



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

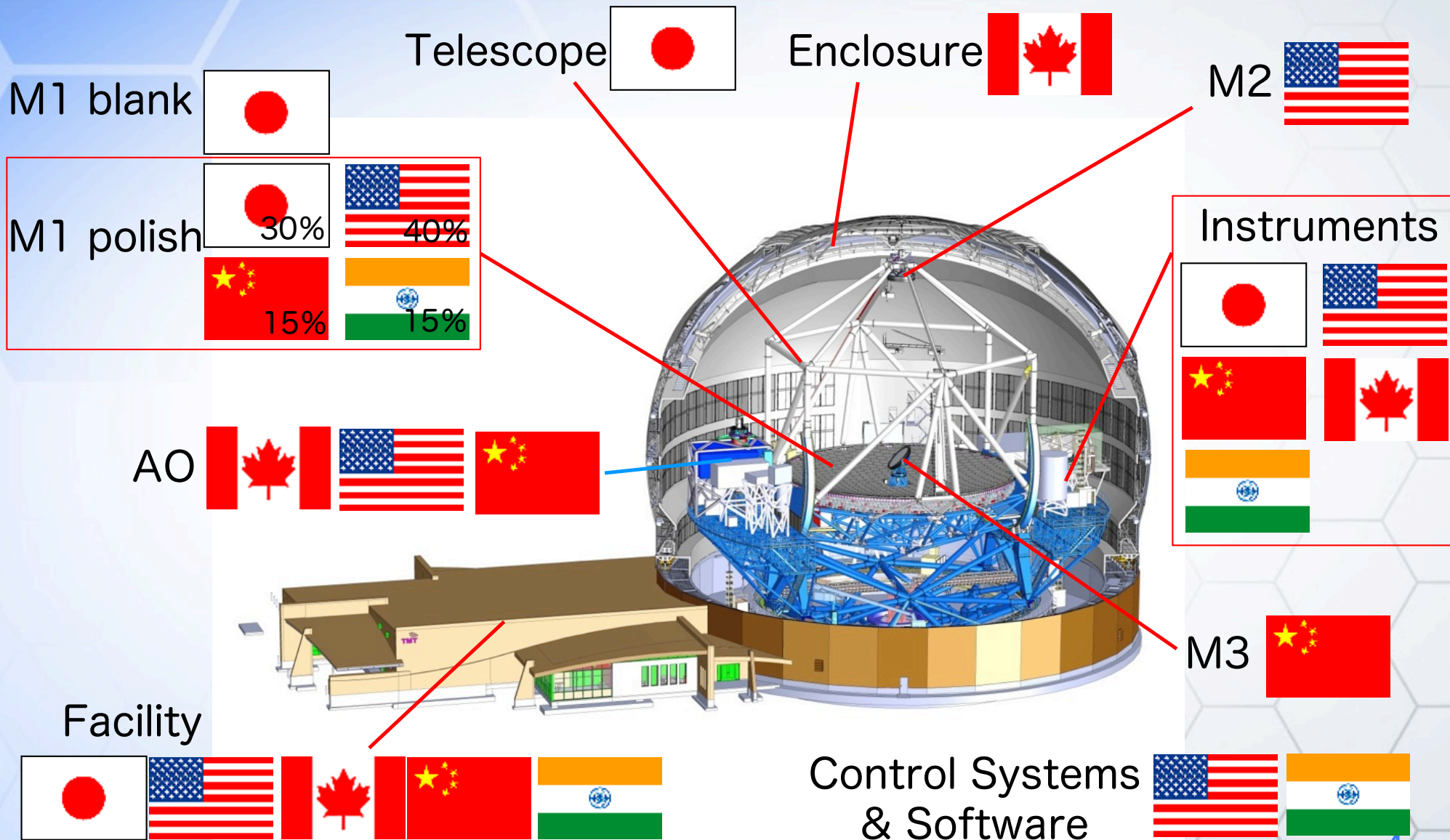


- ✓ Introduction of TMT Structure (STR)
 - **Workshare of NAOJ in TMT, Status/history of STR,**
Highlight of STR design

