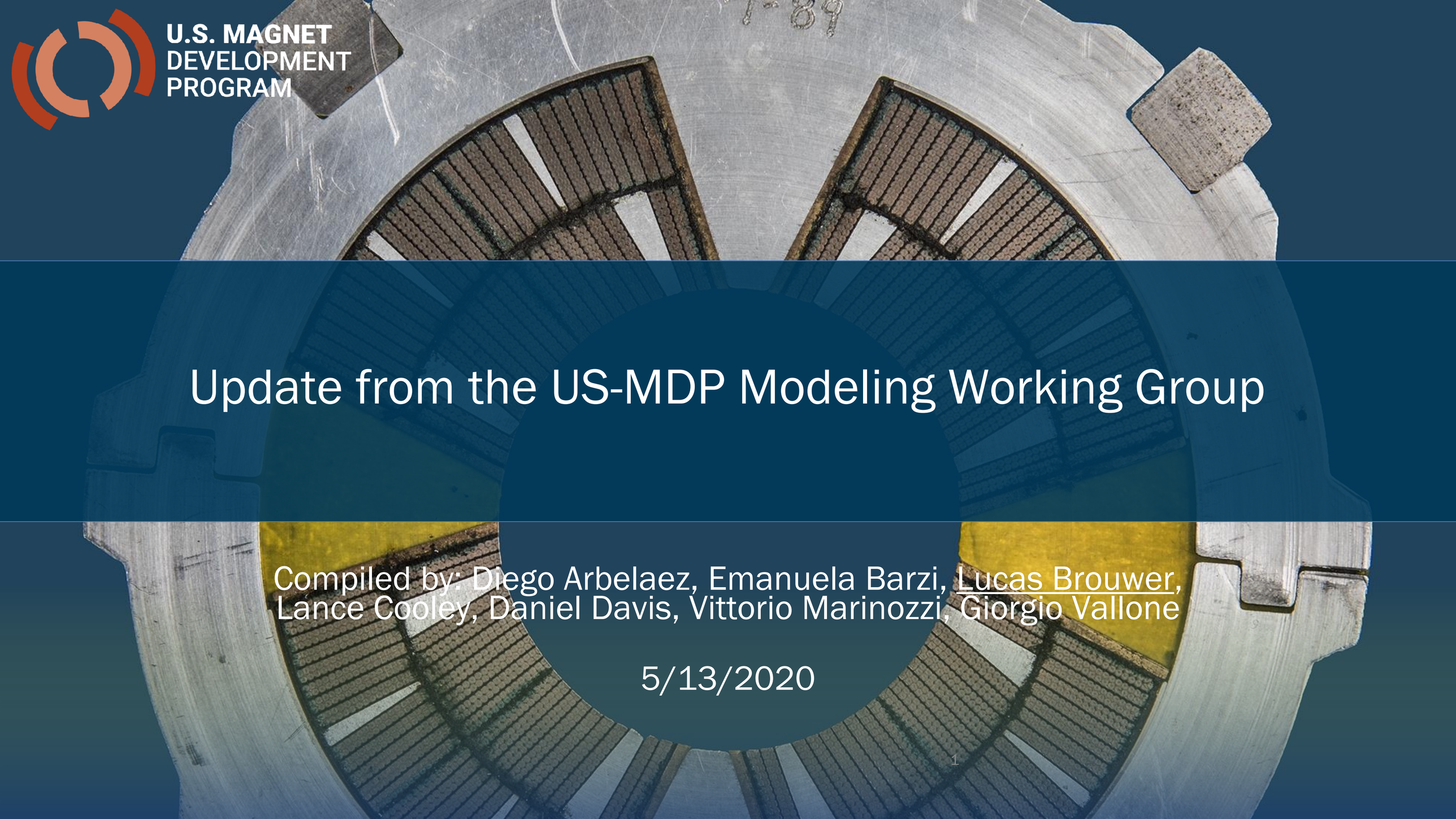


U.S. MAGNET DEVELOPMENT PROGRAM

Update from the US-MDP Modeling Working Group

Compiled by: Diego Arbelaez, Emanuela Barzi, Lucas Brouwer, Lance Cooley, Daniel Davis, Vittorio Marinozzi, Giorgio Vallone

