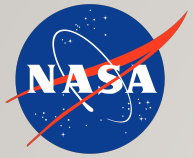
TUTORIAL SESSION I
A GUIDE TO THE NASA PYTHON PROGNOSTICS PACKAGES

NASA'S DIAGNOSTICS AND PROGNOSTICS GROUP & PCOE

PHM SOCIETY ANNUAL CONFERENCE, NOVEMBER 29, 2021



AGENDA

1. Brief Intro
2. prog_models Tutorial
3. Brief Break
4. prog_algs Tutorial
5. Contributing and Next Steps
6. Other Examples [As Time Allows]

Will stop frequently for questions. Raise your hand and unmute to ask questions at stopping points

Join Session

This session will be available on November 29, 2021

Please use our Q&A to ask any question you would like to have answered during the live session. Q&A will be open throughout the Conference. Enjoy!

November 29, 2021

7:15 AM – 9:15 AM PST *10:15 am–12:15 pm EST*

Tutorial 1: A Guide to the NASA Python Prognostics Packages

MODERATOR

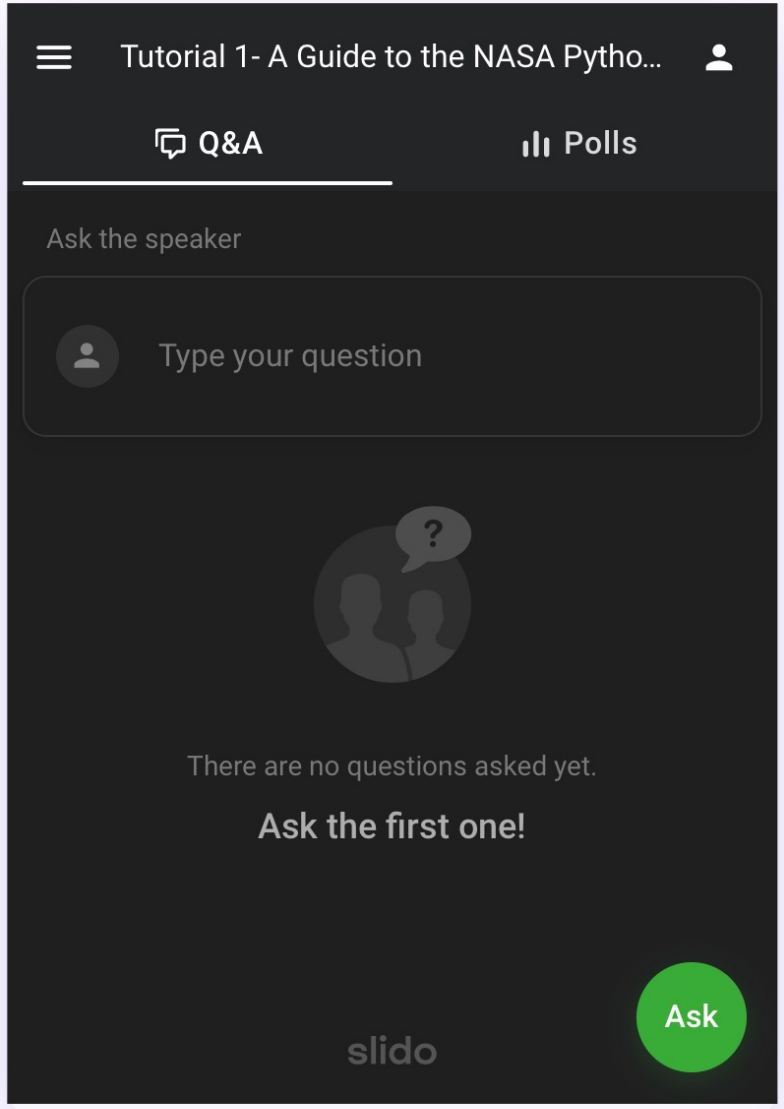
Kai Goebel
PARC

SPEAKERS

Chris Teubert
NASA Ames

Ask for help with technical issues or ask questions in the sli.do chat

Group Members helping solve technical Issues during Tutorial



This year, NASA Released the Prognostics Python Packages, a collection of research tools for developing prognostic models, simulating degradation of systems, performing prognostics, analyzing results, and developing new prognostic algorithms. The Prognostics Python Packages encapsulate design improvements based on experience gained with the previously open-sourced Generalized Software Architecture for Prognostics (GSAP) and Prognostics Matlab Libraries. The tools have been extended to include new features such as approaches for resource-constrained prognostics (e.g., sample shedding), hybrid models, model validation tools, online system identification, and surrogate model generation. This tutorial is a hands-on overview of these tools, including how to use and extend them. This tutorial will also include examples about how the tools are used at NASA.

Add to Calendar

FOLLOWING ALONG

- **Part 1**
  https://mybinder.org/v2/gh/nasa/prog_models/master/?labpath=tutorial.ipynb
- **Part 2**
  https://mybinder.org/v2/gh/nasa/prog_algs/master/?labpath=tutorial.ipynb

Alternately, you can download the package on your machine using pip:

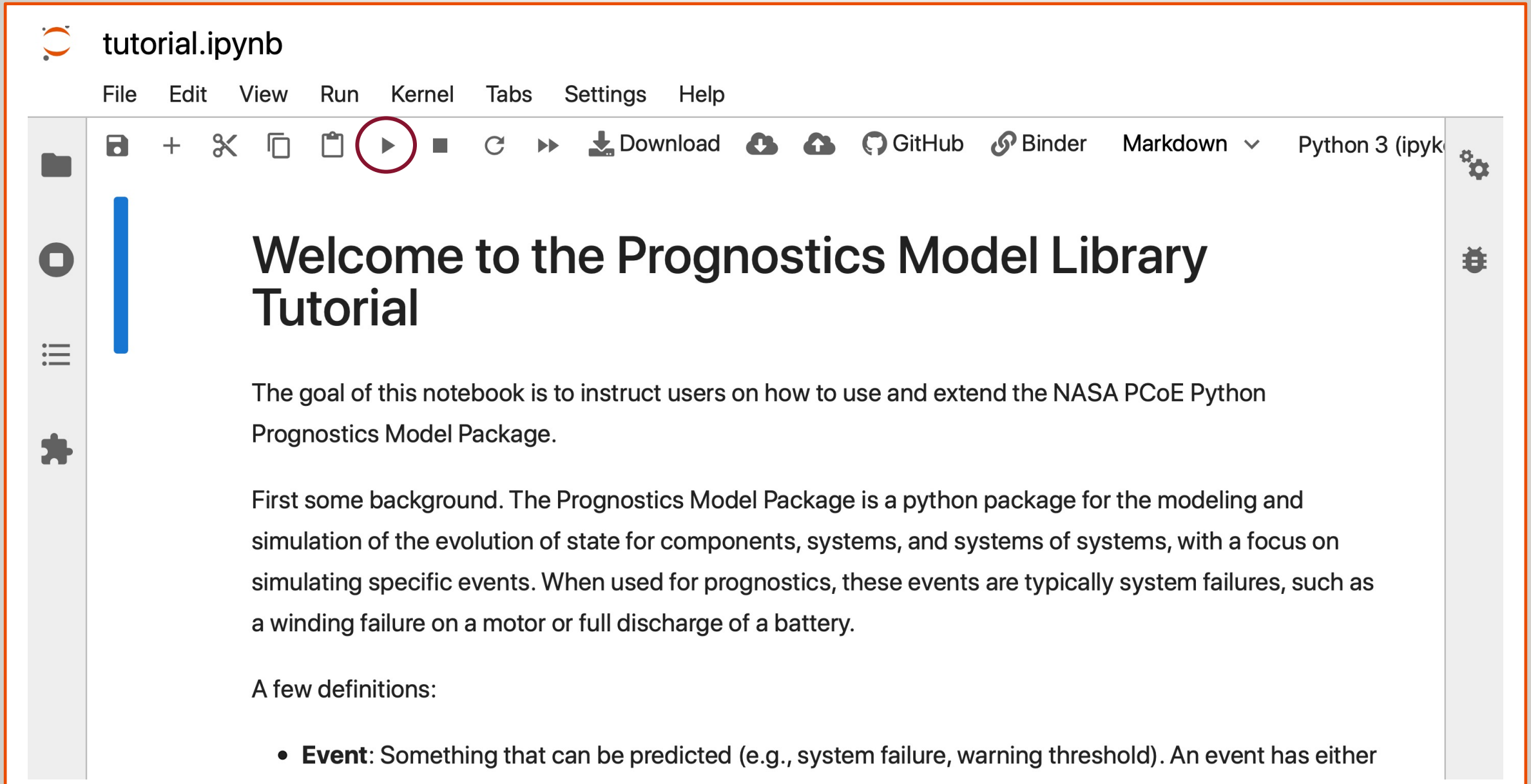
pip install prog_algs

Documentation