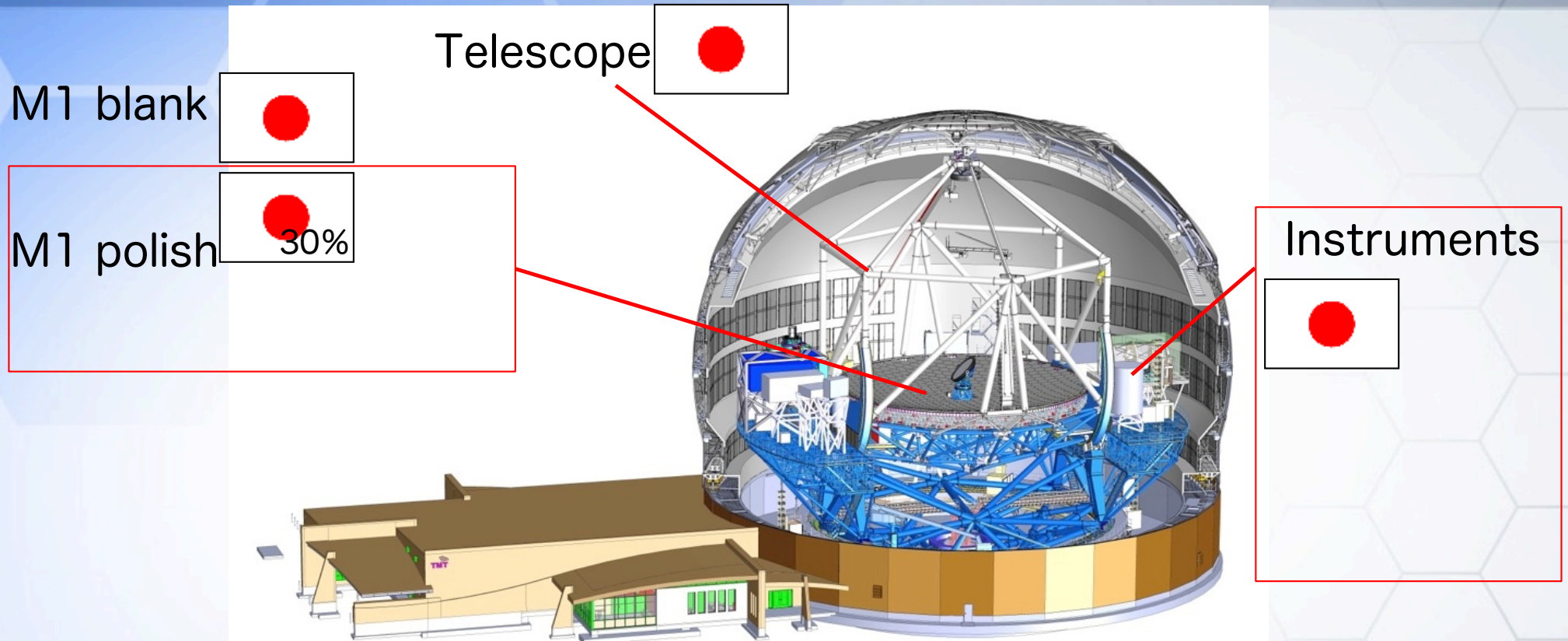
- ✓ Challenges and Key Contributions of NAOJ staffs to STRs
 - Organization of STR and NAOJ's member roles,
Challenges to proceed the project, Contribution of NAOJ



Members' contributions

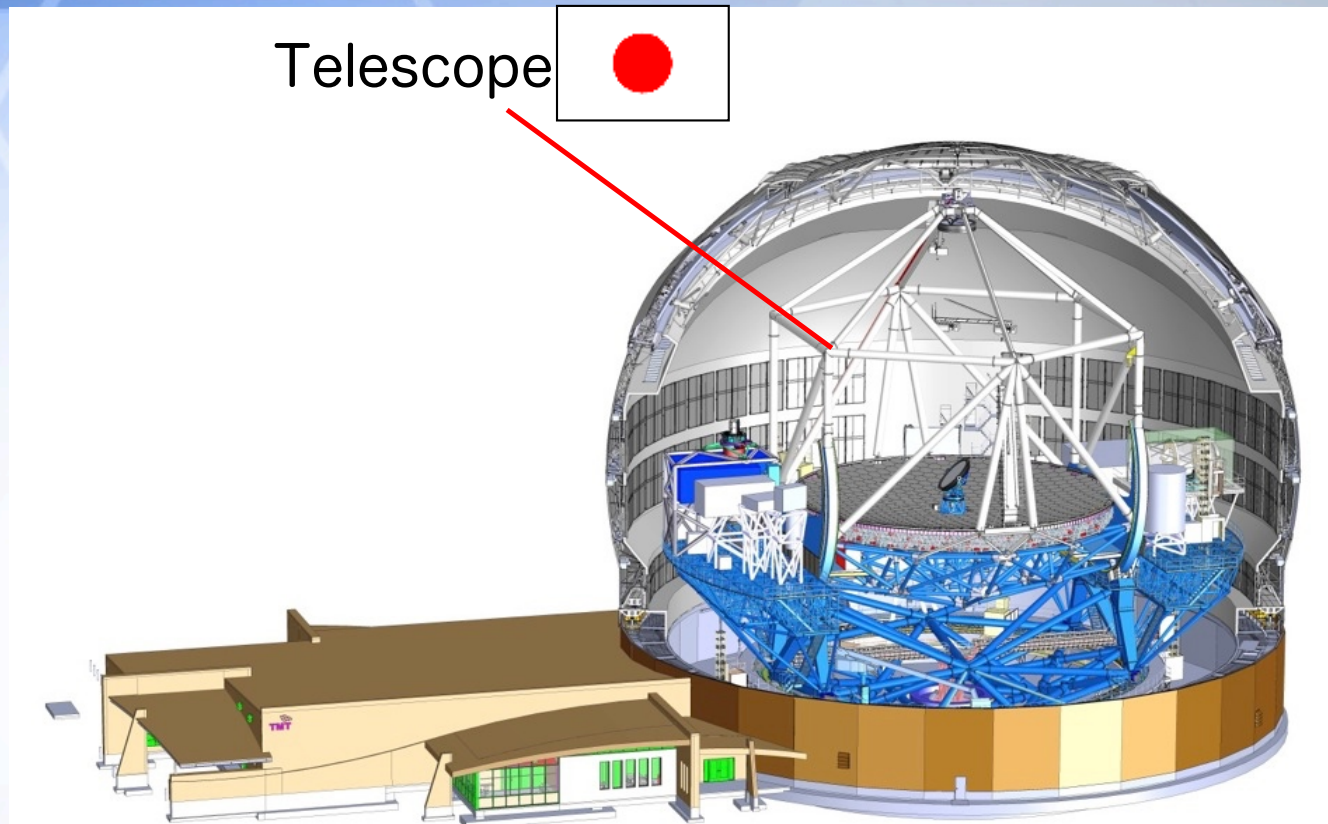


Japan's Contributions



- 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)



