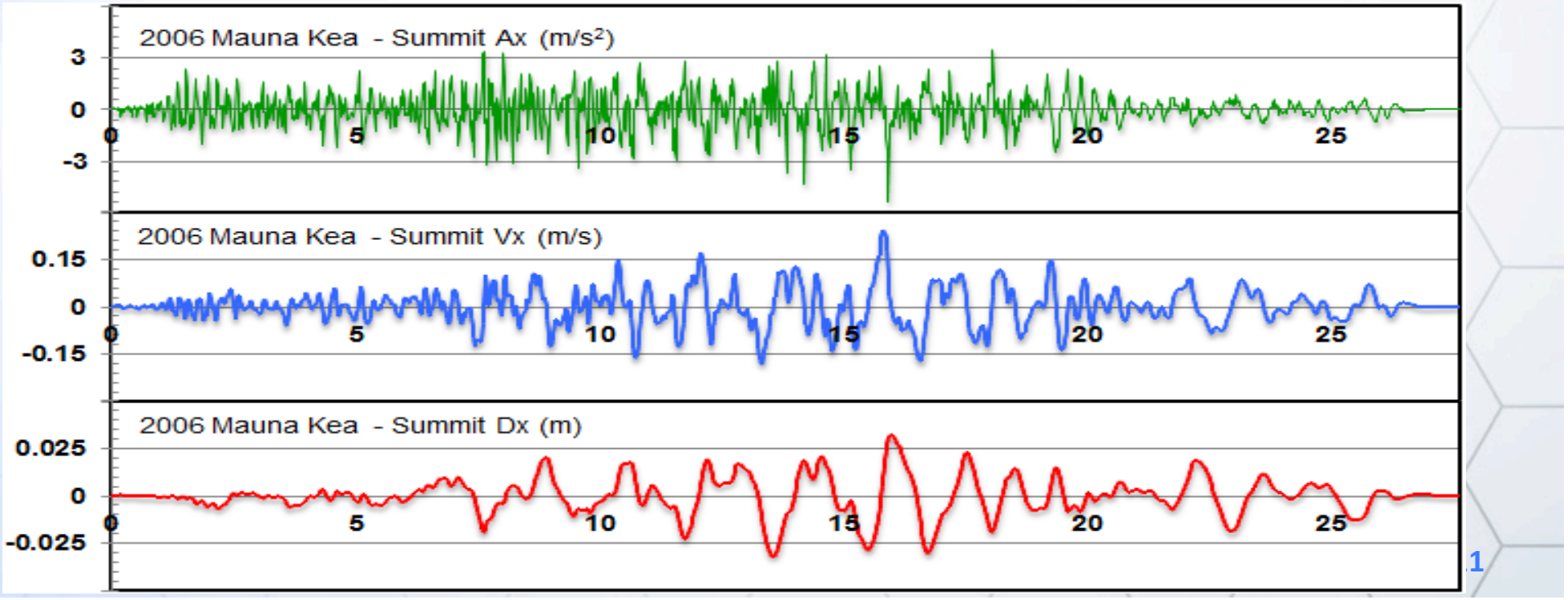
Seismic Isolation System
TMT Seismic Requirement

TMT Thirty Meter Telescope

NAOJ National Astronomical Observatory of Japan

- TMT specifies time-series seismic wave patterns of 1000yr return periods, which scaled from past seismic
- Example of wave(typical 23 sec, dT=5 msec)

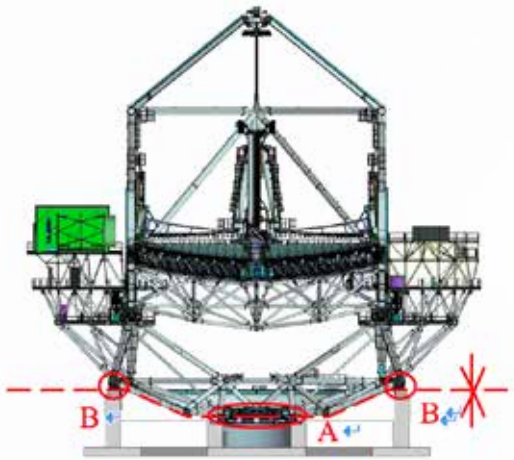
	Max Ground Motion (cm) (g)		
Seismic Event	Lateral X	Lateral Y	Vertical Z
1992 N Palm Springs	12	15 0.44	5
1989 Gilroy Array #3	8	20 0.51	8
1994 UCLA Grounds	9	9 0.51	4
1979 SAHOP Casa Flores	3 0.45	5	2
1980 Convict Creek	4	6 0.42	5
1983 Mauna Loa	15	8 0.50	7
2006 Mauna Kea	3 0.54	4	2



