TMT
Thirty Meter Telescope

NAOJ
National Astronomical Observatory of Japan

望遠鏡設計とプロジェクト・観測所のデジタル化について

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望遠鏡構造(STR) SE/WPM
国立天文台 TMTプロジェクト

内容

- ✓ 技術シンポテーマ「実験観測装置の運用保守のDX化と効率化」
- ✓ DXというより、IT化/デジタル化に近い(?)が、
  - (1) プロジェクト・観測所等におけるIT・デジタル化(文書管理EDMS, 在庫管理WMS)の例として、プロジェクト管理ツール(JIRA, Redmine, Trello, Backlog, MS Planner…)の利用の仕方(ALMA/TMT: JIRA)について紹介
  - (2) TMT望遠鏡構造の紹介、特にCAD/FEM/制御モデル等CAEデータの設計者-プロジェクト間の共有状況

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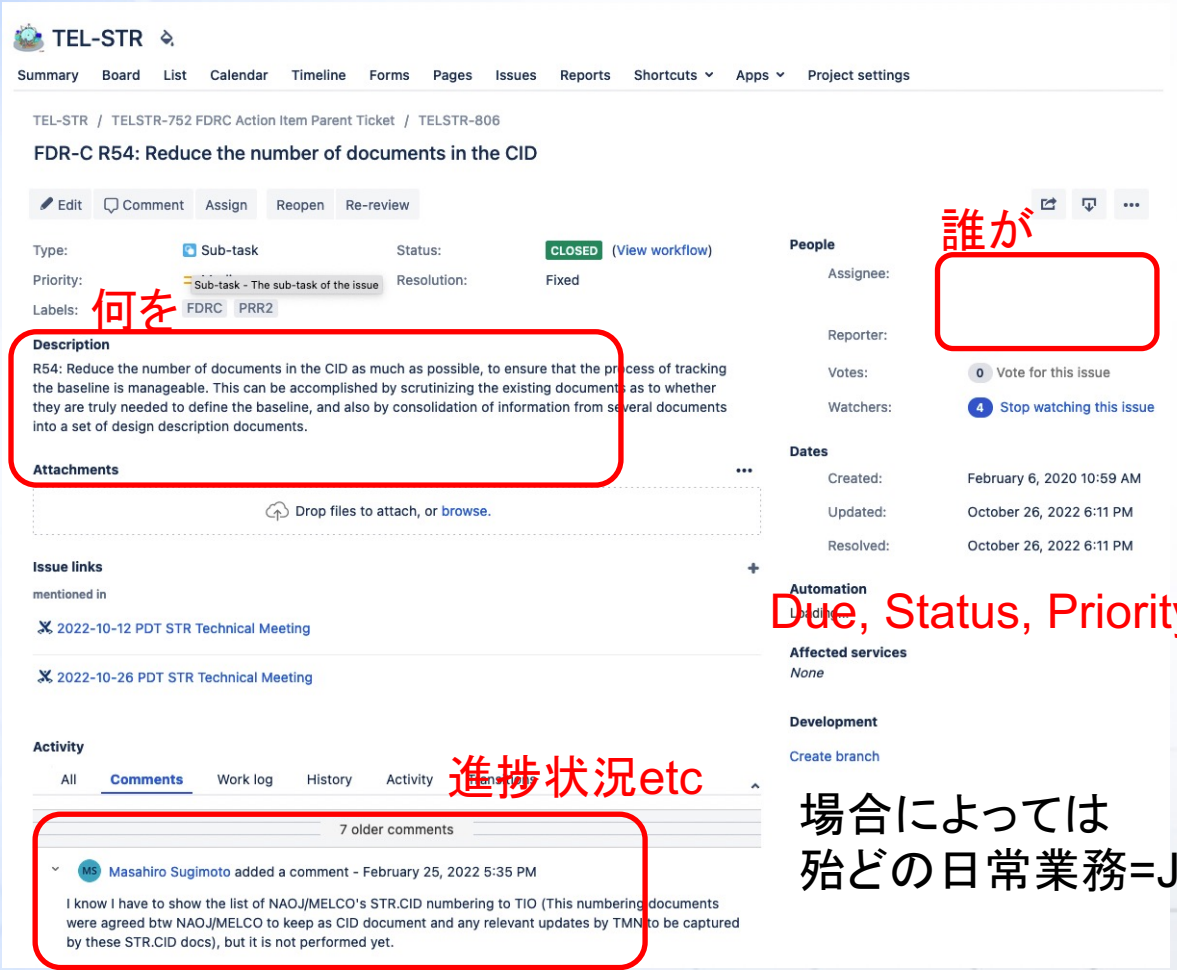
プロジェクト管理ツールの必要性

- ✓ プロジェクト(タスク)管理とは
  - ➢ プロジェクト管理ツールを家庭に導入!?
  - ➢ 家事分担に必要かどうかわからないが、、、”大規模な”プロジェクト・観測所でToDo List(誰が、いつ、何をやるか+Statusと履歴)を共有するのは有益
- ✓ 観測所(建設・運用)における課題(タスク)とは?
  - ➢ 建設期の例
    - 複数グループ(人)による設計作業、インテグレーション・検証作業、etc
    - 審査会のアクショントラック
  - ➢ 運用期の例
    - トラブル対応(観測者/オペレーター → エンジニア)
    - メンテ作業、etc

JIRA

- JIRA: タスク管理ソフトの一つ。天文観測所では比較的利用されつつある (ALMA, TMT, EELT, DKIST, SKA, LSST…..)



