CHANGING WHAT'S POSSIBLE

Grid Optimization (GO) Competition

FERC Software Conference

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Outline

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INTRODUCTION

Fast Evolving Grid Requires Innovation in Management Systems / Decision Support Tools

What is Optimal Power Flow?

Input

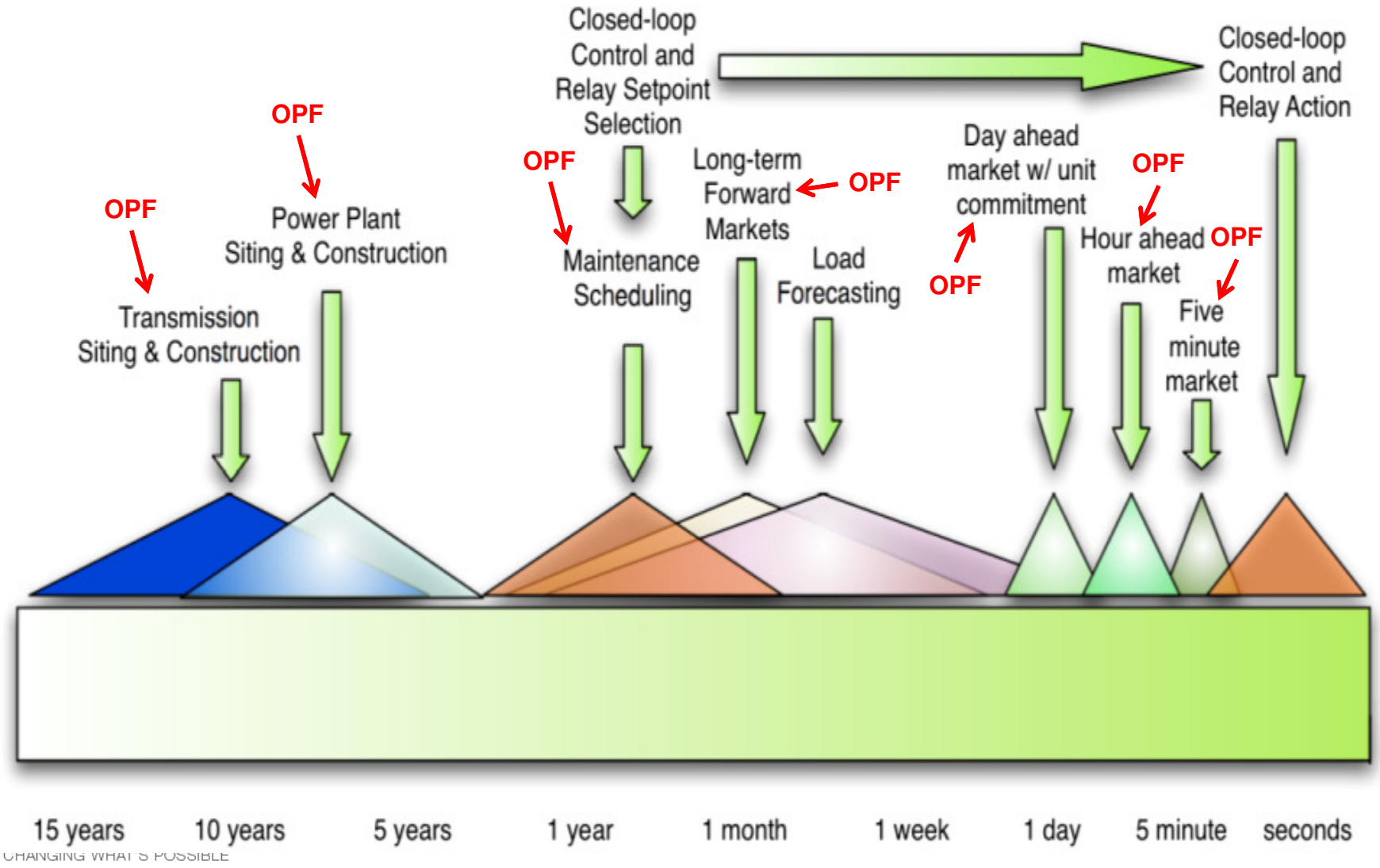
- Transmission grid
- Generator characteristics and availability
- Other control device characteristics
- Demand characteristics
- Wind/Solar forecast