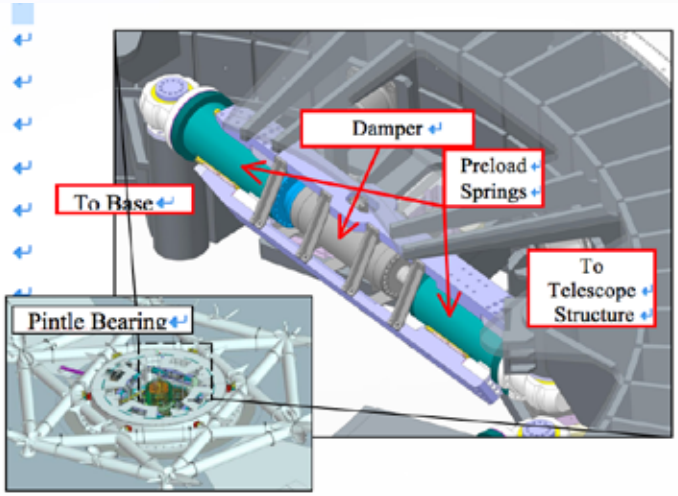
Seismic Isolation System

- Seismic Isolation (only lateral direction)
  - Damper work only when EQ happen

MITSUBISHI ELECTRIC Ezaki+ SPIE 2016



Pintle bearing



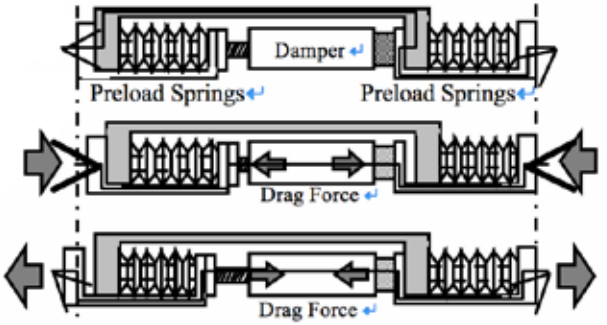
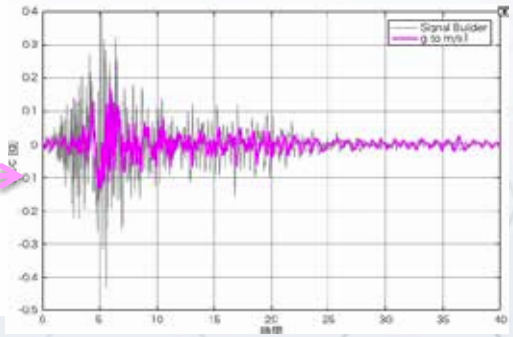