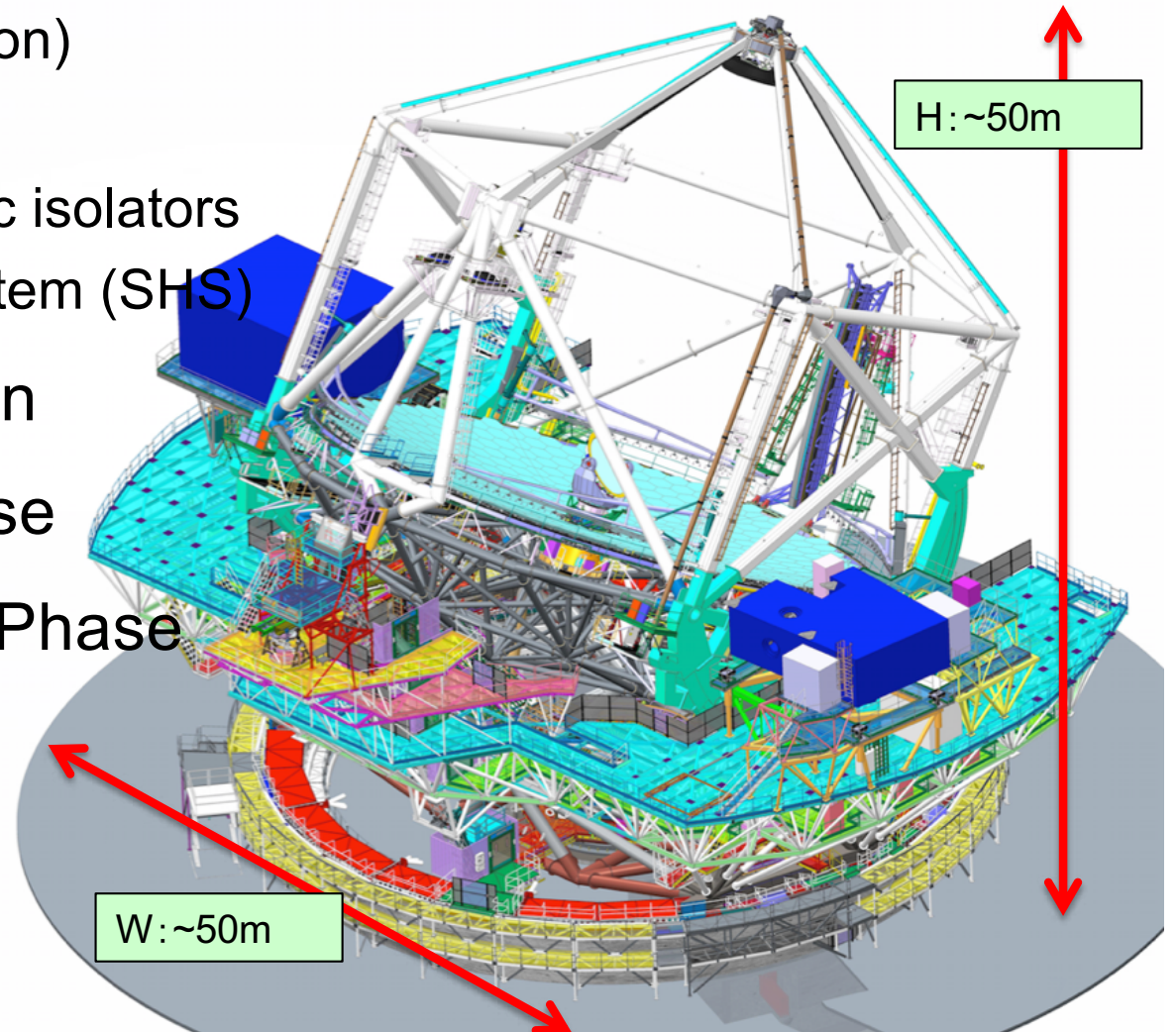
◆ Key Design Features

- 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



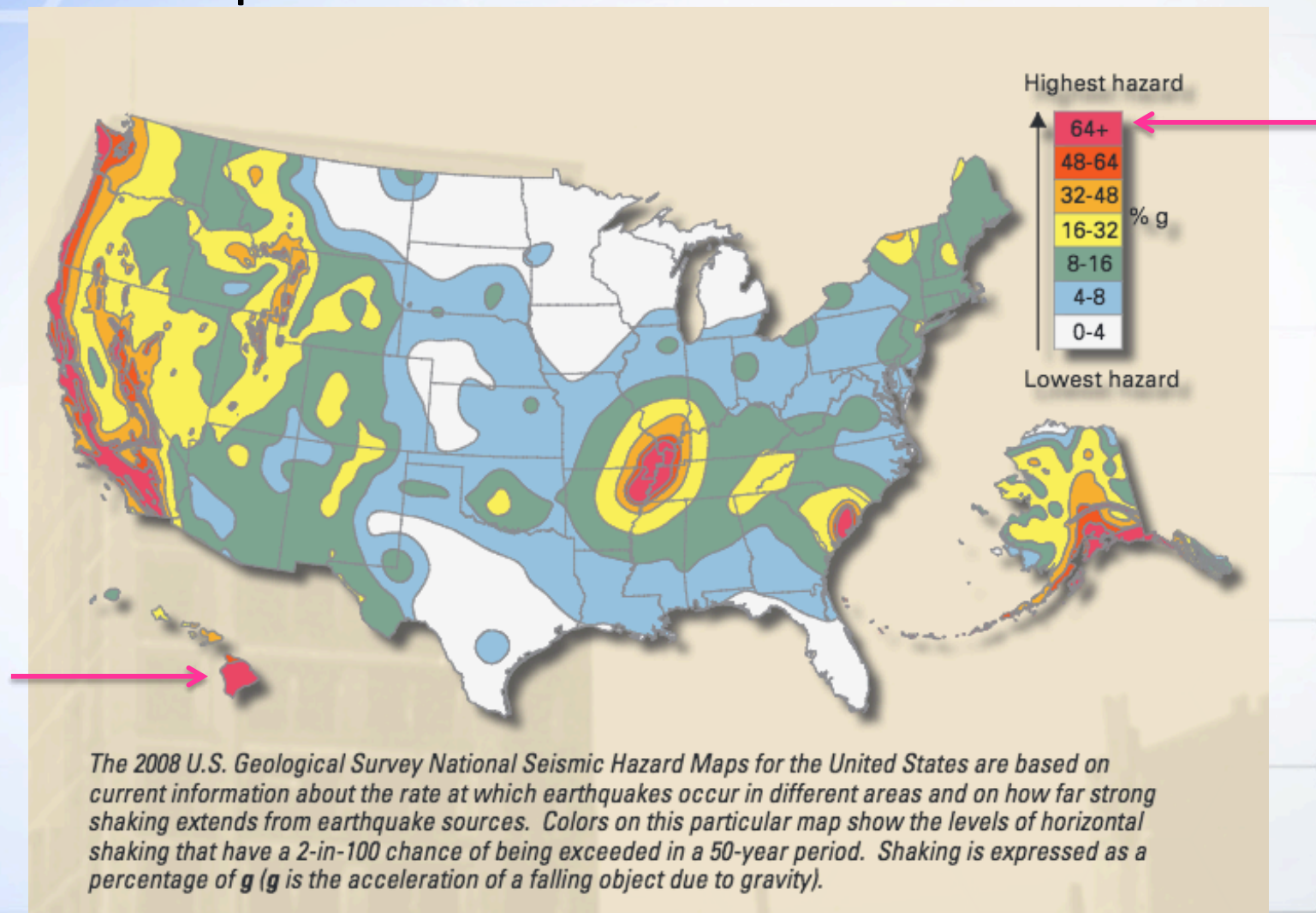
- ✓ Introduction of TMT Structure (STR)
 - Workshare of NAOJ in TMT, Status/history of STR, **Highlight of STR design (Drive, Seismic, SHS)**