Optimization algorithm

Output

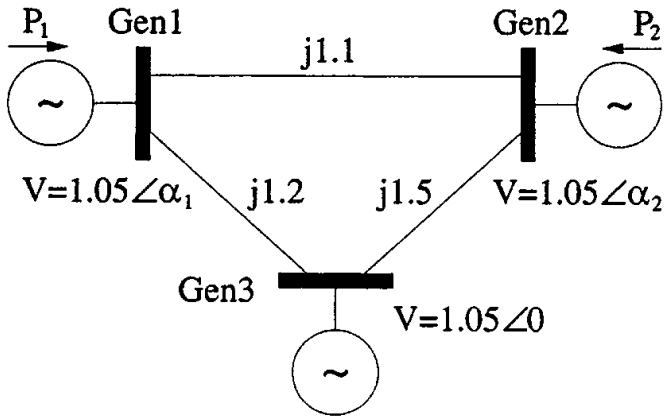
- Generator dispatch such that:
  - ✓ Overall cost is minimized
  - ✓ Reliability requirements are met
  - ✓ Demand is satisfied
  - ✓ Operating limits not violated

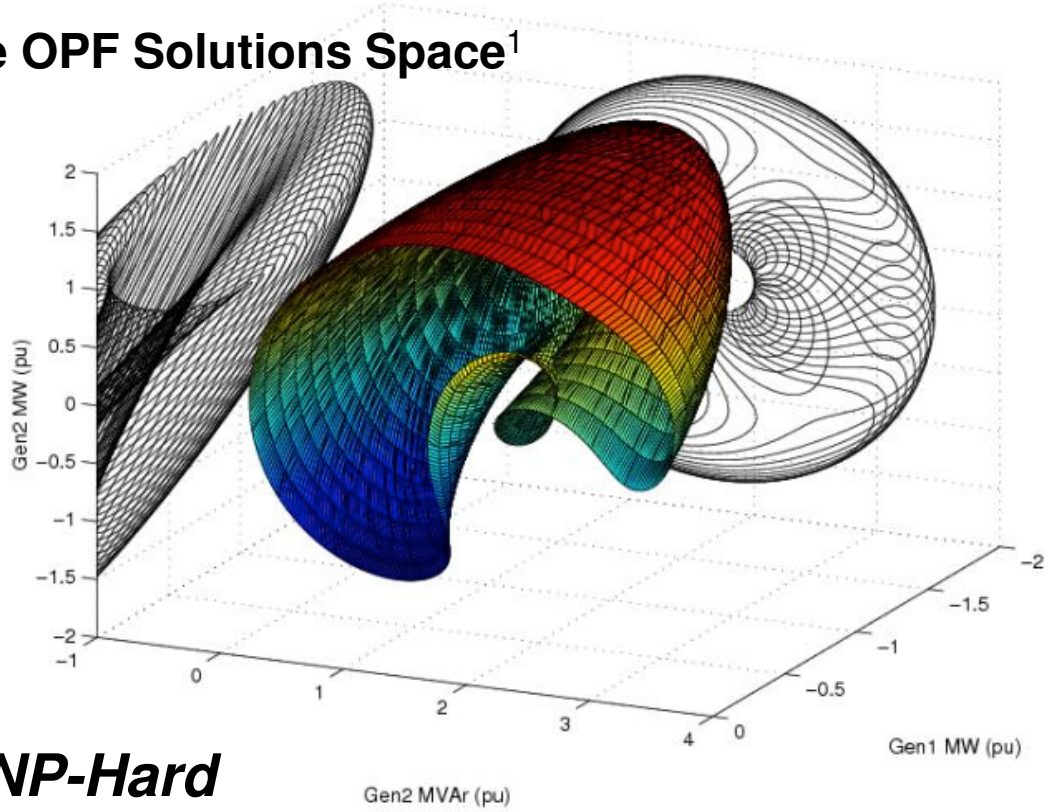
The heart of most grid software/optimization is Optimal Power Flow (OPF)



Optimizing Grid Power Flows is ARPA-E Hard

3-bus Example OPF Solutions Space[1]





- OPF is ***non-convex*** and ***NP-Hard***
- Exact optimal solution methods are computational non-tractable
- Various approximations are widely used today (linearizations, iterative approximations)