Figure 10 Seismic isolation mechanisms and Lock mechanism using preload springs

地震波形

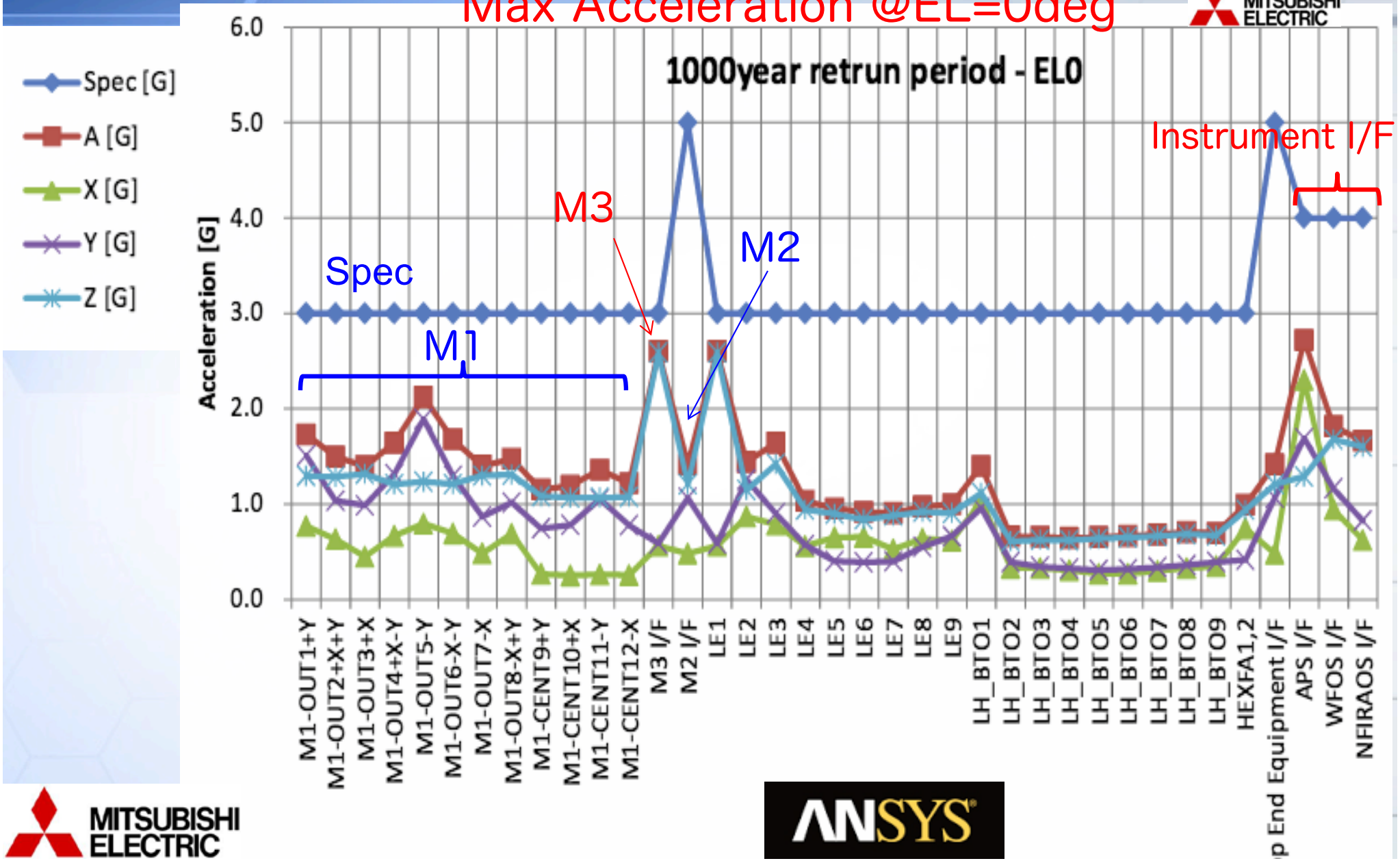
2500ton

Mass M5



Seismic Isolation System Acceleration

Max Acceleration @EL=0deg



Contents

- ✓ Introduction of TMT Structure (STR)
  - ➢ Workshare of NAOJ in TMT, Status/history of STR, Highlight of STR design
- ✓ Challenges and Key Contributions of NAOJ staffs to STR
  - ➢ Organization of STR and NAOJ's member roles, Challenges to proceed the project, Contribution of NAOJ

TMT Thirty Meter Telescope

Challenges in STR

NAOJ National Astronomical Observatory of Japan

- ✓ Huge work volume because of the largest/complicated subsystem in TMT
  - ➢ The number of ICDs (18 ICDs ~ 600 requirements)
  - ➢ Design requirement (~400 requirements)
  - ➢ The number of parts?: million?
- ✓ Many relevant stakeholders as physically/culturally-separated parties. Challenges to share common understanding about:
  - ➢ Responsibility/Action (who should do what)
  - ➢ Criteria of completion of action (⟺ Clarity of requirement)
  - ➢ Priority of action
  - ➢ QCD (quality, cost, delivery)
  - ➢ etc….