- ✓ 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?

✓ Hazard Map





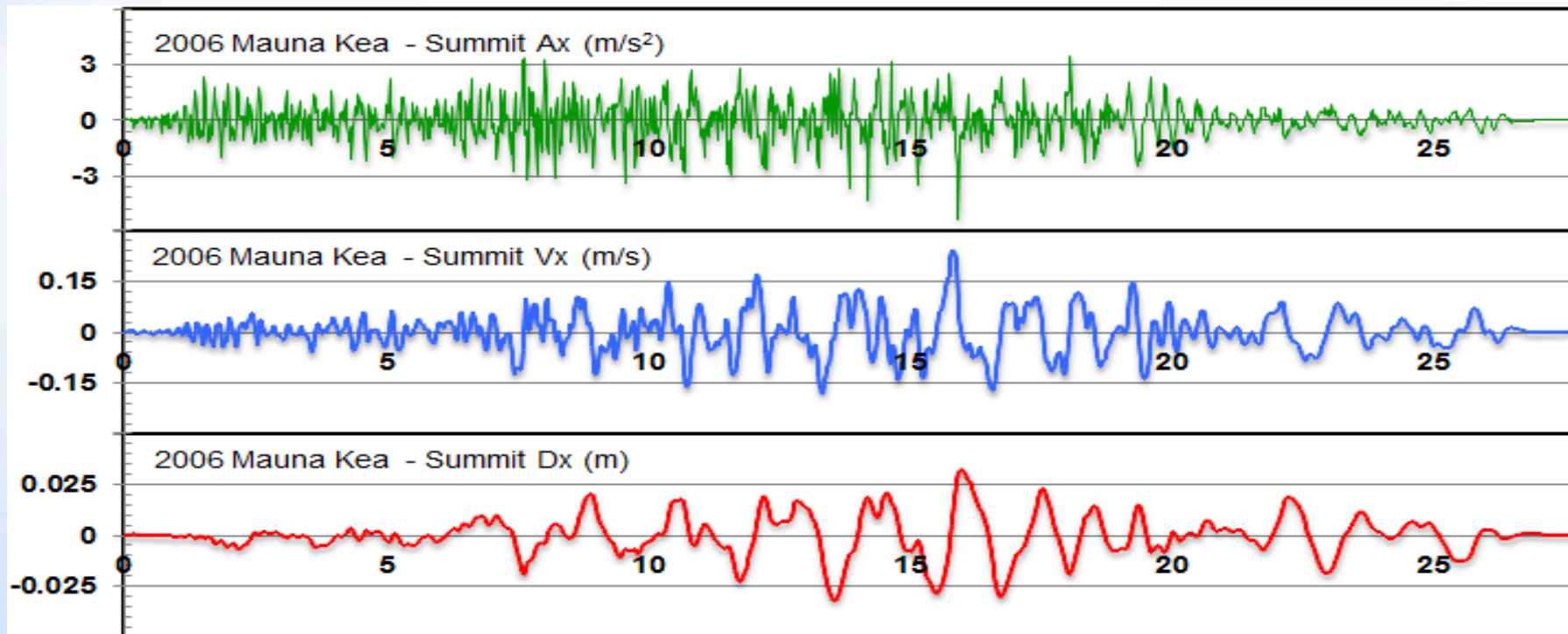
Seismic Isolation System

TMT Seismic Requirement



- ◆ 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)