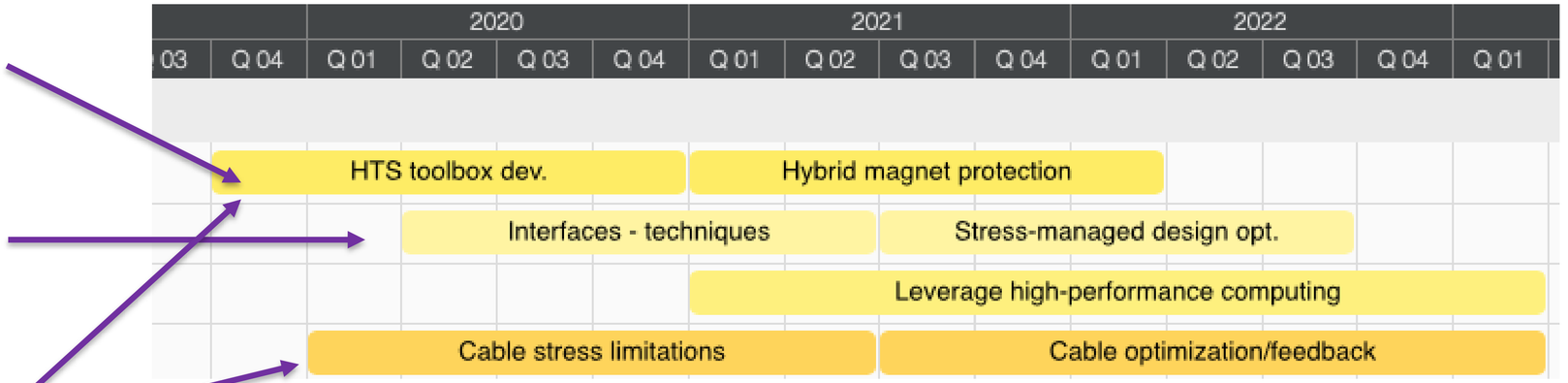
5/13/2020

Key Questions to Answer in the MDP Modeling Roadmap

How do we best protect LTS/HTS hybrid magnets and interpret results?

How does interface behavior in stress managed designs impact training?

Can we better understand and improve LTS/HTS conductor and cable?



Connection to MDP Goals and Roadmaps

Interface Modeling

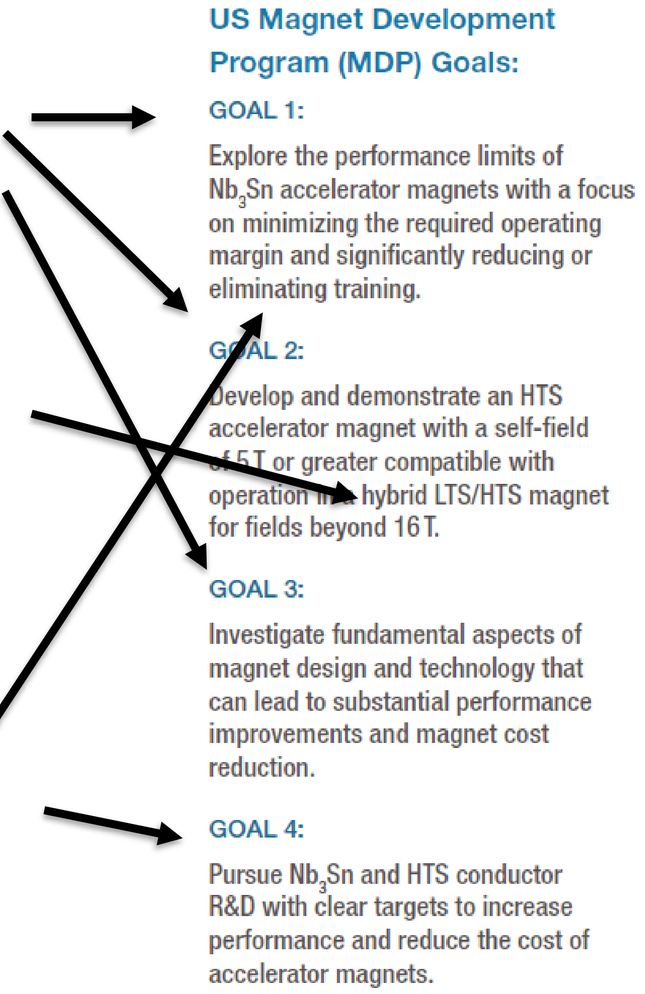
- explores performance limits of Nb_3Sn and HTS in stress managed designs
- guides technology development in epoxies and impregnation techniques

Hybrid Magnet Design and Quench Protection

- new LTS/HTS roadmaps quickly converge with hybrid testing becoming a key priority for MDP