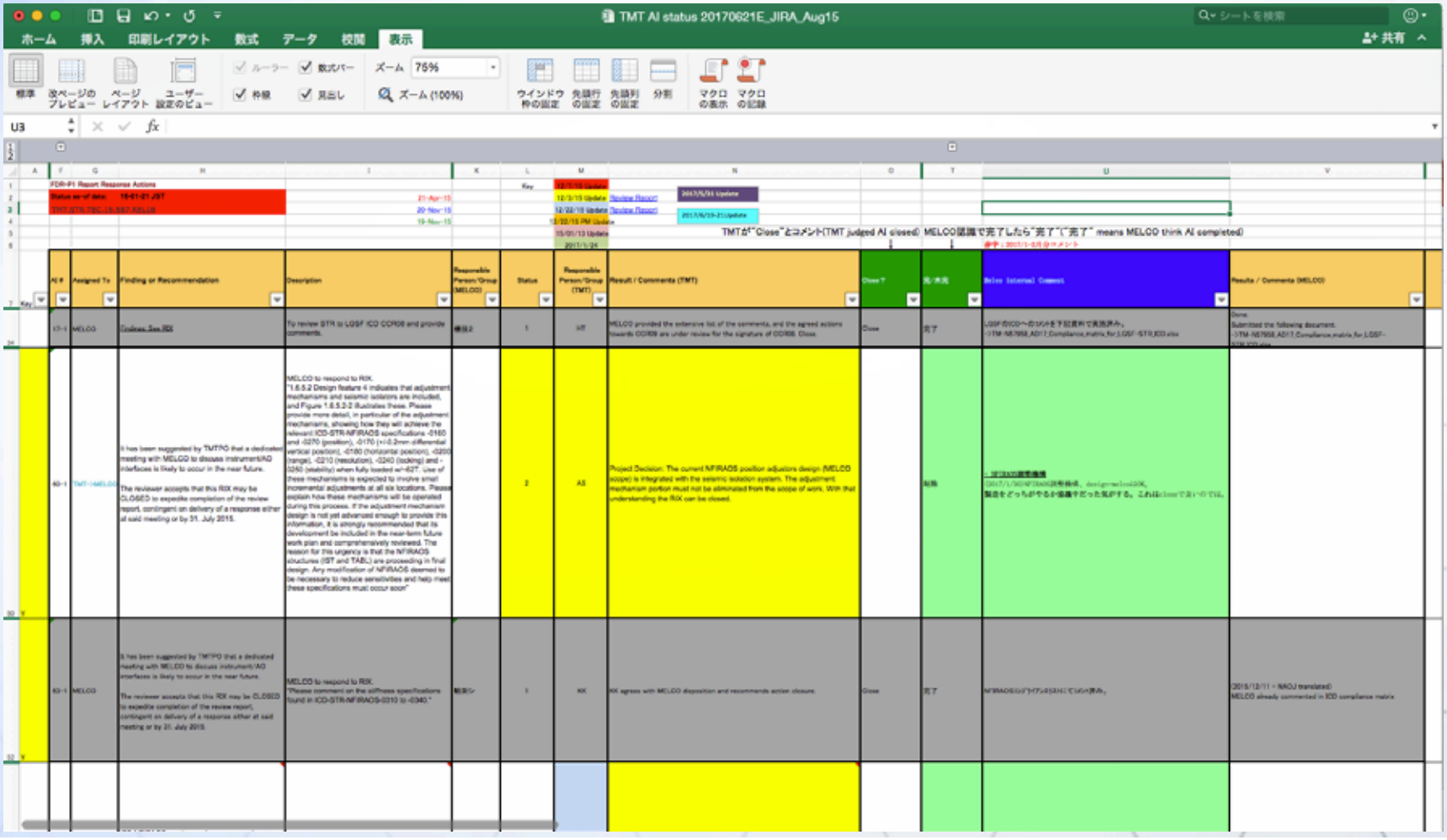
Key Contribution of NAOJ

(All parties contributed to tackle with challenges… of course)

- ✓ (Contract management)
- ✓ Coordination between customer (TIO) and vendor (MELCO)
  - ➢ Interface coordination between other subsystem group and MELCO
  - ➢ Interface Coordination specific for Telescope Utility Service (TUS)
  - ➢ Action/Verification management and Requirement clarification by JIRA
- ✓ Contribution to decision of design for major performance (Control, Seismic, etc)

Management of Review Action

- ✓ Before: Spread sheet (100AI / review)
  - ➢ Difficult to version control (difficult to find the update) → Difficult to communicate