Seismic Event	Max Ground Motion (cm) (g)		
	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

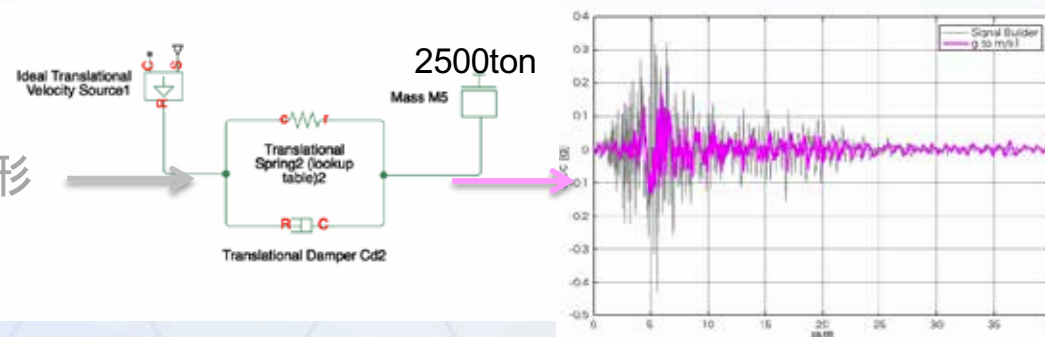
Pintle bearing

To Base
To Telescope Structure
Damper
Preload Springs
Pintle Bearing

Preload Springs
Damper
Drag Force

Figure 10 Seismic isolation mechanisms and Lock mechanism using preload springs

地震波形

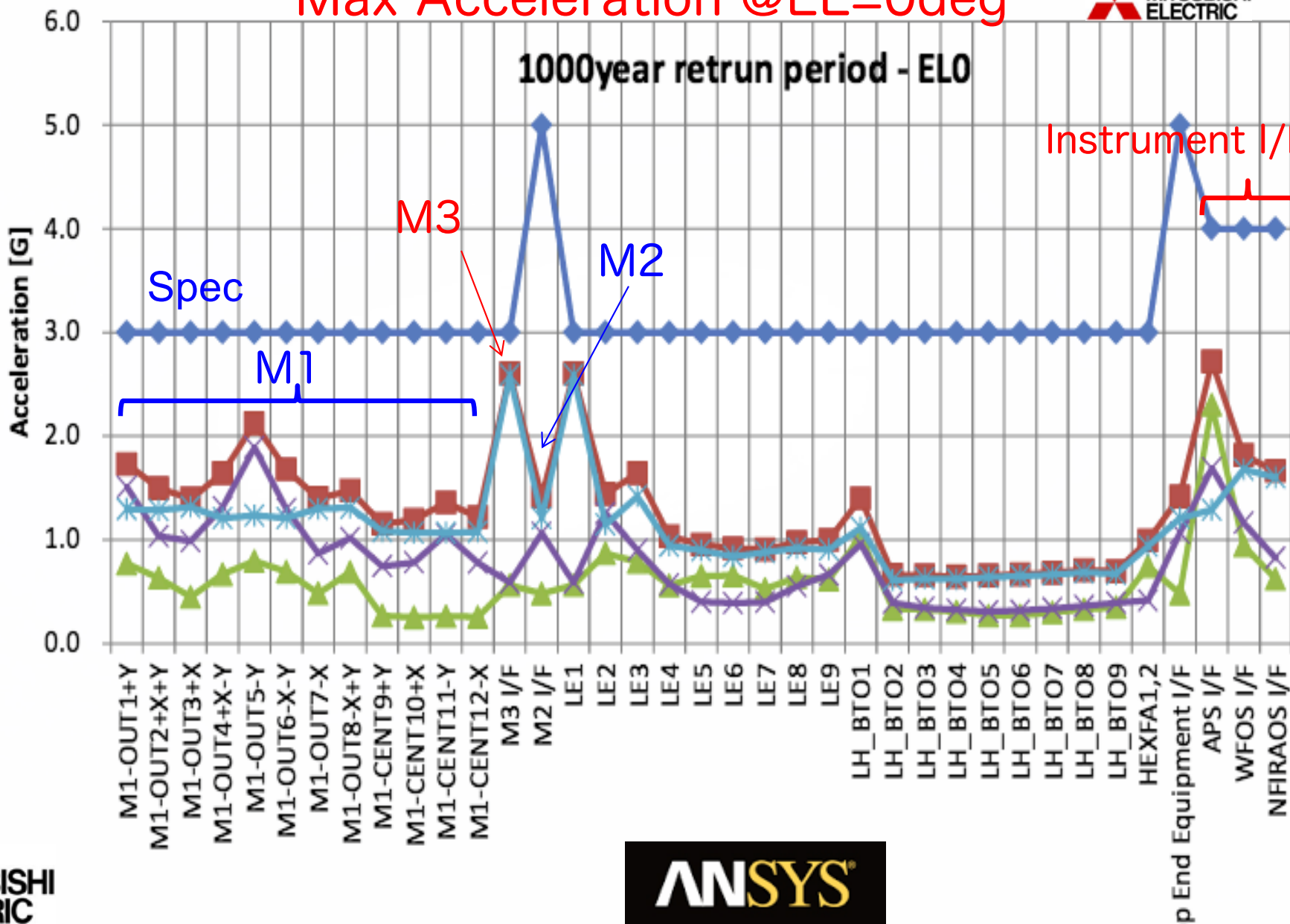




Seismic Isolation System Acceleration



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



Challenges in STR



- ✓ 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)