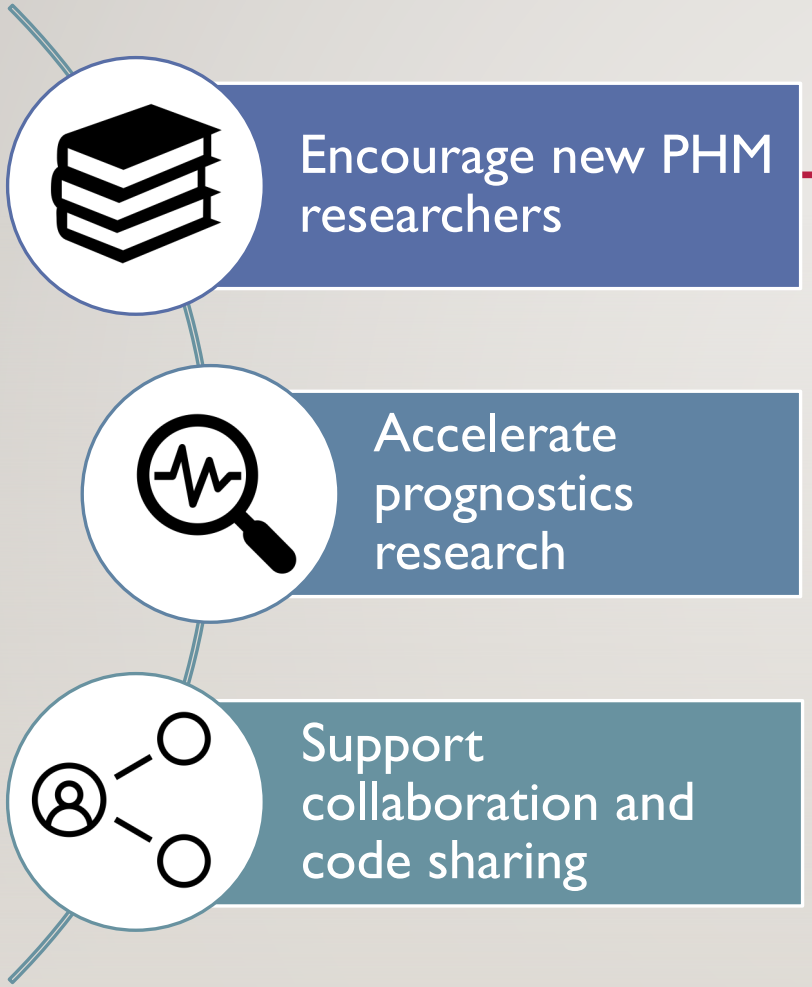
- nasa.github.io/prog_models
- nasa.github.io/prog_algs