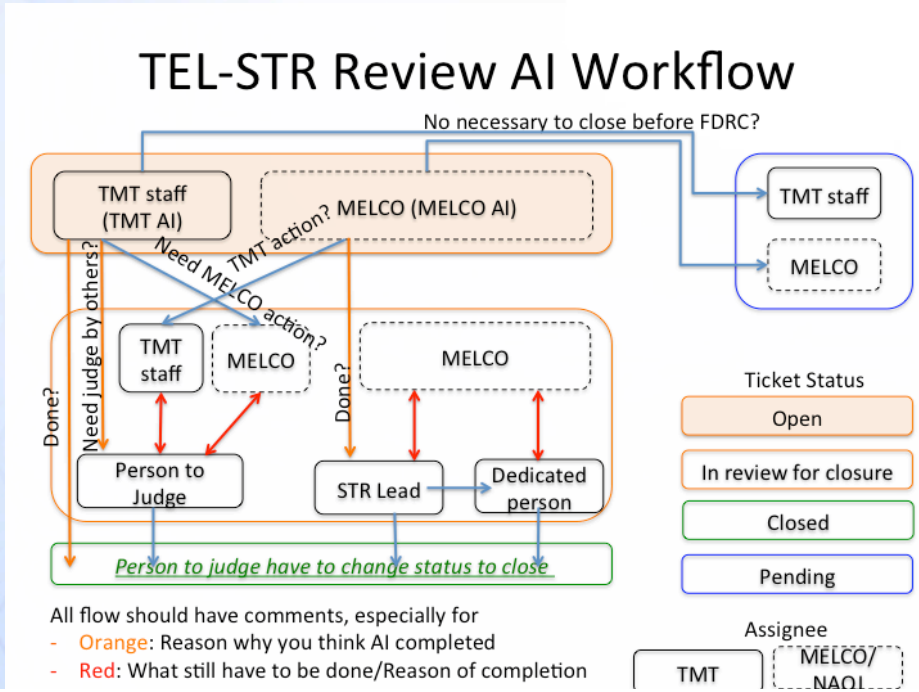


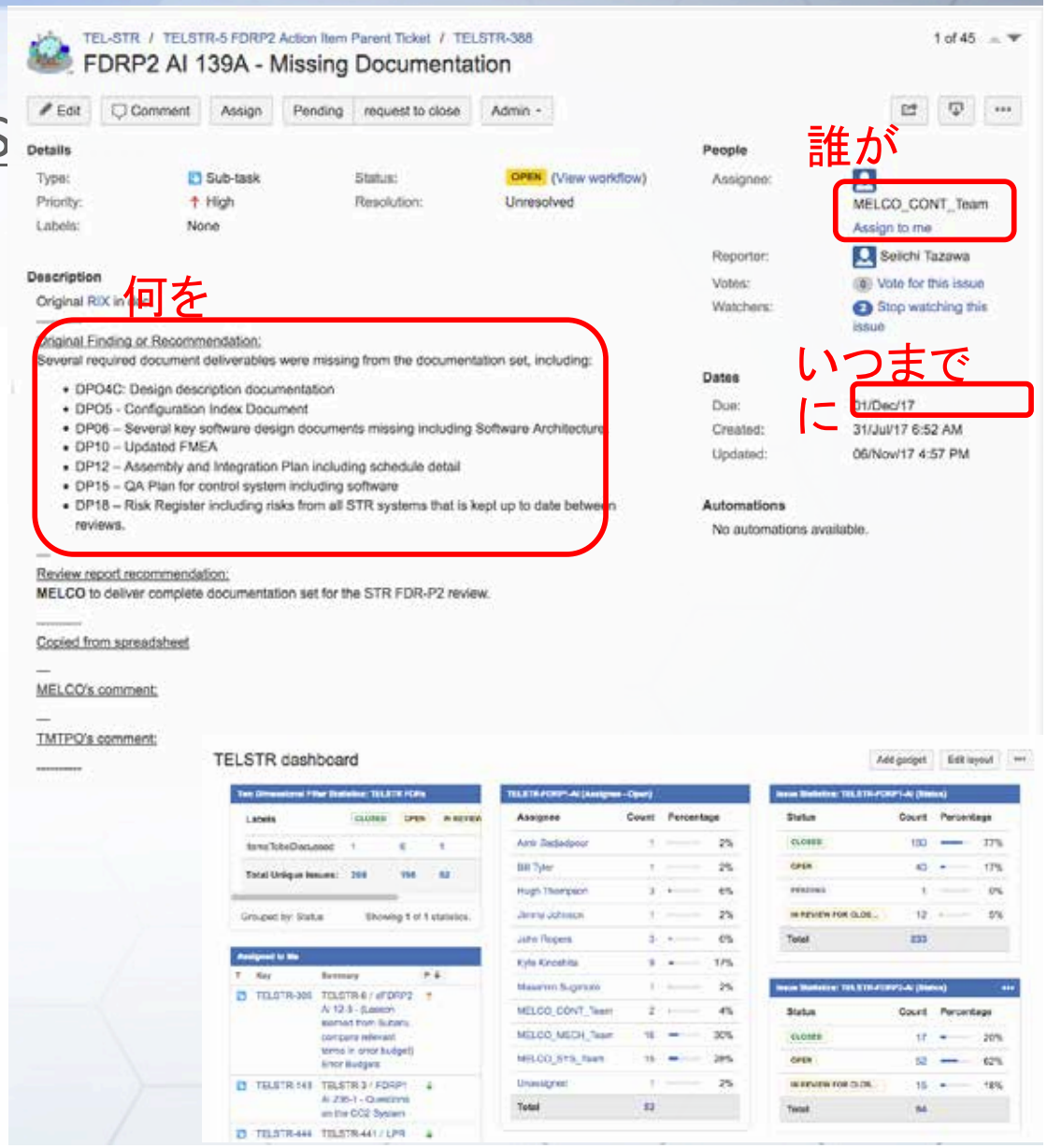
Management of Review Action

- ✓ After: Spread sheet to JIRA

ALMA, TMT, EELT, DKIST, SKA, LS

- ✓ Define usage/role (flow)
- ✓ Statistics page to overview





Key Contribution of NAOJ

(All parties contributed to tackle with challenges… of course)

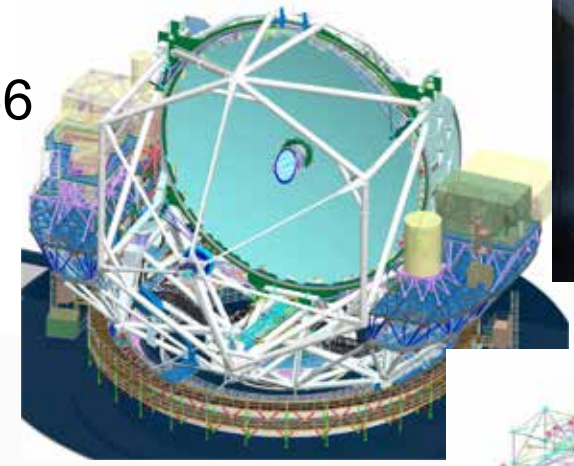
- ✓ (Contract management)