TMT Management of Review Action



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

ID	Assigned To	Finding or Recommendation	Description	Responsible Person/Group (MELCO)	Status	Responsible Person/Group (TMT)	Result / Comments (TMT)	Date	Result / Comments (MELCO)
10-1	MELCO	Guidance, See RIK	To review STX to LOSF ICD CORON and provide comments.	横山	1	AI	MELCO provided the extensive list of the comments, and the agreed actions towards CORON are under review for the signatures of CORON Class.	Done	Done. Submitted the following document. - STM-ME768-AD11 Compliance matrix for LOSF-STX ICD class
40-1	TMT-MELCO	It has been suggested by TMTPO that a dedicated meeting with MELCO to discuss instrument/AD interfaces is likely to occur in the near future. The reviewer accepts that this RIK may be CLOSED to expedite completion of the review report, contingent on delivery of a response either at said meeting or by 31 July 2015.	MELCO to respond to RIK. "1.6.5.2 Design feature 4 indicates that adjustment mechanisms and sensor isolators are included, and Figure 1.6.5.2.2 Subfigure Three. Please provide more detail, in particular of the adjustment mechanisms, showing how they will achieve the relevant ICD-STR-MIRACOS specifications: -0160 and -0270 (position), -0170 (+/-0.2mm differential vertical position), -0180 (horizontal position), -0200 (range), -0210 (resolution), -0240 (loading) and -0300 (stability) when fully loaded w/-027. Use of these mechanisms is expected to involve small incremental adjustments at all six locations. Please explain how these mechanisms will be operated during this process. If the adjustment mechanism design is not yet advanced enough to provide this information, it is strongly recommended that its development be included in the near-term future work plan and comprehensively reviewed. The reason for this urgency is that the MIRACOS structures (ST and TABL) are proceeding in final design. Any modification of MIRACOS seemed to be necessary to reduce sensitivities and help meet these specifications must occur soon"	横山	2	AS	Project Decision: The current MIRACOS position adjusters design (MELCO scope) is integrated with the sensor isolation system. The adjustment mechanism position must not be abstracted from the scope of work. With that understanding the RIK can be closed.	Done	対応済 2015/12/04 設計仕様書 製造をどっちがやるか協議が完了した。これはissueで取りたい。
40-1	MELCO	It has been suggested by TMTPO that a dedicated meeting with MELCO to discuss instrument/AD interfaces is likely to occur in the near future. The reviewer accepts that this RIK may be CLOSED to expedite completion of the review report, contingent on delivery of a response either at said meeting or by 31 July 2015.	MELCO to respond to RIK. Please comment on the stiffness specifications found in ICD-STR-MIRACOS-0310 to -0340."	横山	1	KK	KK agrees with MELCO disposition and recommends action closure.	Done	Done (12/11 - NAOJ translated) MELCO already commented in ICD compliance matrix.

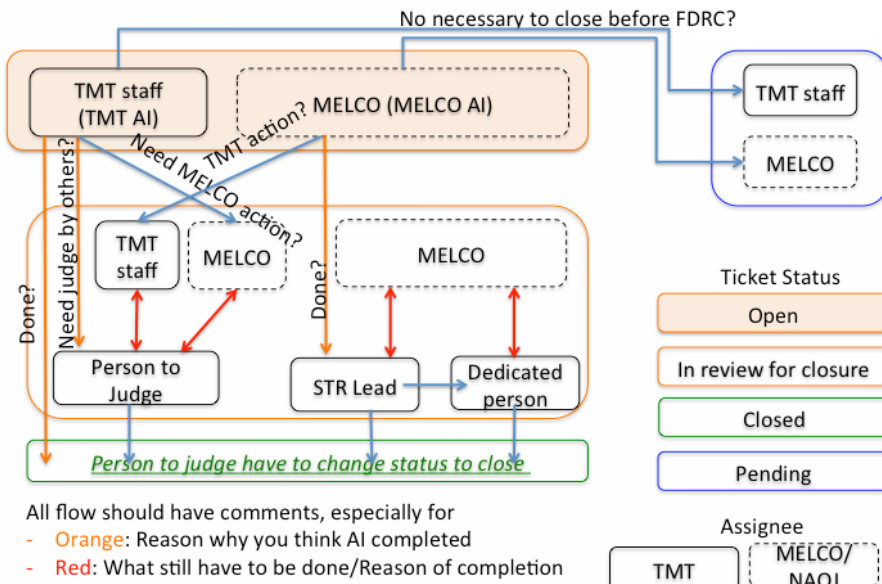


TMT Management of Review Action

✓ After: Spread sheet to JIRA
ALMA, TMT, EELT, DKIST, SKA, LS

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

TEL-STR Review AI Workflow



All flow should have comments, especially for

- Orange: Reason why you think AI completed
- Red: What still have to be done/Reason of completion

TELSTR dashboard

Labels	CLOSED	OPEN	IN REVIEW
Items To Be Discussed	1	6	1
Total Unique Issues:	268	186	82