(1) タスクごとにページを作成 (固有番号)し担当者へアサイン

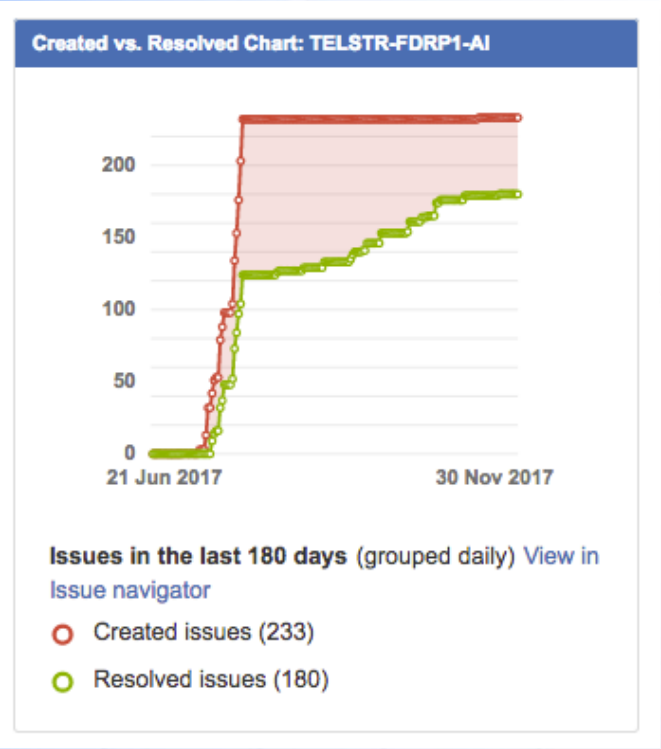
(2) 担当者は作業進捗等を記録

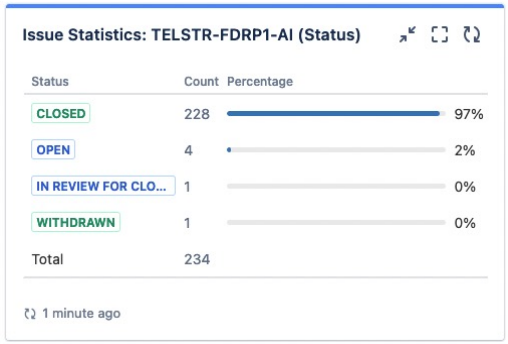
(3) タスク完了したら、担当者(or 権限者)がクローズする

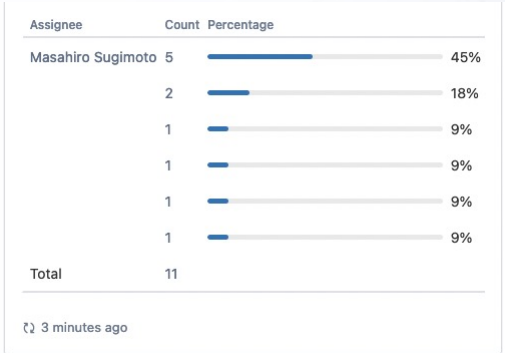
場合によっては
殆どの日常業務=JIRAを完了させること

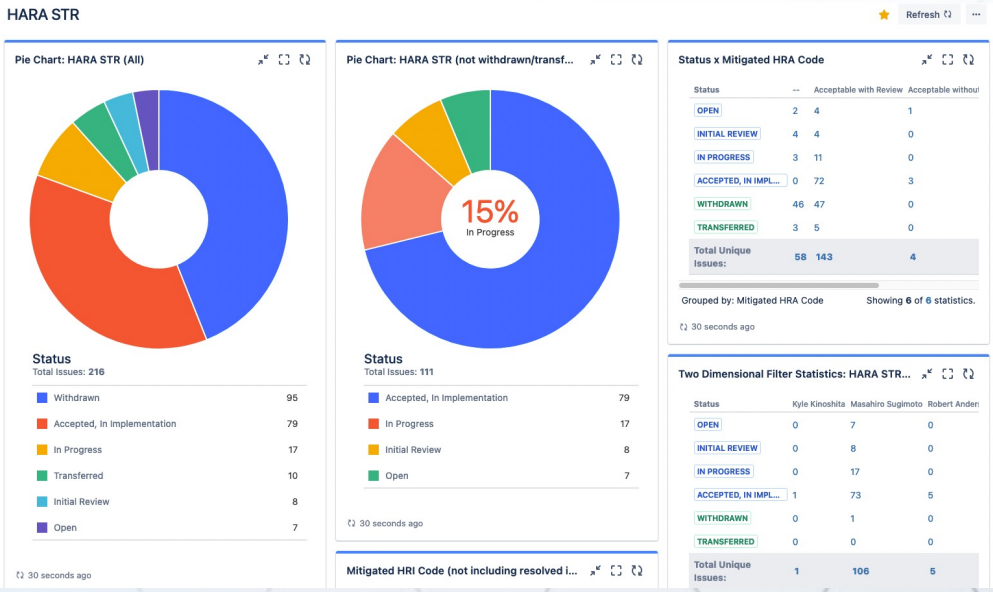
プロジェクト管理でのメリット例

- ✓ 要した作業時間やタスク全体の統計など自動で集計されるので、プロジェクト全体の状況をモニター(共有)できる。

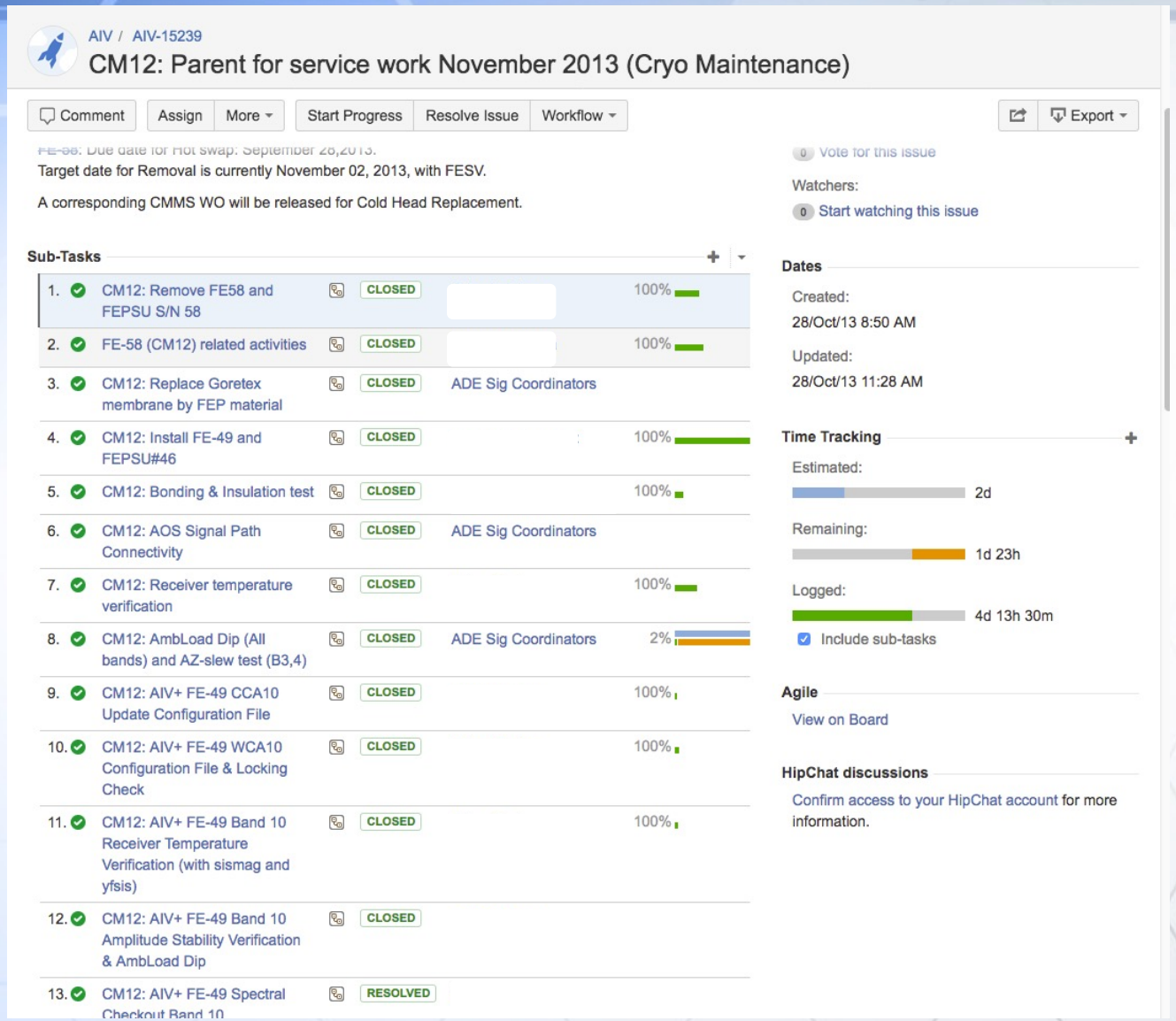








利用例:
インテグレーション(流作業)



AIV / AIV-15239

CM12: Parent for service work November 2013 (Cryo Maintenance)

Comment | Assign | More | Start Progress | Resolve Issue | Workflow | Export

~~FE-58~~: Due date for Hot swap: September 28,2013.

Target date for Removal is currently November 02, 2013, with FESV.

A corresponding CMMS WO will be released for Cold Head Replacement.

Sub-Tasks

1.	CM12: Remove FE58 and FEPSU S/N 58	CLOSED		100%
2.	FE-58 (CM12) related activities	CLOSED		100%
3.	CM12: Replace Goretex membrane by FEP material	CLOSED	ADE Sig Coordinators	
4.	CM12: Install FE-49 and FEPSU#46	CLOSED		100%
5.	CM12: Bonding & Insulation test	CLOSED		100%
6.	CM12: AOS Signal Path Connectivity	CLOSED	ADE Sig Coordinators	
7.	CM12: Receiver temperature verification	CLOSED		100%
8.	CM12: AmbLoad Dip (All bands) and AZ-slew test (B3,4)	CLOSED	ADE Sig Coordinators	2%
9.	CM12: AIV+ FE-49 CCA10 Update Configuration File	CLOSED		100%
10.	CM12: AIV+ FE-49 WCA10 Configuration File & Locking Check	CLOSED		100%
11.	CM12: AIV+ FE-49 Band 10 Receiver Temperature Verification (with sismag and yfsis)	CLOSED		100%
12.	CM12: AIV+ FE-49 Band 10 Amplitude Stability Verification & AmbLoad Dip	CLOSED		
13.	CM12: AIV+ FE-49 Spectral Checkout Band 10	RESOLVED		

Vote for this issue

Watchers:

Start watching this issue

Dates

Created:
28/Oct/13 8:50 AM

Updated:
28/Oct/13 11:28 AM

Time Tracking

Estimated: 2d

Remaining: 1d 23h

Logged: 4d 13h 30m

Include sub-tasks

Agile

View on Board

HipChat discussions

Confirm access to your HipChat account for more information.

利用例: トラブル対応

- ✓ 観測者/オペレーターがタスクを作成 → エンジニアが診断・対応

Investigation Reports / PRTSIR-4761 Negative (or too high) Trx Investigations

AOS: ACA: CM05 Negative Trec Pol Y in one

Edit | Comment | Assign | More | Reopen Issue

Details

Type:	Sub-task	Status:	
Priority:	Normal	Resolution:	
Affects Version/s:	None	Fix Version/s:	
Labels:	None		

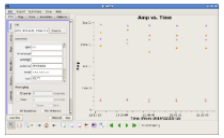
Description Description

Band ALMA_RB_03
ALMA Build 201404-CYCLE2-ON-B-2014-12-22-01-00-00
Array Name Array004 Array/Corr 7 [m]/ACA

Above project showed only in scan 10 negative Trec Pol Y for CM05:

```
AtmosphereReducedEvent:  71 SUCCESS execBlockEntityId  uid://A002/X9
=== New result: CAL_ATMOSPHERE FULL_RESOLUTION_AUTO Scans: [10]
Validity start: 2014-12-23T21:46:26.785000 duration: 0.50h Type: TEM
.
.
.
Ant: CM05 Band: ALMA_RB_03 Freq:  91.99- 93.99GHz Pres.: 555.27hPa T
          Polar: X Tsys:  48.3K Trec:  39.8K Tatm : 258.0K Tau: 0.03
```

Edit | Comment | Assign | More | Reopen Issue | Export



X24e_CM05BB3.png
71 kB 01/Jan/15 2:59 PM

Issue Links

Cloned from

~~PRTSPR-9877~~ AOS: ACA: CM05 Negative Trec Pol Y in one scan CLOSED

Activity

All | **Comments** | Work Log | History | Activity | Links Hierarchy | Transitions

Masahiro Sugimoto added a comment - 24/Dec/14 10:05 AM

linked to ~~PRTSIR-4761~~.

added a comment - 24/Dec/14 2:21 PM

Trx looks fine

Masahiro Sugimoto added a comment - 01/Jan/15 2:59 PM

I attached initial check of asdm.
X24e_CM05_spectra.pdf
X24e_CM05_time.pdf
X24e_CM05BB3.png

As written in description, only atmscan#10 showed negative trx in polY BB3/BB4 (pol1 USB). As shown in the plot X24e_CM05BB3.png (orange is polY), auto-corr values of ambient is relatively low - this led negative trx. I checked att setting recorded in monitordata but no change was detected (altough time resolution is not enough as usual).

プロジェクト管理ツールのまとめ(私見)

- メリット:
  - (比較的)大きな組織(の複数人)共有するタスク(家事分担では…?)、一定以上の時間・期間を要するタクス、に有効
  - 過去の似たタスクを検索できる(引き継ぎ不要とまでは言わないが)
  - (私自身あまり使ってないが) マネージャーとしては時間・リソース管理に有用
  - 見える化(結果として達成感、プレッシャー、etc)
- デメリット(ツールの問題でないものもあるが)
  - タクス作成・管理自体もそれなりの負担
  - クローズ条件の明確化、権限(フロー)の明確化(どう使うかのルール共通化)
  - ミスコミュニケーション(ツール上を通した喧嘩)を防ぐための配慮(背景説明、冷静な対応、etc)

利用経験者の皆様、ご意見を!