- ✓ Coordination between customer (TIO) and vendor (MELCO)
  - ➢ Interface coordination between other subsystem group and MELCO
  - ➢ Interface Coordination specific for Telescope Utility Service (TUS)
  - ➢ Action/Verification management and Requirement clarification by JIRA
- ✓ Contribution to decision of design for major performance (Control, Seismic, etc)

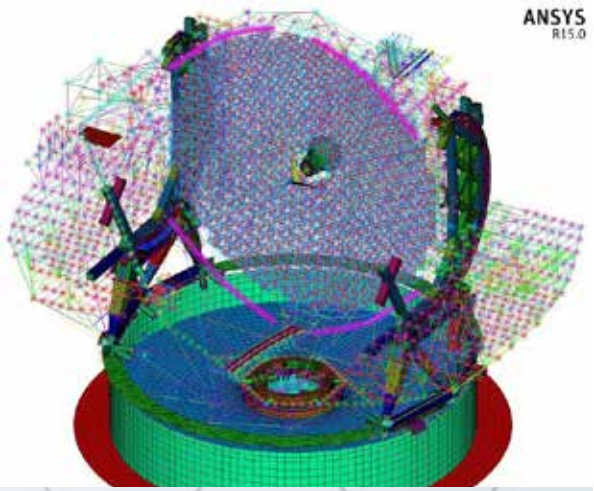
Seismic Analysis with NAOJ Super Computer