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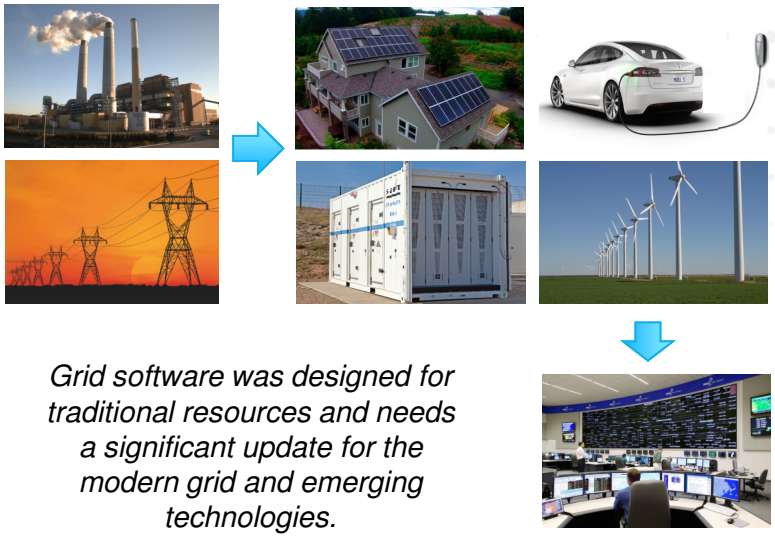
1. I.A. Hiskens and R.J. Davy, "Exploring the power flow solution space boundary", IEEE Transactions on Power Systems, Vol. 16, No. 3, August 2001, pp. 389-395.

The GO Competition: Grid modernization requires software development modernization

- Impacts efficiency of a $500B/year sector
- Impacts reliability and resilience
- New software can be an enabler of emerging technologies:
  - Increased variability / stochasticity from wind and solar, distributed energy resources