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TMT Thirty Meter Telescope

Members' contributions

NAOJ National Astronomical Observatory of Japan

Telescope

Enclosure

M2

M1 blank

M1 polish

30%

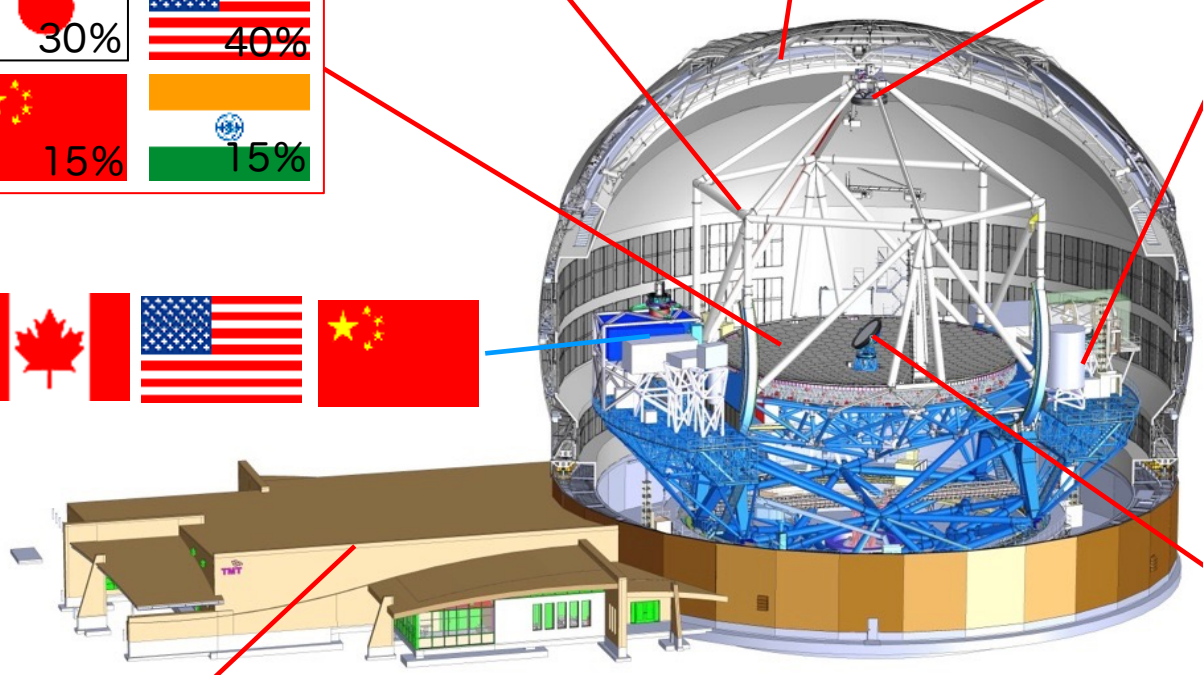
40%

15%

15%

Instruments

AO

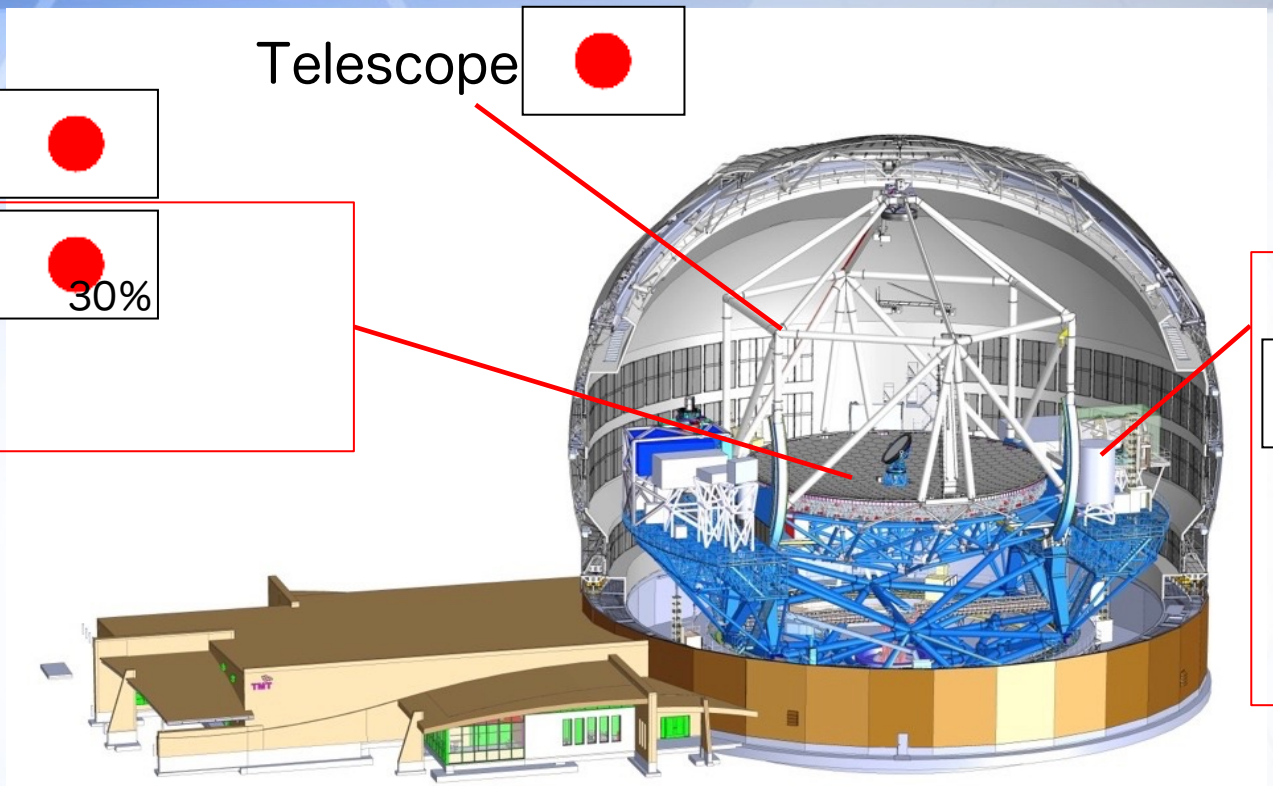


M3

Facility

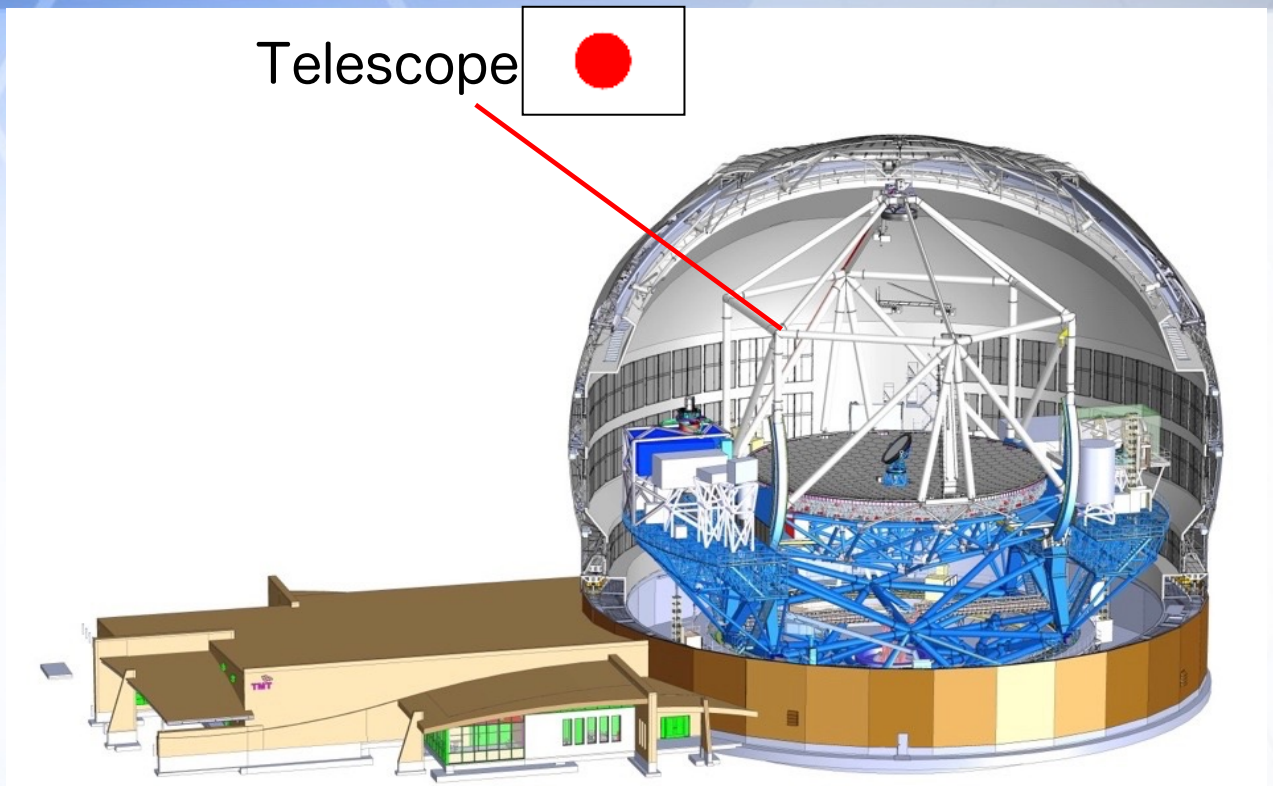
Control Systems
& Software

Japan's Contributions



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)



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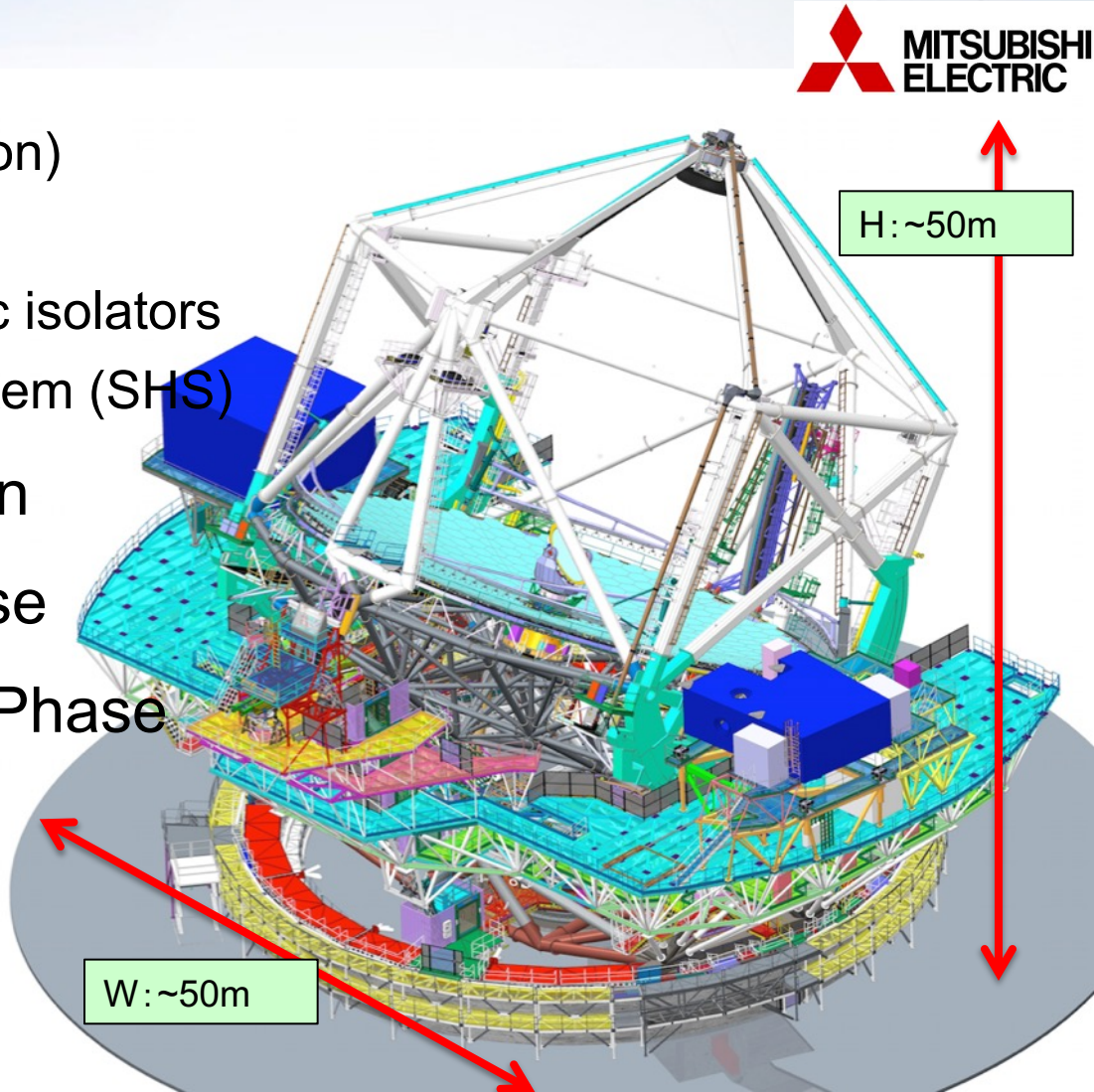
TMT-J activities: Telescope Structure (STR)