TMT Thirty Meter Telescope

NAOJ National Astronomical Observatory of Japan

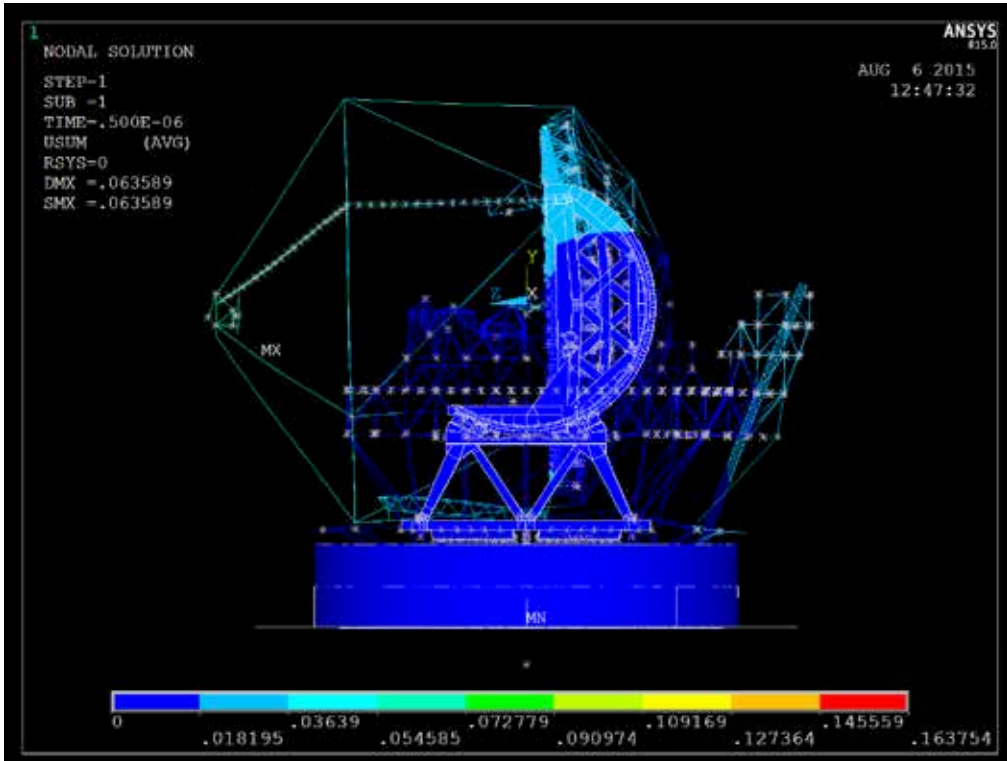
- Computer:
  - NAOJ Super Comp: ATERUI (Cray XC30→XC50)
  - HP Z800 (Intel Xenon X5687@3.60GHz)
- Software: ANSYS Mechanical APDL ver 15.0+HPC
- FE Model Parameters
  - Element/Nodes = 306,531/331,356
  - Seismic Time: 15~50 sec
    - → 23 sec (average)
- Time interval: 5 msec (4,600 steps)
- STR EL Angles=0, 25, 60, 90 degs
- Seismic wave 7 patterns
- Materials: Steel, Aluminum, Concrete(pier), CFRP