  - Decreasing stability and validity of steady state assumptions
  - Decentralization with millions of distributed assets
  - Power flow controllers
  - Storage
  - Responsive demand



Grid software was designed for traditional resources and needs a significant update for the modern grid and emerging technologies.

Competition: identify breakthrough technologies & initiate overhaul of legacy management systems via a fair and transparent evaluation of innovative approaches

COMPETITION TIMELINE AND DIVISIONS

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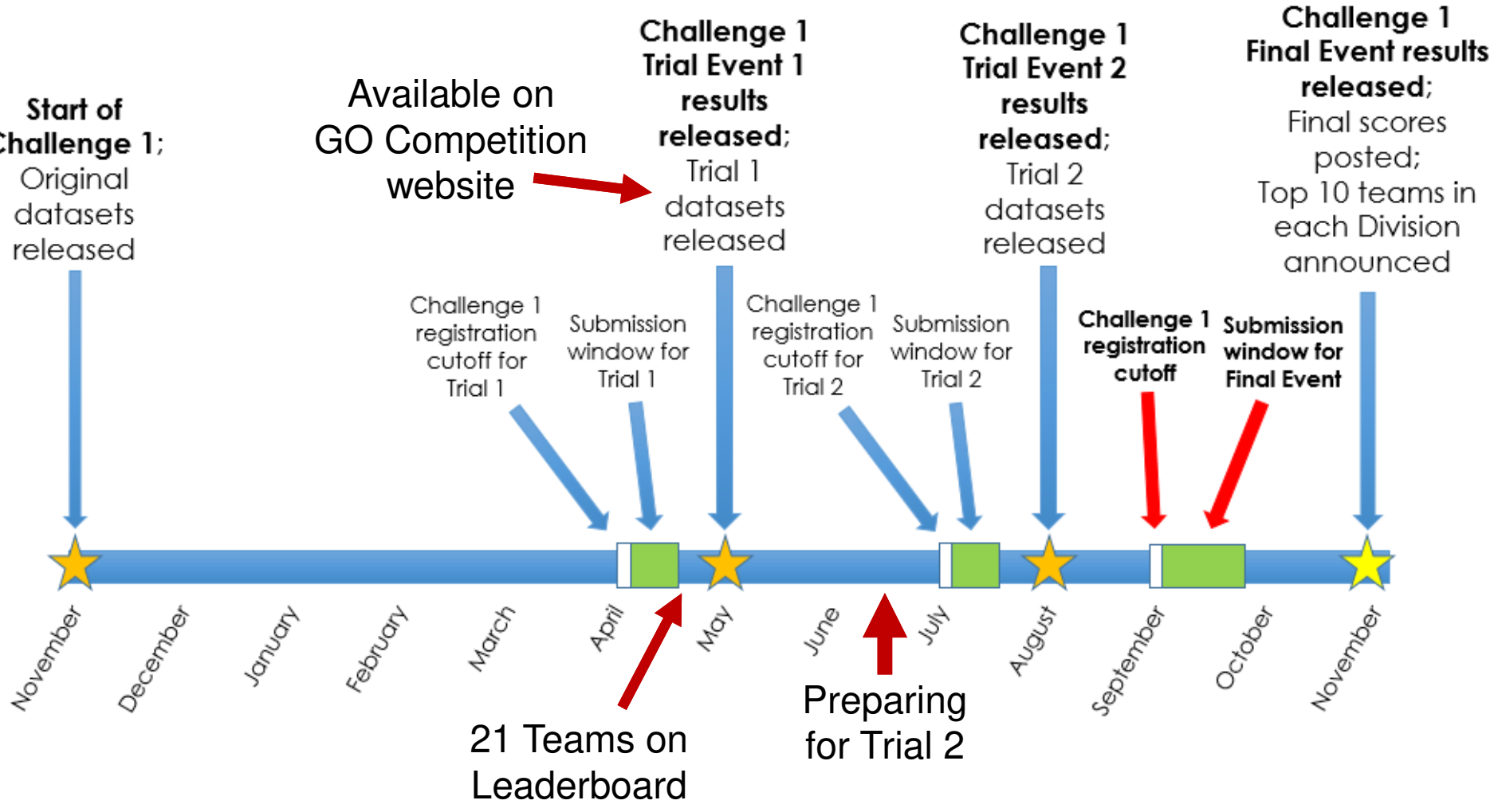
Competition Timeline