Assignee	Count	Percentage
Amir Dehghani	1	2%
Bill Tyler	1	2%
Hugh Thompson	3	6%
Jenny Johnson	1	2%
Jiho Peoples	3	6%
Kyle Koshida	9	17%
Masaru Sugisawa	1	2%
MELCO_GONT_Team	2	4%
MELCO_MECH_Team	16	30%
MELCO_STR_Team	16	30%
Unassigned	1	2%
Total	82	

Status	Count	Percentage
CLOSED	130	37%
OPEN	40	17%
IN REVIEW FOR CLOSE	1	0%
IN REVIEW FOR CLOS...	12	5%
Total	283	

Status	Count	Percentage
CLOSED	17	26%
OPEN	52	62%
IN REVIEW FOR CLOS...	15	18%
Total	84	



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)

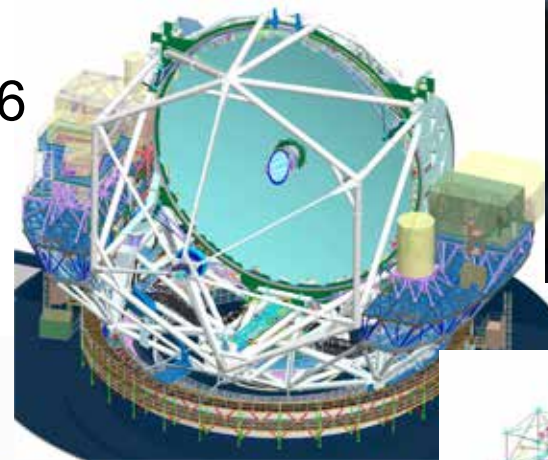


Seismic Analysis

with NAOJ Super Computer



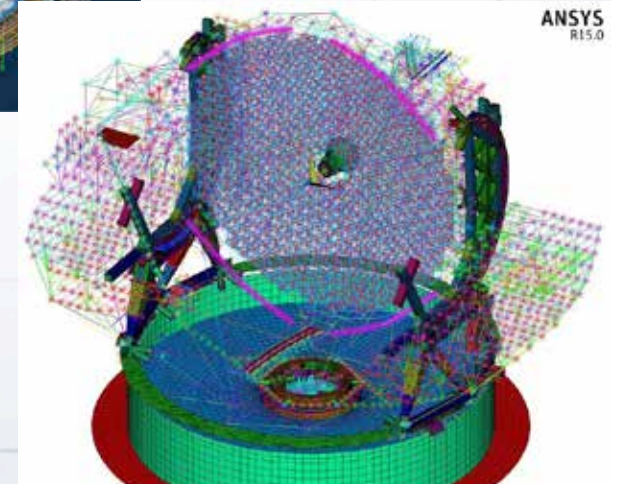
- ◆ Computer:
 - ◆ NAOJ Super Comp: ATERUI (Cray XC30→XC50)
 - ◆ HP Z800 (Intel Xenon X5687@3.60GHz)
- ◆ Software: ANSYS Mechanical APDL ver 15.0+HPC
- ◆ FE Model Parameters
 - ◆ Element/Nodes = 306,531/331,356
 - ◆ Seismic Time: 15~50 sec
→ 23 sec (average)
- ◆ Time interval: 5 msec (4,600 steps)
-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