LTS/HTS Conductor and Cable Modeling

- guides the design of new Nb_3Sn strand for training reduction (high Cp)
- refines strain limits of Nb_3Sn and HTS magnets
- optimization of LTS/HTS cable for accelerator applications



We now have a dedicated, open, monthly meeting of the modeling working group

Goals/Purpose:

(1) detailed discussion of modeling techniques (opportunity to go “into the weeds” and learn from each other)
(2) coordinating and working together towards MDP roadmap milestones
(3) form the basis of future updates to the general MDP (in summary / conclusions)

April 21st, 2020 (kickoff)

- discussion of working group goals and purpose/format for future meetings
- selection of initial topics for upcoming meetings

We plan to announce meeting topics ahead of time so anyone interested from MDP can join – email lnbrouwer@lbl.gov to be placed on mailing list

Topics for the next several months are set

April 21st, 2020 (kickoff)
- discussion of working group goals and purpose/format for future meetings
- selection of initial topics for upcoming meetings

May 19th, 2020 (multi-scale modeling of conductor and strain limits – 1)
- Diego Arbelaez, “multi-scale modeling of conductor and magnets”
- Giorgio Vallone, “a methodology to compute the critical current limit in Nb_3Sn magnets”

June 16th, 2020 (multi-scale modeling of conductor and strain limits – 2)
- Emanuela Barzi, “overview of sub-modelling at FNAL and in the broader community”

July 21st, 2020 (review of multi-physics tools for quench protection studies)
- TBD: (pos. Dan Davis and/or Vittorio Marinozzi), “overview of STEAM/LEDET for quench protection”
- Lucas Brouwer, “ANSYS user elements for hybrid magnet protection studies”

Future topics: advanced techniques for interface modeling, simulation tools for HTS, current sharing in HTS cables, …..

Summary

- MDP modeling effort supports general R&D roadmap: interfaces in stress managed coils, conductor development, magnet protection for hybrids, + more …..
- a standing monthly meeting is established for review of existing work and development of new modeling techniques relevant to the MDP program plan
- meetings are open with upcoming topics advertised to the larger MDP group

Extra

Interface Modeling Roadmap Elements and Milestones

2020				2021			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

Interface Modeling

Identify/develop FEM interface techniques

technique developed

Cross-connection: feedback from CCT subscale testing

Integration of these techniques into existing CCT/CMCT mechanical models

techniques integrated

Detailed study of current magnet interface behavior and identification of desired interface behavior

report on existing design behavior

identification of desired behavior and design changes

Cross-connection to resin and impregnation technology development

input on baseline + range of interface properties in existing designs (bond strength etc.)

development of new materials or techniques as desired interface becomes clear

Novel impregnation techniques

Resin optimization for magnets

Hybrid Modeling Roadmap Elements and Milestones

2020				2021			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

Hybrid Modeling

Review hybrid quench protection

identify critical capabilities missing in LTS codes (likely HTS specific behavior)

Develop techniques and add them to existing codes (ANSYS, STEAM, LEDET)

techniques integrated

Benchmarking with existing hybrid test data

Codes benchmarked

Enables study of hybrid designs in comparative roadmap (see Paolo's talk)

Conductor Modeling Roadmap Elements and Milestones

2020				2021			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

HTS

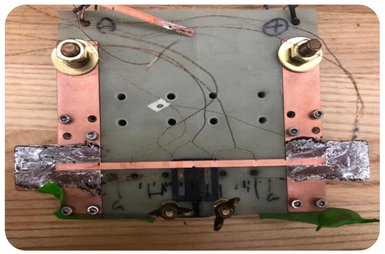
Equivalent circuit models — continued feedback on cable parameters: contact res., length, lubricant, etc.

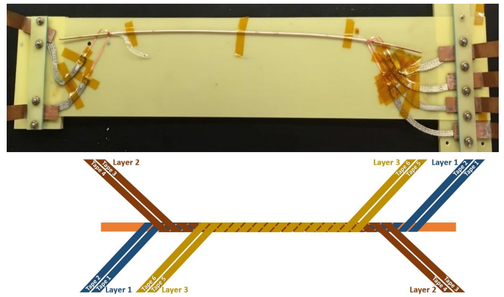
Extension of FEM techniques for HTS cables — FEM for HTS cables in ANSYS uel, or other codes

Exploration/development of new techniques – high risk (xFEM etc.) — new techniques

parallelization/clusters — efficient HPC for HTS FEM

Feedback/ benchmarking from controlled experiments





development of new experiments with input from modeling

High Cp: timeline and effort is captured by “training rate enhancement” roadmap