- 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
  - ✓ 11-12 Mar 2020: PRR1 (機械構造の一部) PASS
  - ✓ 16-17 Feb 2023: PRR2/3 (STR回転機械構造部)

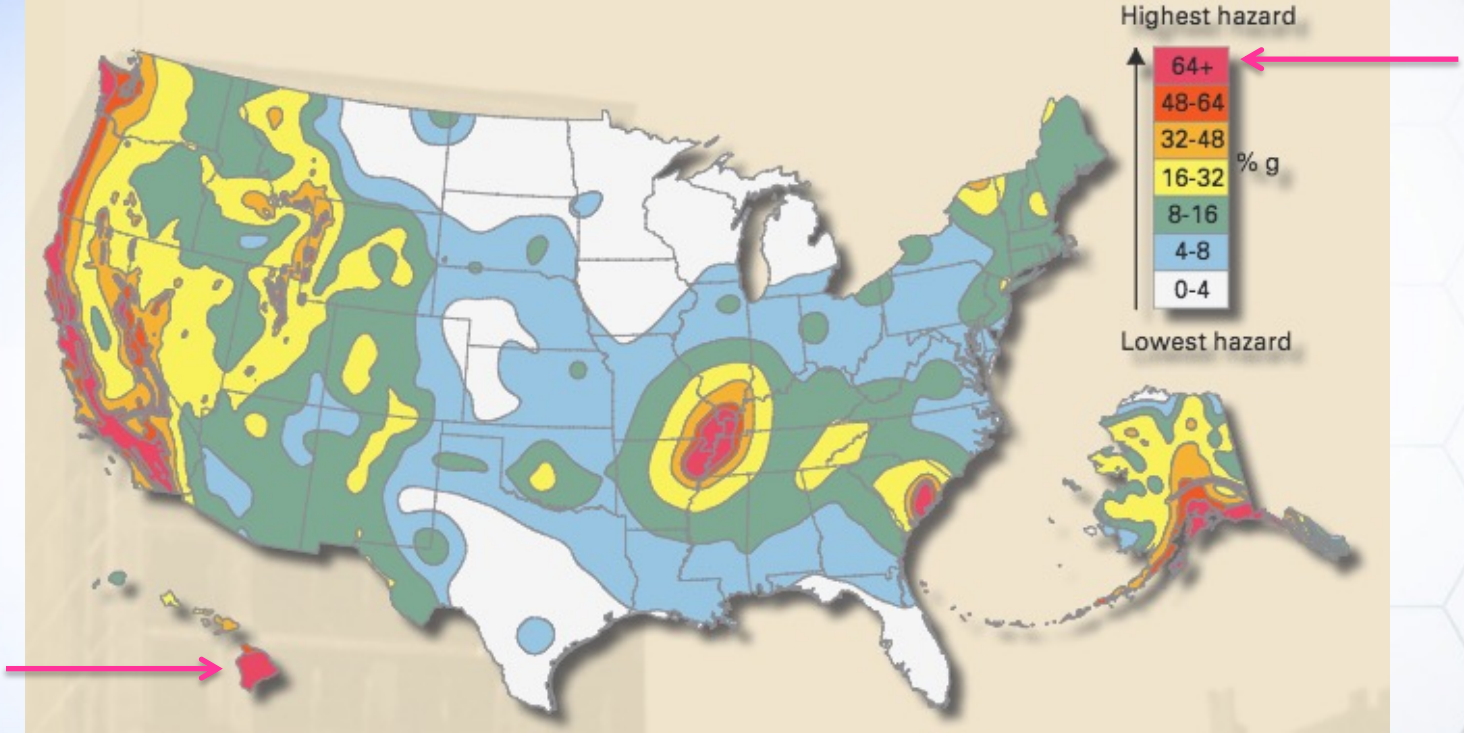
13 reviews / 10 years ~ 1.3 review per year

Organization working for TMT STR

TIO ~20	Partner agreement	NAOJ ~10	Contract	MELCO >20	Contract	Subcontractors (?
STR Group (3) Lead/Structural /Utilities Eng		Full time for STR Group (5)		Key (~20) MGT/SYS (~5) Mecha (~5) Control (~3) Utilities (~2) From R&D etc (~3) Support(?)		Subsidiary (CAD/Coding)
SE Group (~5) Lead/SE/Config SE/Req SE Cont Group (~3) Lead/Soft Eng Other Sys (~10) Optics/Inst Eng Safey/QA(~2)		Part time for STR Group Part (4)				Construction company
		Others MGT/Business/Translation/ etc		Contract		Specific Subsystem (eg ELV)
Others MGT etc						⋮

Seismic Isolation System
How big EQ could happen?

✓ Hazard Map

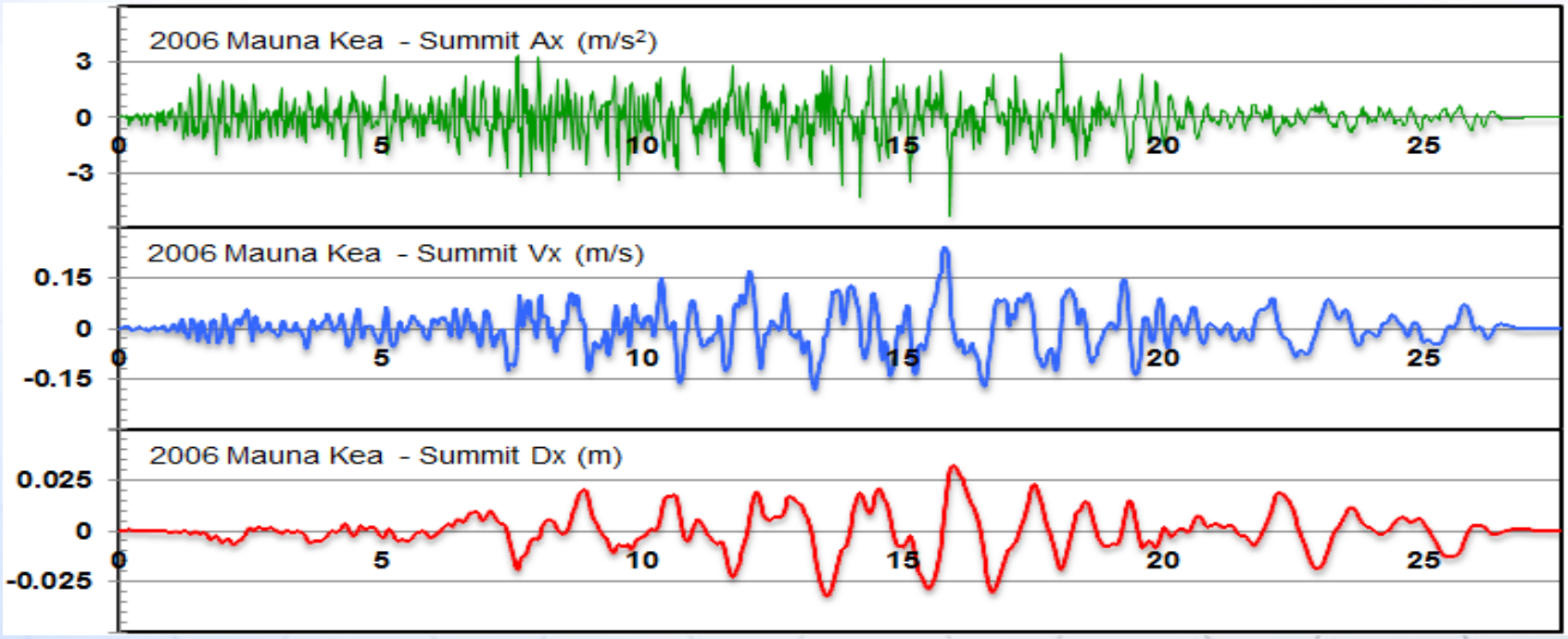


*The 2008 U.S. Geological Survey National Seismic Hazard Maps for the United States are based on current information about the rate at which earthquakes occur in different areas and on how far strong shaking extends from earthquake sources. Colors on this particular map show the levels of horizontal 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 specifies time-series seismic wave patterns of 1000yr return periods, which scaled from past seismic
- Example of wave(typical 23 sec, dT=5 msec)

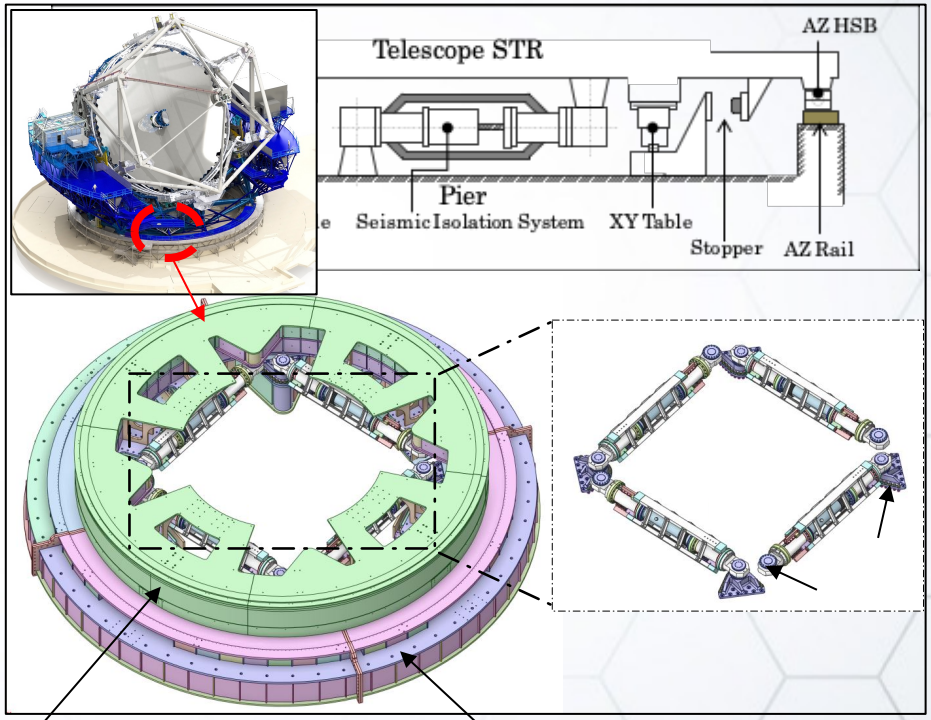
	Max Ground Motion (cm) (g)		
Seismic Event	Lateral X	Lateral Y	Vertical Z
1992 N Palm Springs	12	15 0.44	5
1989 Gilroy Array #3	8	20 0.51	8
1994 UCLA Grounds	9	9 0.51	4
1979 SAHOP Casa Flores	3 0.45	5	2
1980 Convict Creek	4	6 0.42	5
1983 Mauna Loa	15	8 0.50	7
2006 Mauna Kea	3 0.54	4	2



Seismic Isolation System (SIS)

➢ TMT STR has 4 horizontal SISs in the Pintle bearing and base

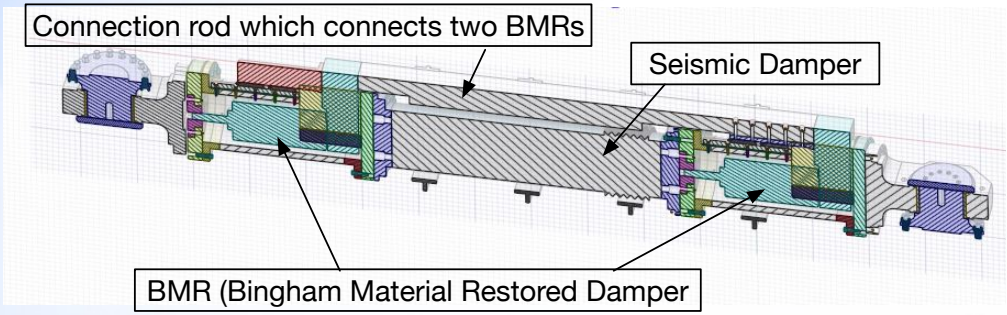
- ✓ Under normal telescope operations, SIS has high rigidity to avoid runout of the rotating Az axis.
- ✓ Under a seismic event above certain threshold, the dampers in SIS start absorbing the seismic energy by expansion and contraction.