Competition Divisions

GRID OPTIMIZATION (GO) COMPETITION

Challenge 1: Final Event

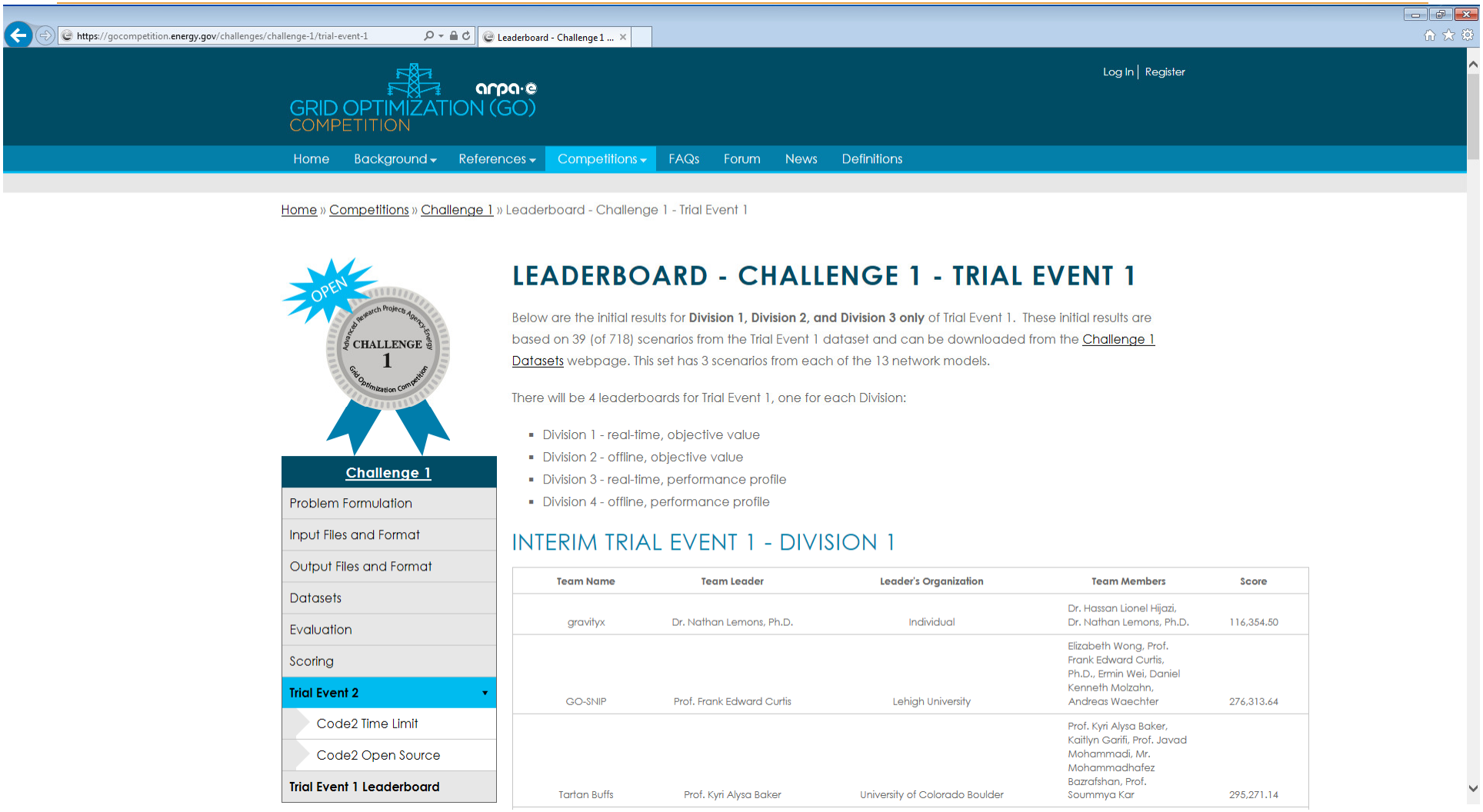
TRIAL 1
DATASETS AND LEADERBOARD

Trial 1 Datasets Online

GRID OPTIMIZATION (GO) COMPETITION

Network Model	Buses	Generators	Loads	Branches	Minimum Contingencies	Maximum Contingencies	Transformers	Areas	Fixed Shunts	Switched Shunts	Scenarios
1	500	90	200	468	349	422	131	1	0	17	3
2	500	224	281	540	784	786	193	1	5	39	3
3	793	210	568	769	86	97	143	1	49	50	3
5	2000	544	1125	2359	3139	3189	847	1	0	153	3
6	2000	384	1010	2743	2594	2618	896	3	32	141	3
7	2312	617	1529	2156	942	1014	857	18	121	201	3
70	2312	444	1529	2156	1008	1015	857	18	121	201	3
8	3013	865	1793	2836	1957	1968	1290	20	129	405	3
81	3288	379	4236	3421	4563	4650	1455	1	0	23	3
84	4601	408	3501	5135	7075	7094	2180	1	0	17	3
9	4918	1340	3070	4412	5058	5085	2315	31	246	486	3
12	9591	365	6659	10927	4377	4377	4988	1	0	122	3
13	10000	2089	3982	10819	9519	9622	2374	6	99	434	3
										Total	39

Trial 1 Leaderboard Online



Variation in Performance by Teams: Trial 1

LESSONS LEARNED FROM TRIAL 1

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Key Lessons From Trial 1 (for competitors)

- **Software Development is an Iterative Process**
  - Many teams had initial trouble preparing “industry-ready” programs which reliably solve new datasets and problems.
  - Successful teams submitted their programs for testing on the GO Competition platform early and often.
- **Minimize Penalties and Solve Problem within Scope of Competition**
  - Industry is not looking for the very best theoretical solution to this problem which takes infinite time to solve, they need decision-making tools which provide a very good solution, very quickly.
  - Successful teams prioritize their approach to find the best, secure solution possible within the competition time limits.
- **Not All Development Platforms are Equal**
  - In order to accommodate as many teams and approaches as possible, we offer a wide range of software and platforms for competitors to use in this competition.
  - Some software packages are more useful for commercial software applications than others.