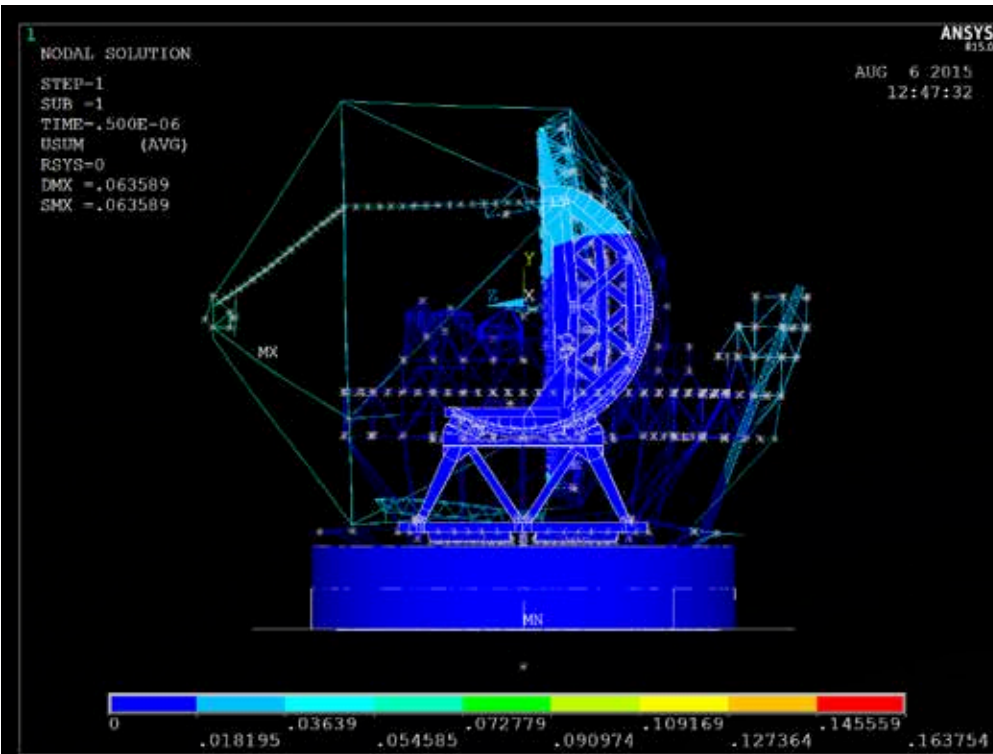


<http://www.cfca.nao.ac.jp/>

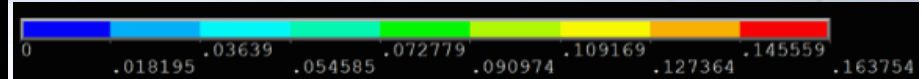


<http://www.cfca.nao.ac.jp/>

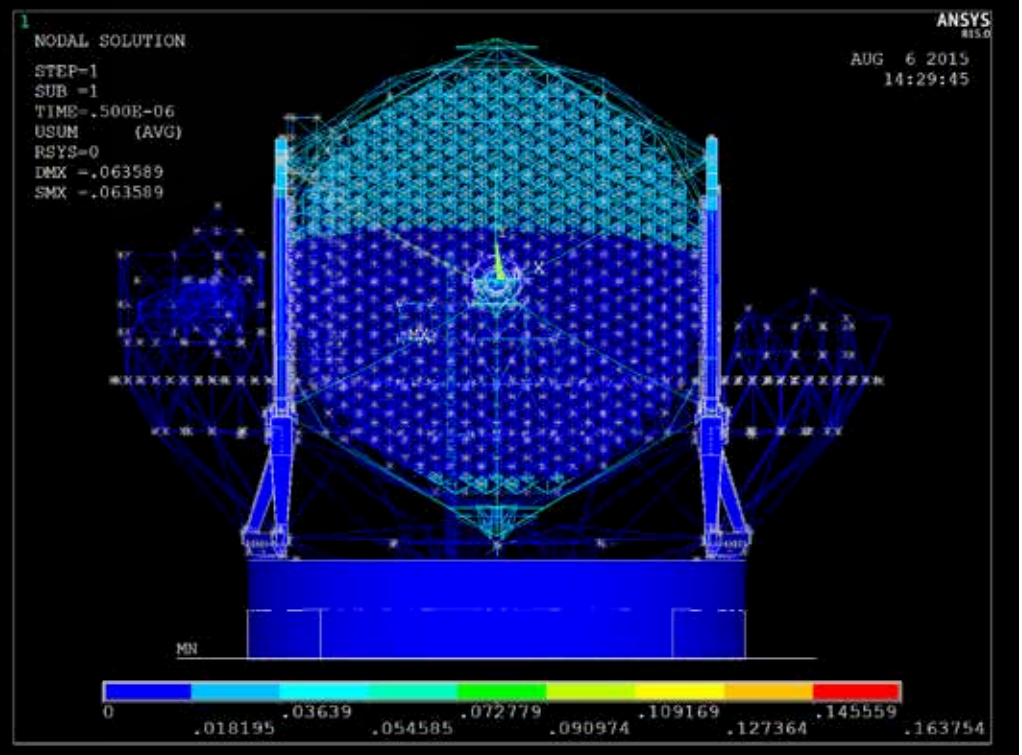
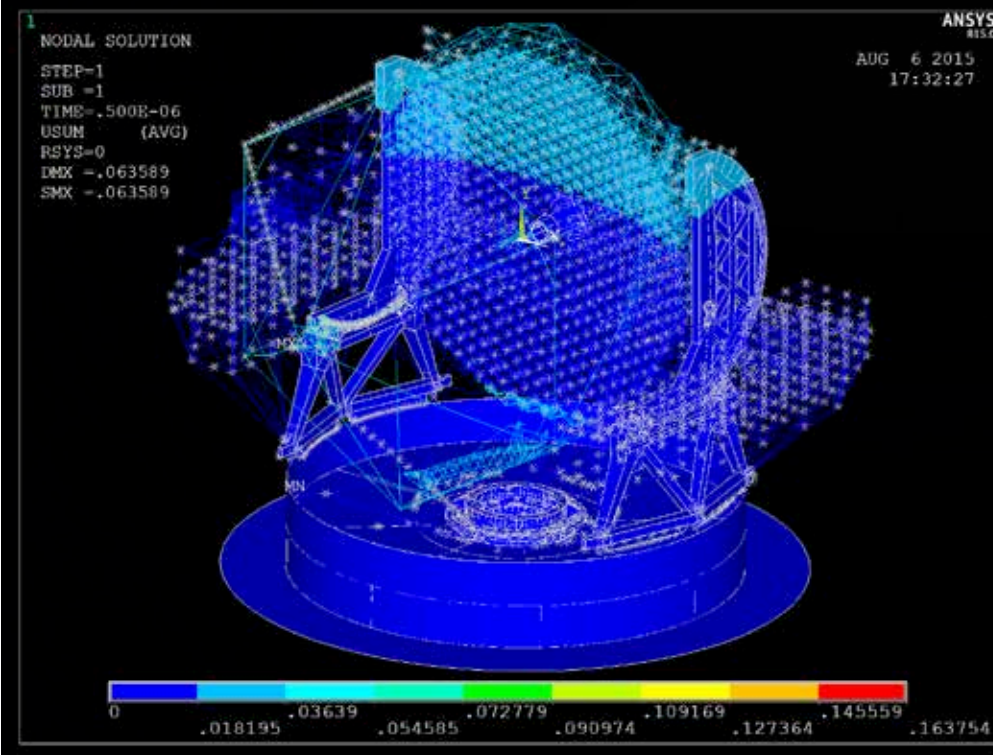




Seismic Analysis Movie



- ◆ 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?



Acknowledgements



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.