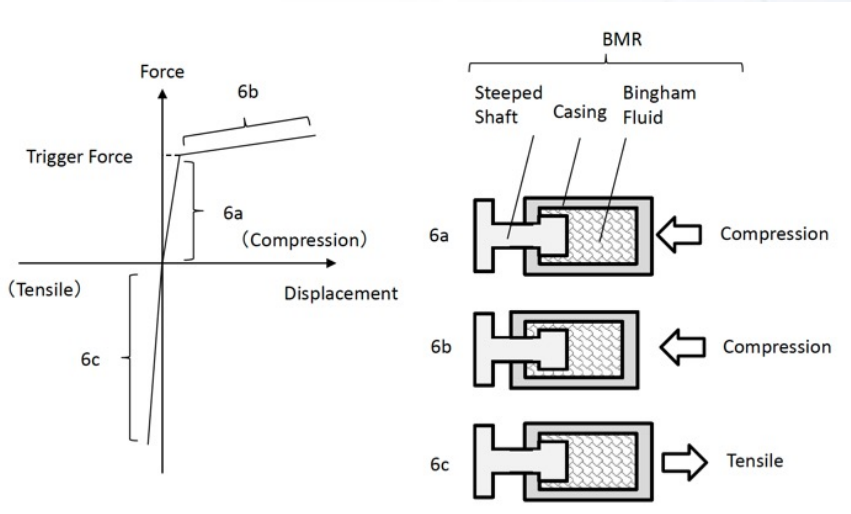


Suigmoto+22 SPIE proc

Seismic Isolation System (SIS)
SIS components

- SIS* has two Bingham Material Restored (BMR)** dampers and seismic linear damper.
  - ✓ BMR stiffness is switched to be low once it starts to move when the applied load exceeds the certain threshold of the trigger force.



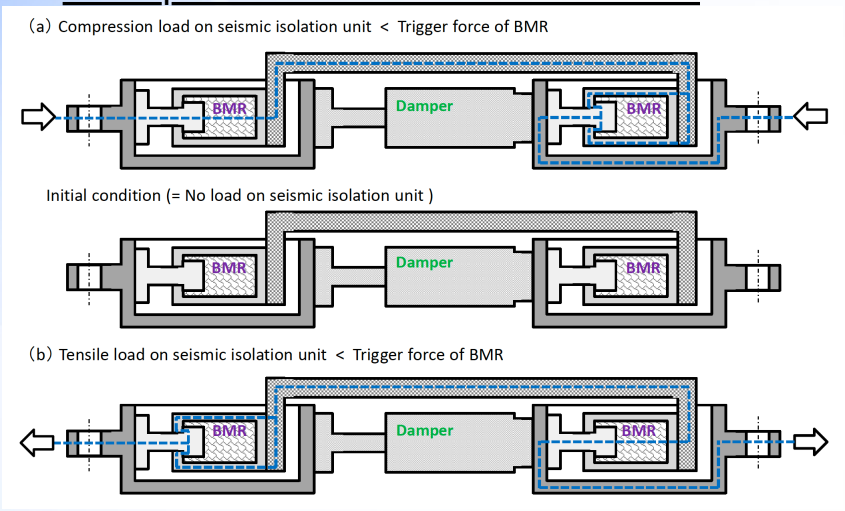


** Hattori+17 Patent WO2017/056265, Kato+20 Patent, WO2020/084848*
** OILES-Corporation. https://www.oiles.co.jp/en/.

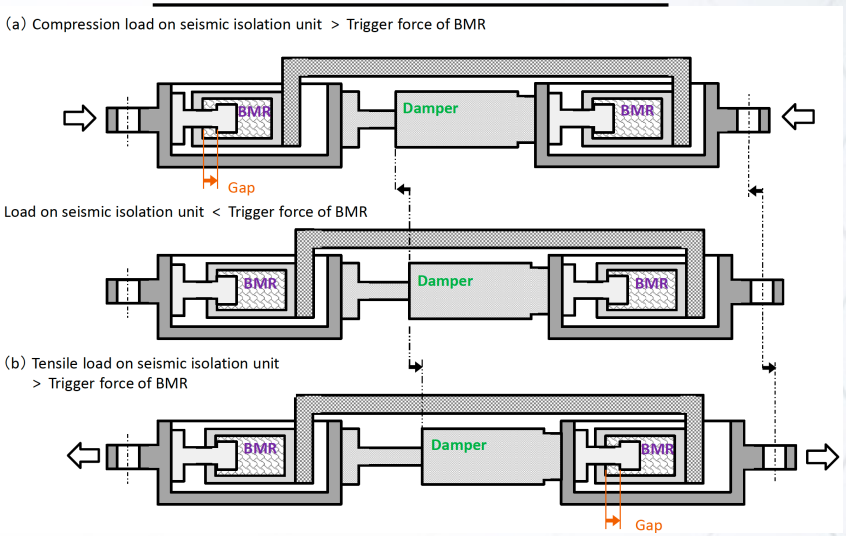
Suigmoto+22 SPIE proc

Seismic Isolation System (SIS)
SIS load path

Load path under normal observation



Behavior under seismic event



Under trigger force of BMR

- ✓ Load is supported by Stiffness of BMR and connection rod.
- ✓ Damper does not move.

Above trigger force of BMR

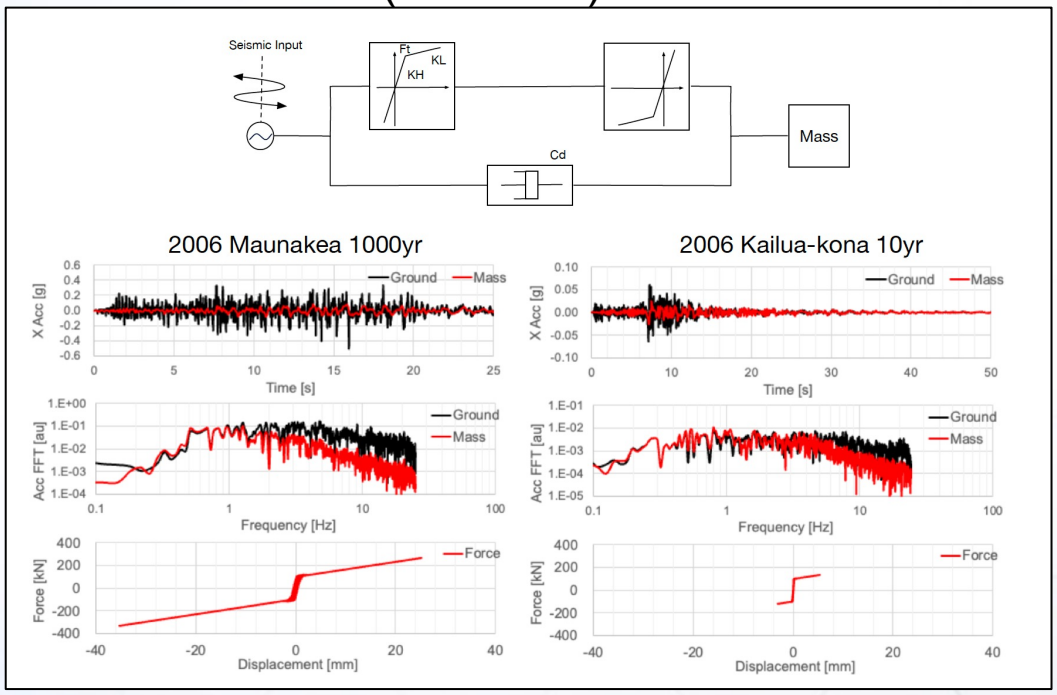
- ✓ BMR shaft starts to move.
- ✓ Damper also start to move and absorb the seismic energy

Suigmoto+22 SPIE proc

Seismic Isolation System (SIS) Performance

- Trigger Force determined to be ~100 kN (F/Mg ~0.01g)
- Cd =5.3x10^6 N/m so that acceleration well reduced and keeping displacement less than mechanical constraints (<=60mm)

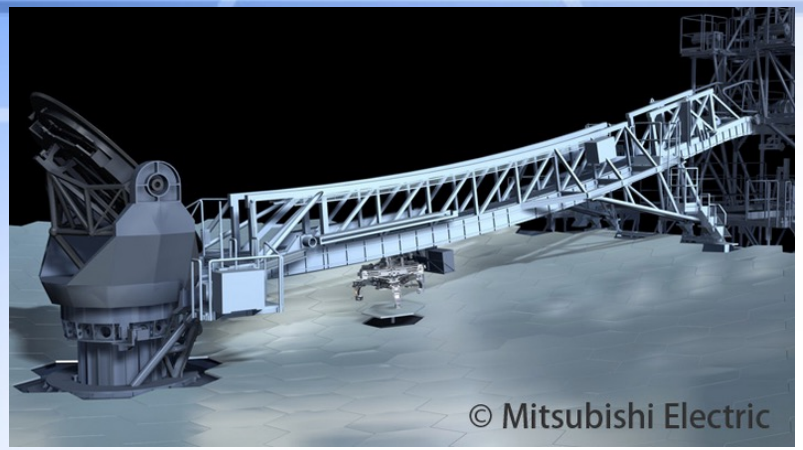
PGA ~ 0.5G
Mass ~0.09G



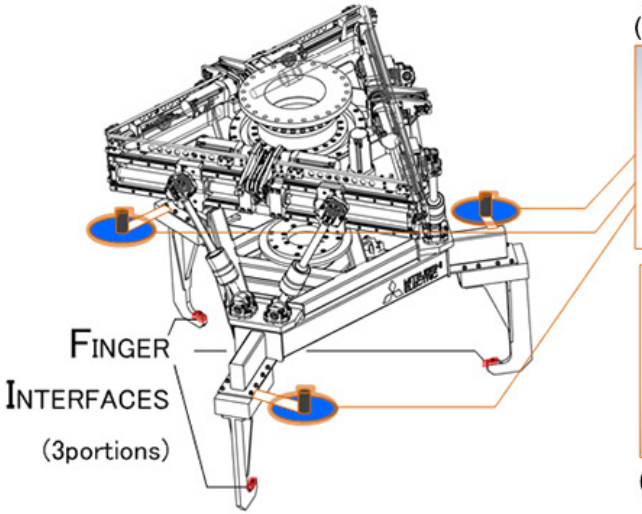
PGA ~ 0.06G
Mass ~ 0.03G

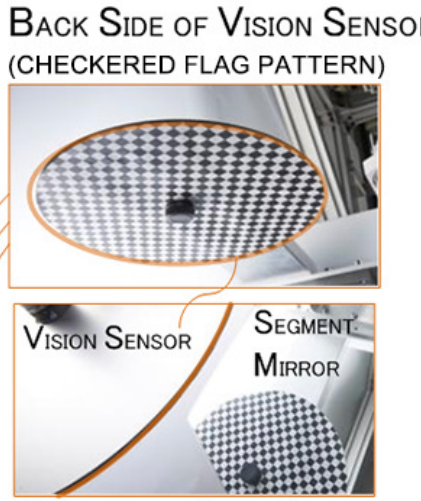
Suigmoto+22 SPIE proc

Segment Handling System Vision sensor



Vision sensor (画像認証)