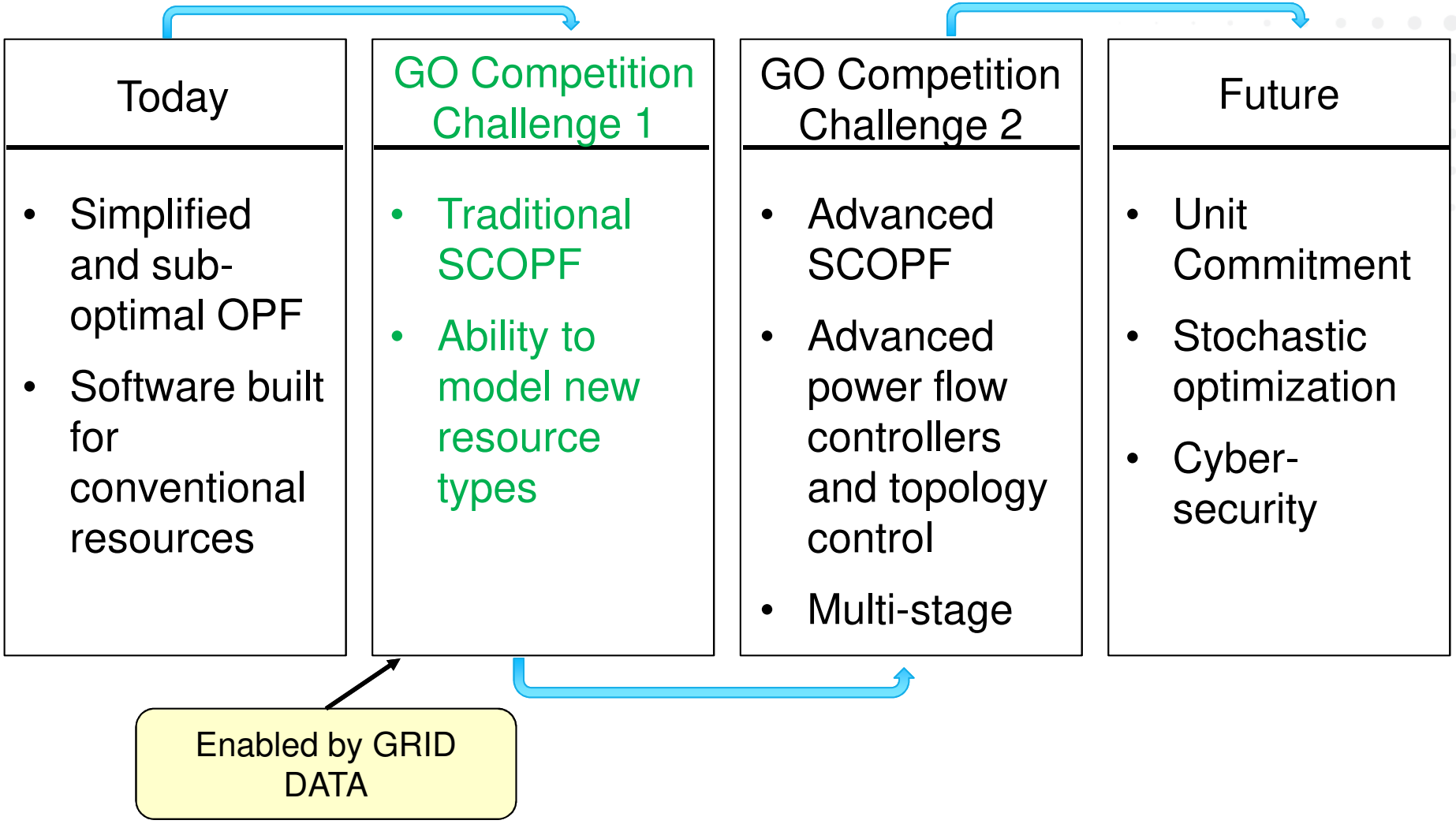
Key Lessons From Trial 1 (for ARPA-E)

- **If you give teams unlimited evaluation time…**
  - …they will use it.
  - For Trial 2 we are applying new time limits for contingency analysis to keep competitors on track to build innovative new approaches that are commercial-ready for industry deployment.
- **Streamline Hardware and Evaluation Processes**
  - Licensing, hardware, and evaluation process issues.
  - For Trial 2, PNNL has prepared a uniform testing environment for both development and evaluations for all competitors.
  - We will follow a tighter evaluation schedule for trial 2.
- **New focus on development**
  - Contingency screening and SCOPF solution is crux of the GO Competition.
  - ARPA-E has provided a sample open-source algorithmic approach for contingency analysis so that all teams may re-focus their efforts on innovating in the SCOPF space.

Summary

- Legacy grid software systems inhibit emerging technologies, innovative solutions
- The GO Competition provides a platform for open and fair evaluation of innovative grid software
- The competition starts with an existing problem that is core to most grid software -- SCOPF
  - ARPA-E Hard
  - Could save beyond $10B in costs per year
- Mission: start here and continue to break ground to bring innovative grid software solutions to practice
- Be an enabler for emerging grid technologies

Continued Evolution of Grid Software



Questions?

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