MITSUBISHI ELECTRIC

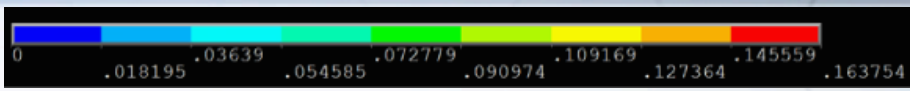
ANSYS



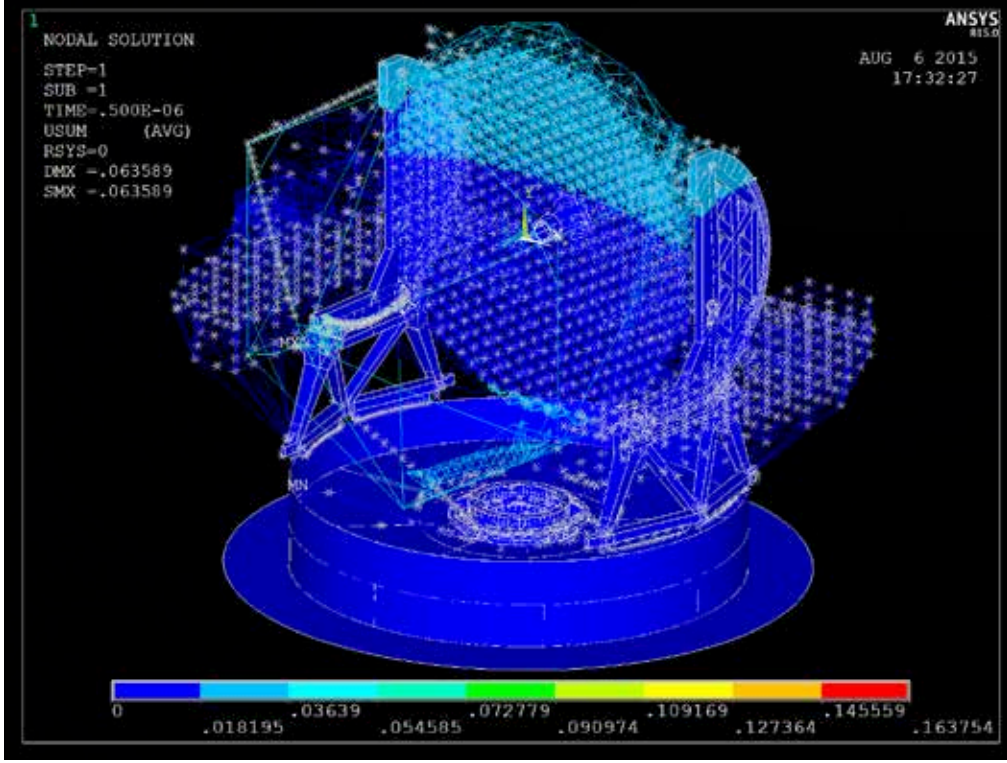
Seismic Analysis Movie

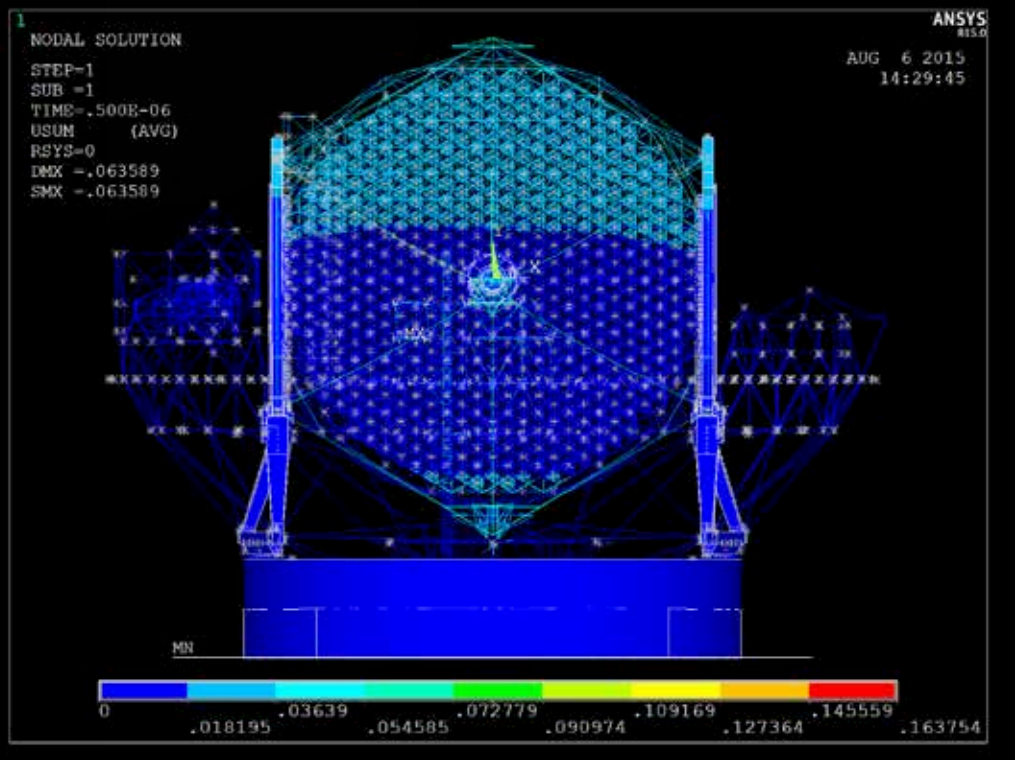
ANSYS

NAOJ National Astronomical Observatory of Japan



- Color scale: 0.0 ~ 0.165m
- FE Model Parameters
  - Number of Elements = 306,531
  - Number of Nodes = 331,356





Summary

- ✓ Introduction of TMT Structure (STR)
- ✓ Challenges in big group consisted from physically/culturally-separated parties
  - ➢ Challenges to share common understanding
- ✓ Examples of Contributions of NAOJ staffs to STRs
  - ➢ Huge effort for smooth coordination
  - ➢ (+ small) Contribution to decision of design for major

Summary2

- ✓ Theme of this Symposium
  - ➢ “Internationalization, the future of astronomical engineering and projects in Japan”.

- ✓ What types of Engineering conducted by NAOJ
  - ➢ developments of the (cutting-edge) devices/software for astronomical instruments
  - ➢ daily preventive maintenance
  - ➢ Diagnostic, trouble shooting, corrective maintenance/replacement activities
  - ➢ MGT/SE tasks….
  - ➢ others?

Acknowlegements

The TMT Project gratefully acknowledges the support of the TMT collaborating institutions. They are the Association of Canadian Universities for Research in Astronomy (ACURA), the California Institute of Technology, the University of California, the National Astronomical Observatory of Japan, the National Astronomical Observatories of China and their consortium partners, and the Department of Science and Technology of India and their supported institutes. This work was supported as well by the Gordon and Betty Moore Foundation, the Canada Foundation for Innovation, the Ontario Ministry of Research and Innovation, the National Research Council of Canada, the Natural Sciences and Engineering Research Council of Canada, the British Columbia Knowledge Development Fund, the Association of Universities for Research in Astronomy (AURA) and the U.S. National Science Foundation.