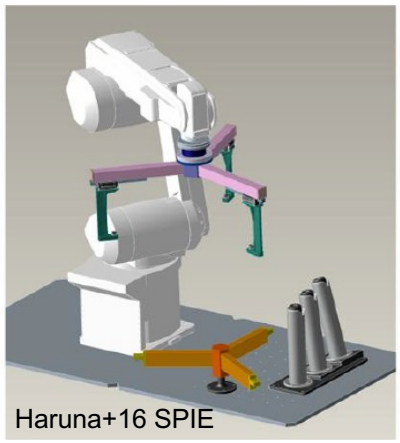


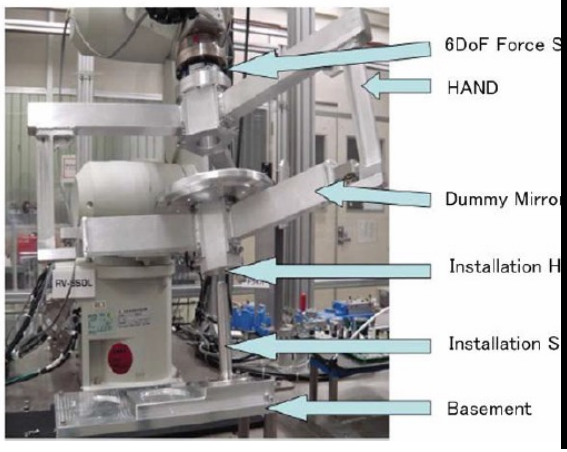


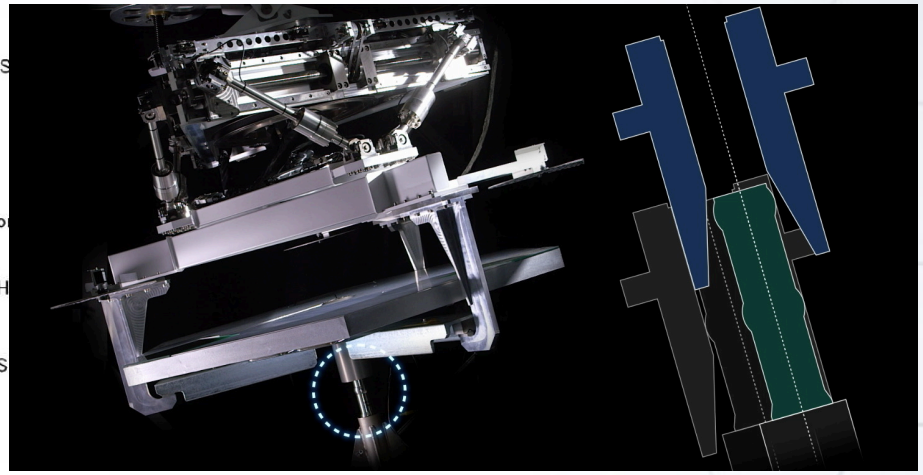
https://www.mitsubishielectric.com/en

Segment Handling System Compliance Control

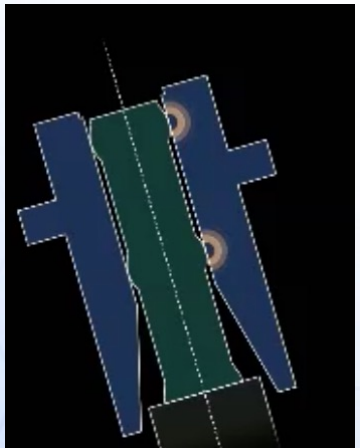
- FA technology applied
  - Realtime monitoring of load cell output


Haruna+16 SPIE

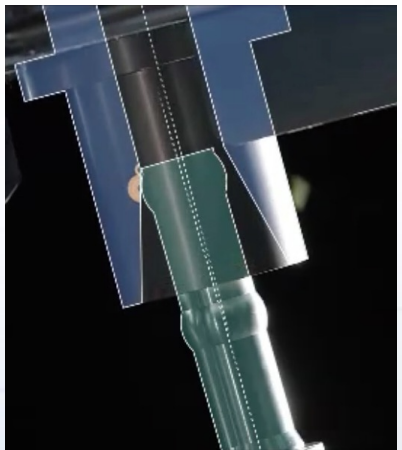


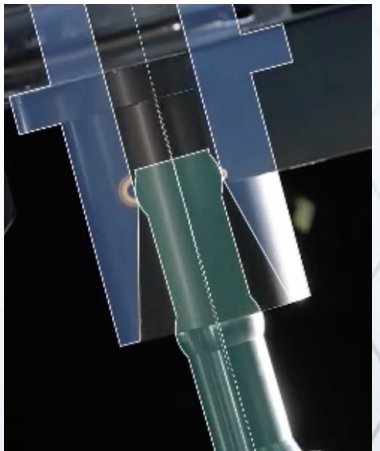


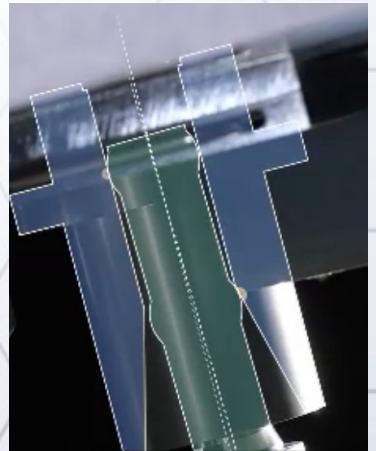
Removal



Installation







内容(2後半)

- ✓ 技術シンポテーマ「実験観測装置の運用保守のDX化と効率化」
- ✓ DXというより、IT化/デジタル化に近い(?)が、
  - (1) プロジェクト・観測所等におけるIT・デジタル化(文書管理EDMS, 在庫管理WMS)の例として、プロジェクト管理ツール(JIRA, Redmine, Trello, MS Planner…)の利用の仕方(ALMA/TMT: JIRA)について紹介
  - (2) TMT望遠鏡構造の紹介、特にCAD/FEM/制御モデル等CAEデータの設計者-プロジェクト間の共有状況

望遠鏡CAEデータ共有の状況

- ✓ 国立天文台の大型望遠鏡構造の多くは望遠鏡メーカーで設計・製造。設計情報が徐々に電子化・開示範囲が増。

- ✓ TMTではCAD, FEM, 制御モデルなどがプロジェクト(観測所)と共有されている。
  - ➢ 設計検証、他のサブシステムとのI/F確認・検証などに利用。例を紹介。

CAD

- ✓ CAD更新版を管理(Solidworks PDM)・インターフェイス確認を常に実施 at プロジェクト

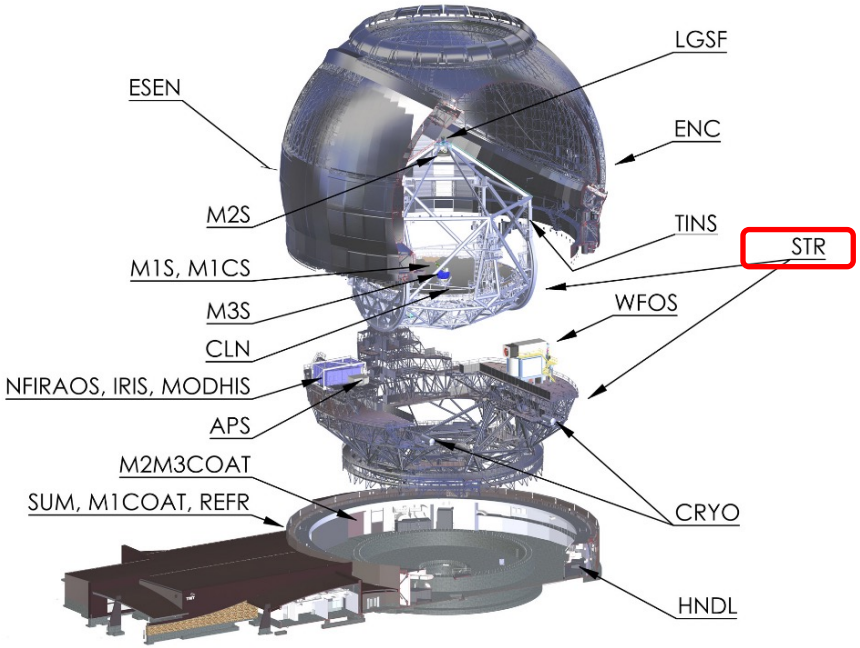


Figure 1. Sectioned and exploded view of the TMT Digital MockUp (DMU) – a top-level observatory CAD model. Selected subsystems are labeled in the figure. Each TMT subsystem is designed by a different team, and various CAD authoring tools are used. Each time a subsystem completes a major CAD revision, the TMT Systems Engineering group performs inspections, documents the results, and integrates the work into this top-level assembly.

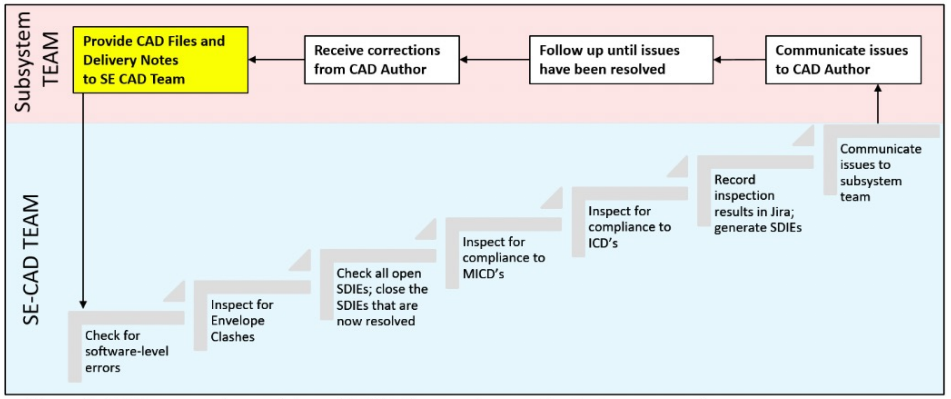
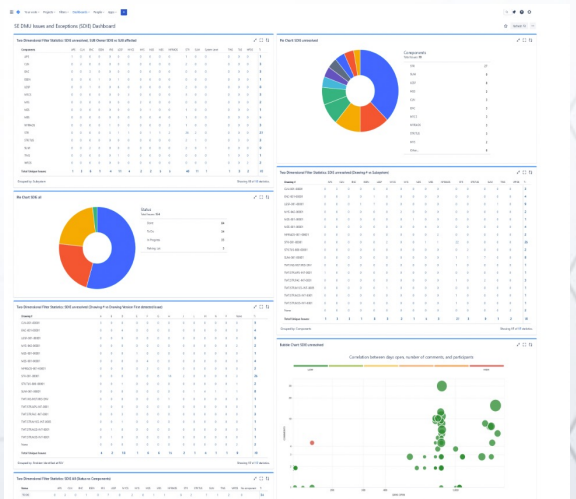


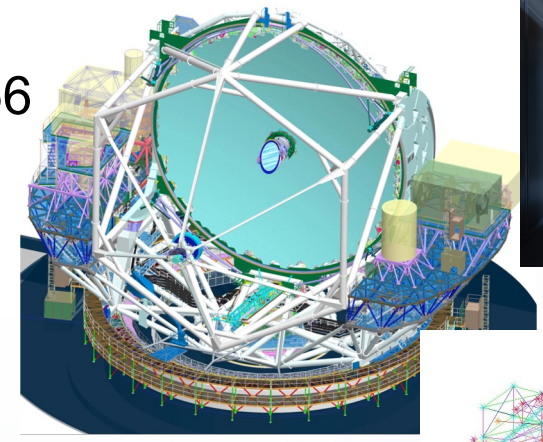
Figure 7: TIO's process for receiving a CAD Delivery and prompting for improvements

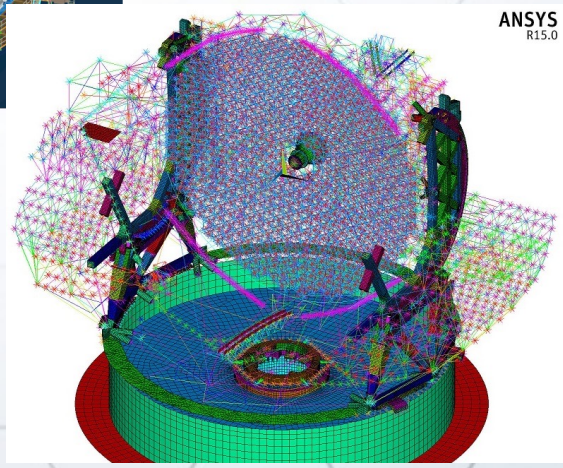


Church+22 SPIE proc. 121871R

FEMの共有
Seismic Analysis with NAOJ ATERUI

- 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

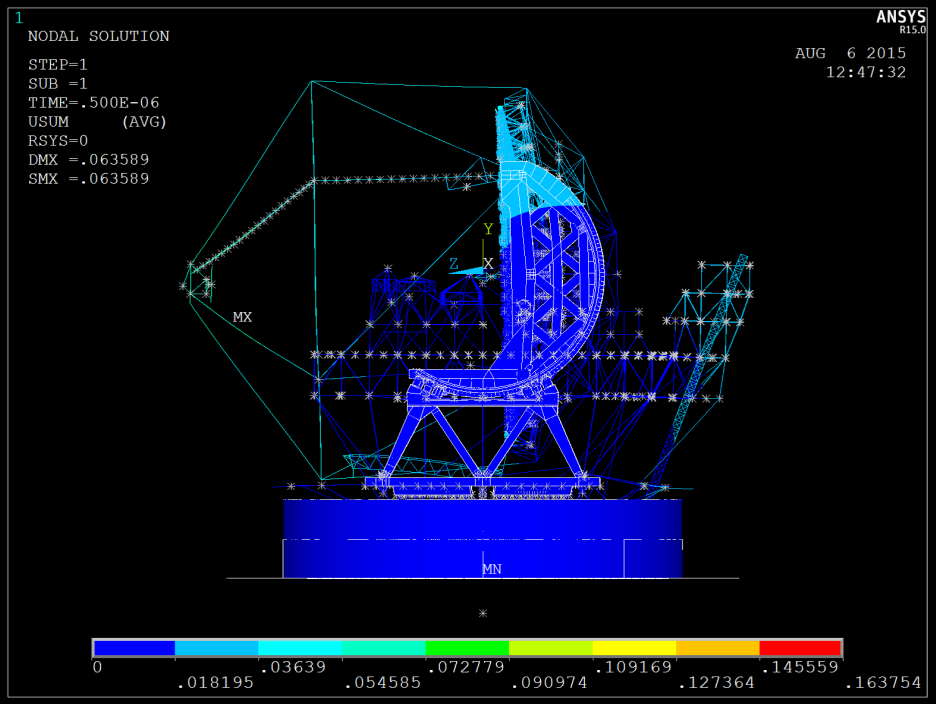


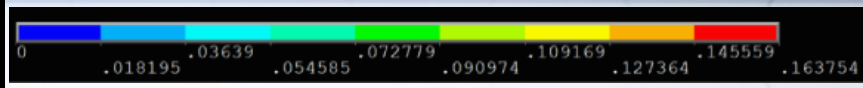


Seismic Analysis Movie

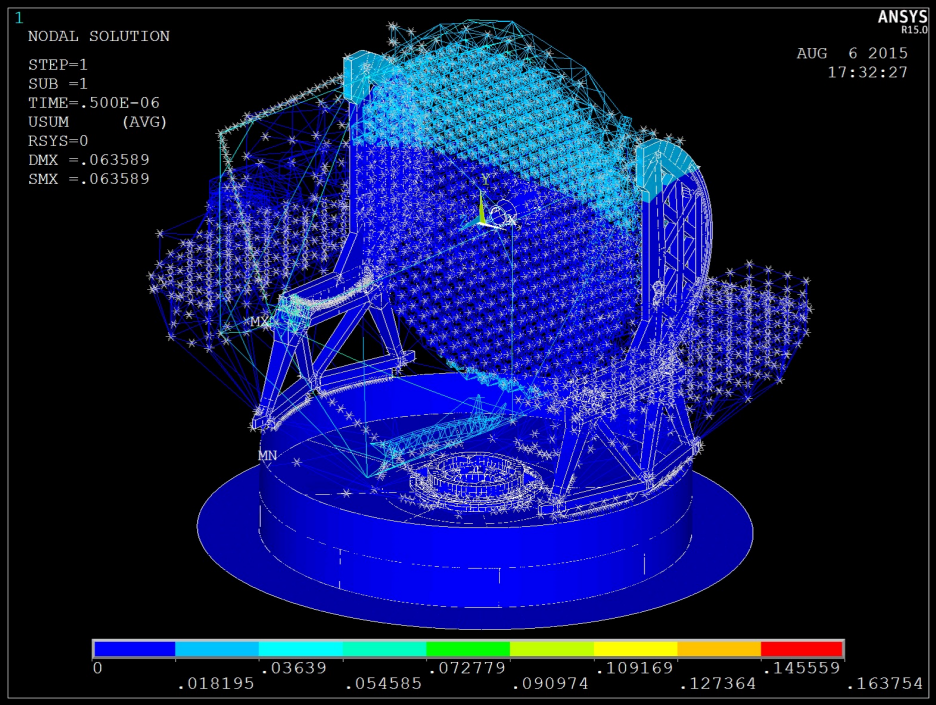
ANSYS

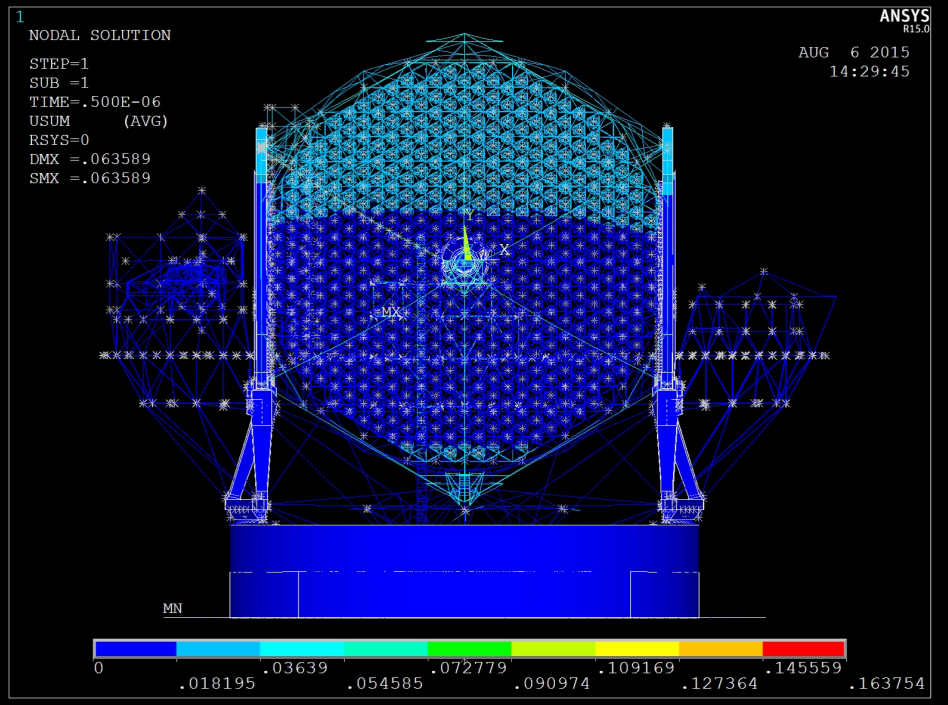
National Astronomical Observatory of Japan





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





FEMの共有: 静解析

- ✓システム設計段階で解析ソフト(ベストフィット、M1 actuator必要ストローク見積もり, etc, by Matlab)を開発
- ✓STR詳細設計段階では、STR仕様検証にも利用。

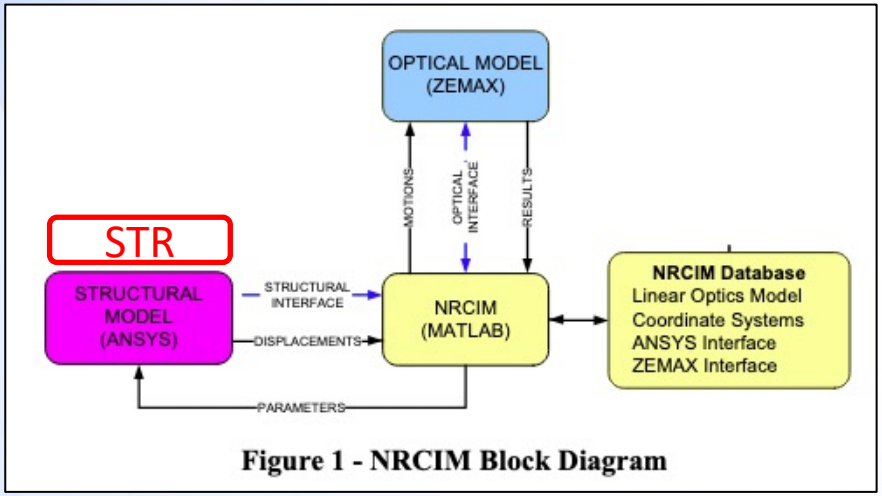


Figure 1 - NRCIM Block Diagram

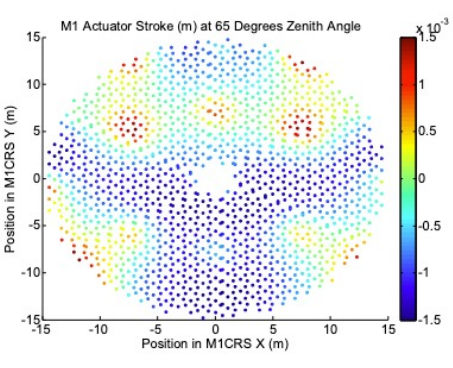


Figure 7 – Actuator stroke requirement at 65 degrees zenith

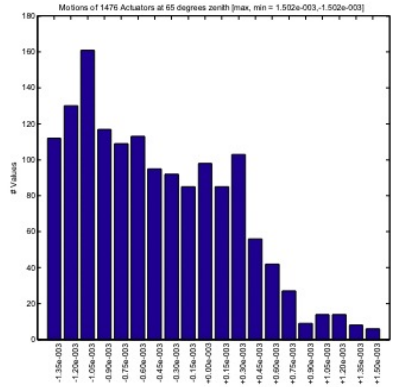
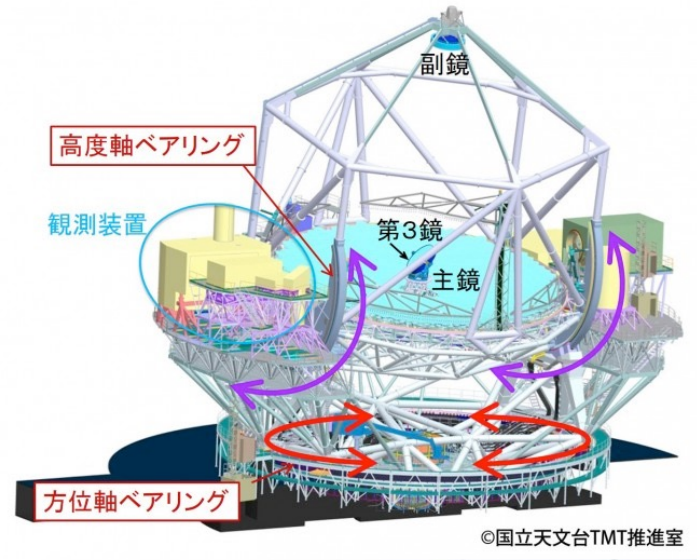


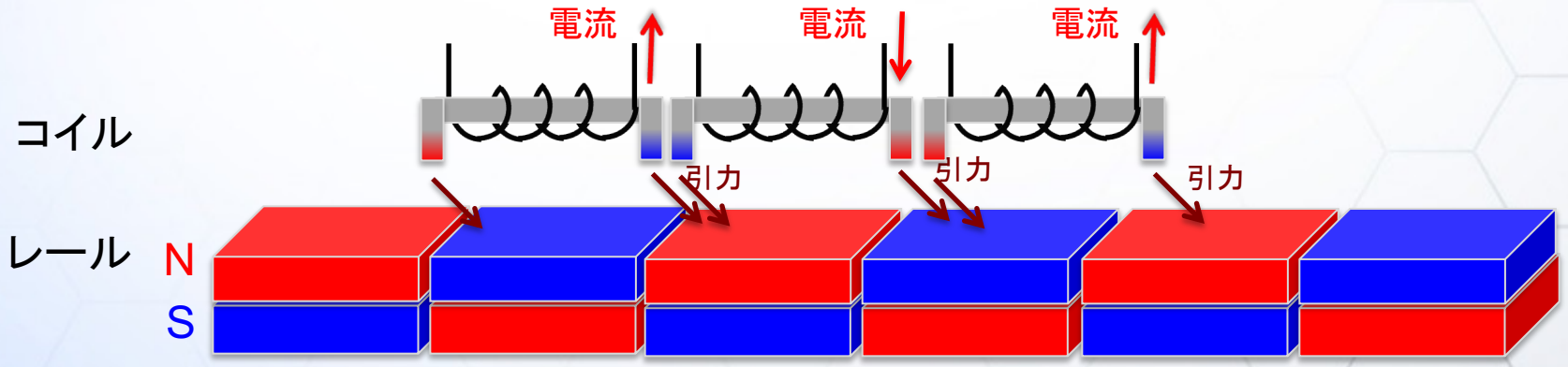
Figure 8 – Histogram of actuator stroke requirement at 65 degrees zenith

Systems engineering of the Thirty Meter Telescope through integrated opto-mechanical analysis. Roberts+10 SPIE proc. 773818

望遠鏡駆動

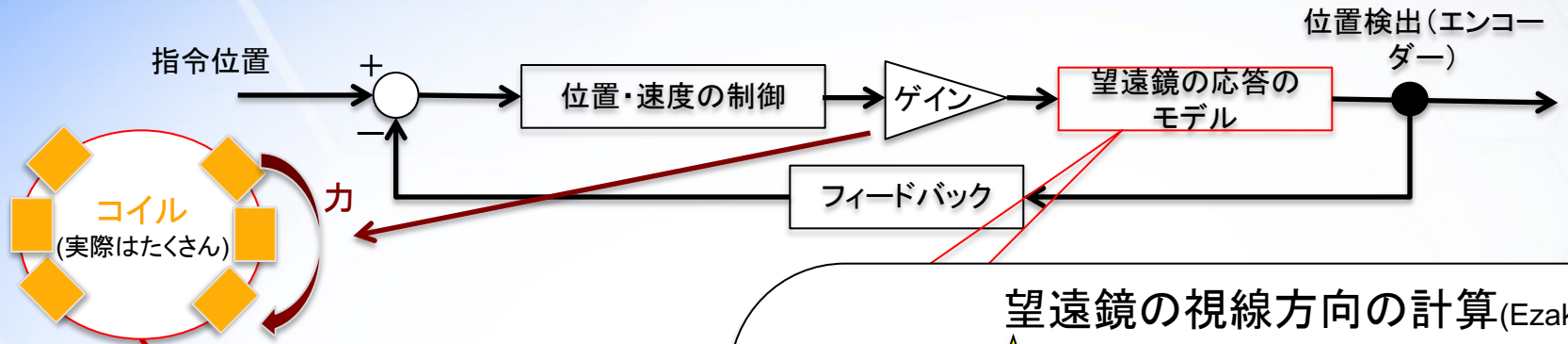
- 駆動軸：方位軸と高度軸
- リニアドライブ
  - ✓ レール側：磁石(NSを交互に配置)
  - ✓ コイル：NSを切り替えて推力を発生



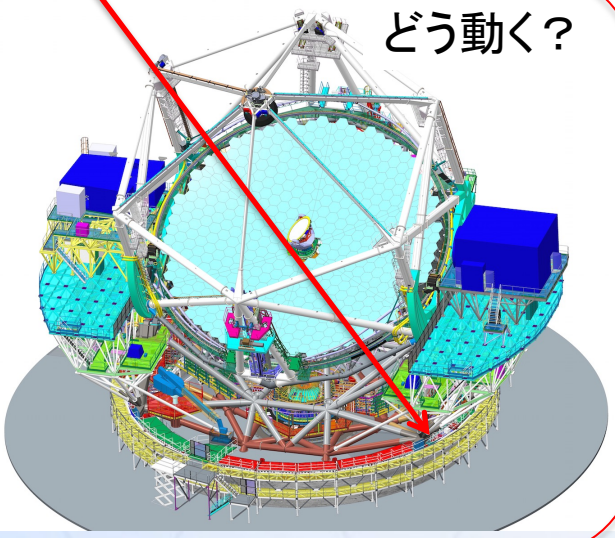


制御モデルの共有

- 動的応答特性と考慮した制御シミュレーション

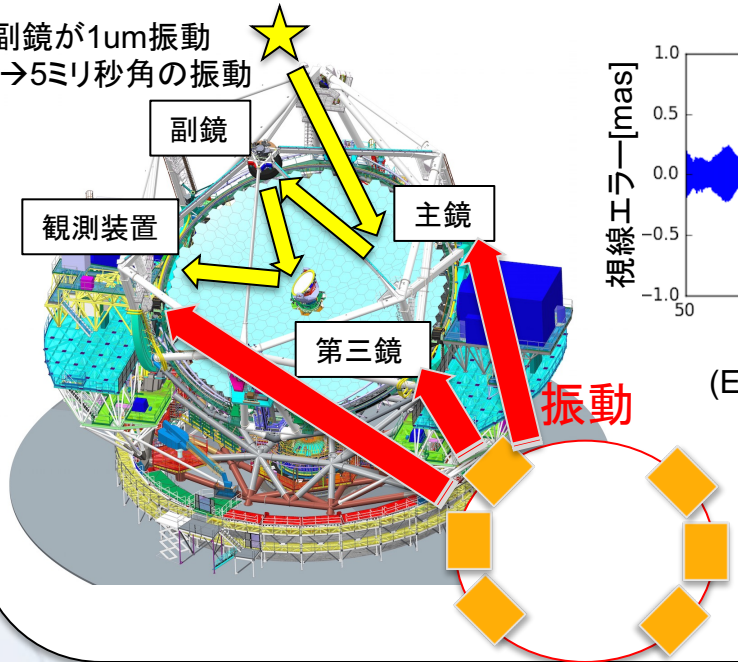


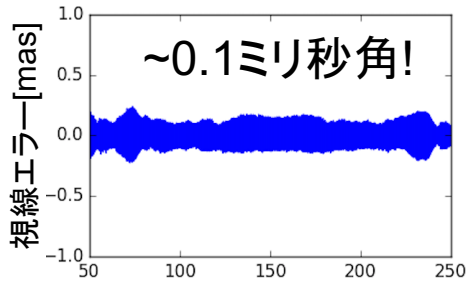
どう動く？



望遠鏡の視線方向の計算(Ezaki+16)

副鏡が1um振動
→5ミリ秒角の振動





(EL=70deg、南中=150s)

望遠鏡CAEデータ共有のまとめ

- ✓ 国立天文台の大型望遠鏡構造の多くは望遠鏡メーカーで設計・製造。設計情報が徐々に電子化・開示範囲が増。

- ✓ TMTではCAD, FEM, 制御モデルなどがプロジェクト(観測所)と共有されている。
  - ➢ 設計検証、他のサブシステムとのI/F確認・検証などに利用。例を紹介。
  - ➢ 共有に至った経緯は様々 (複雑I/Fの検証確認、観測所から初期モデル・ツール提供があった、解析主体が複数、etc)
  - ➢ 運用期においても性能検証・比較、アップグレード・改修等においても有用な情報となると想像

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.