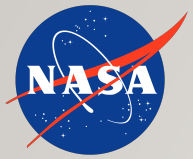
GitHub

- github.com/nasa/prog_models
- github.com/nasa/prog_algs


tutorial.ipynb
File Edit View Run Kernel Tabs Settings Help
Download
GitHub
Binder
Markdown
Python 3 (ipyk
Welcome to the Prognostics Model Library Tutorial
The goal of this notebook is to instruct users on how to use and extend the NASA PCoE Python Prognostics Model Package.
First some background. The Prognostics Model Package is a python package for the modeling and simulation of the evolution of state for components, systems, and systems of systems, with a focus on simulating specific events. When used for prognostics, these events are typically system failures, such as a winding failure on a motor or full discharge of a battery.
A few definitions:
• Event: Something that can be predicted (e.g., system failure, warning threshold). An event has either

SOFTWARE GOALS





- Encourage new PHM researchers
- Accelerate prognostics research
- Support collaboration and code sharing

Easy-to-use software with thorough tutorial, templates, and example set make it easier for new entrants into PHM research

Examples

Model Benchmarking	Future Loading
Dynamic Step Size	Uncertainty and Noise
Creating New Models	Sensitivity Analysis
Model Parameter Estimation	Model Vectorization
Visualizing Result	Prognostics Benchmarking
Simulation	Prognostics
Derived Parameters	Developing State Estimators

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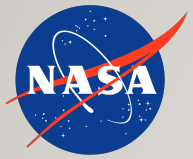

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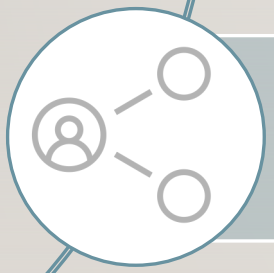
Accelerate prognostics research



Support collaboration and code sharing

Implement common functions of PHM in extendable, capable, optimized manner

Simulation	Model Parameter Estimation
State Estimation	Metrics and Data Analysis
Prediction	Uncertain Data Representation
Visualization Tools	New Model Creation
Future Load Estimation	Noise and Uncertainty Analysis

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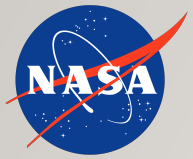

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Standard interfaces and formats so users can share new algorithms and models.

Open Source on GitHub repository

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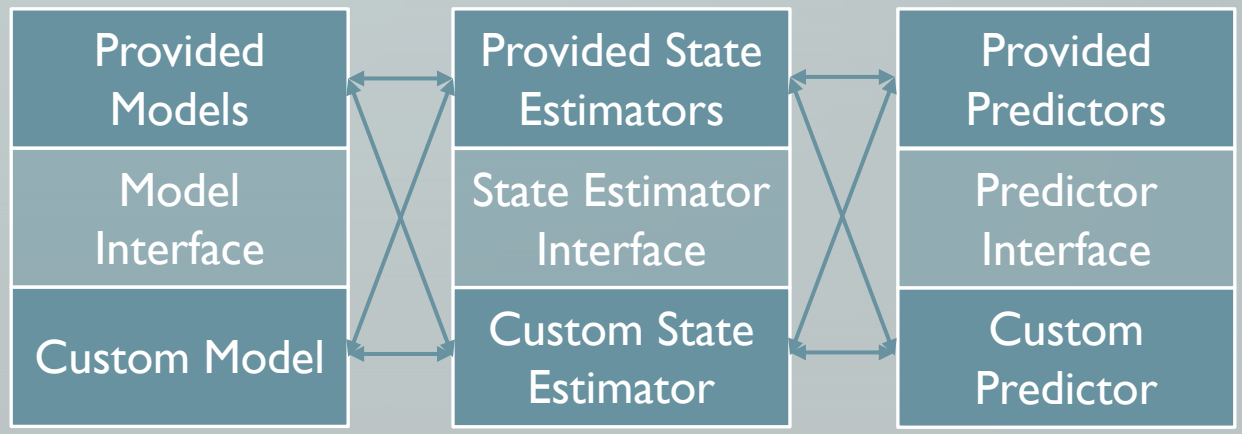

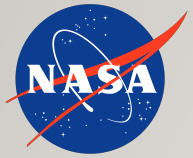

PROBLEM DEFINITION

Prognostics: Prediction of when a system will no longer perform its function, i.e., end of life

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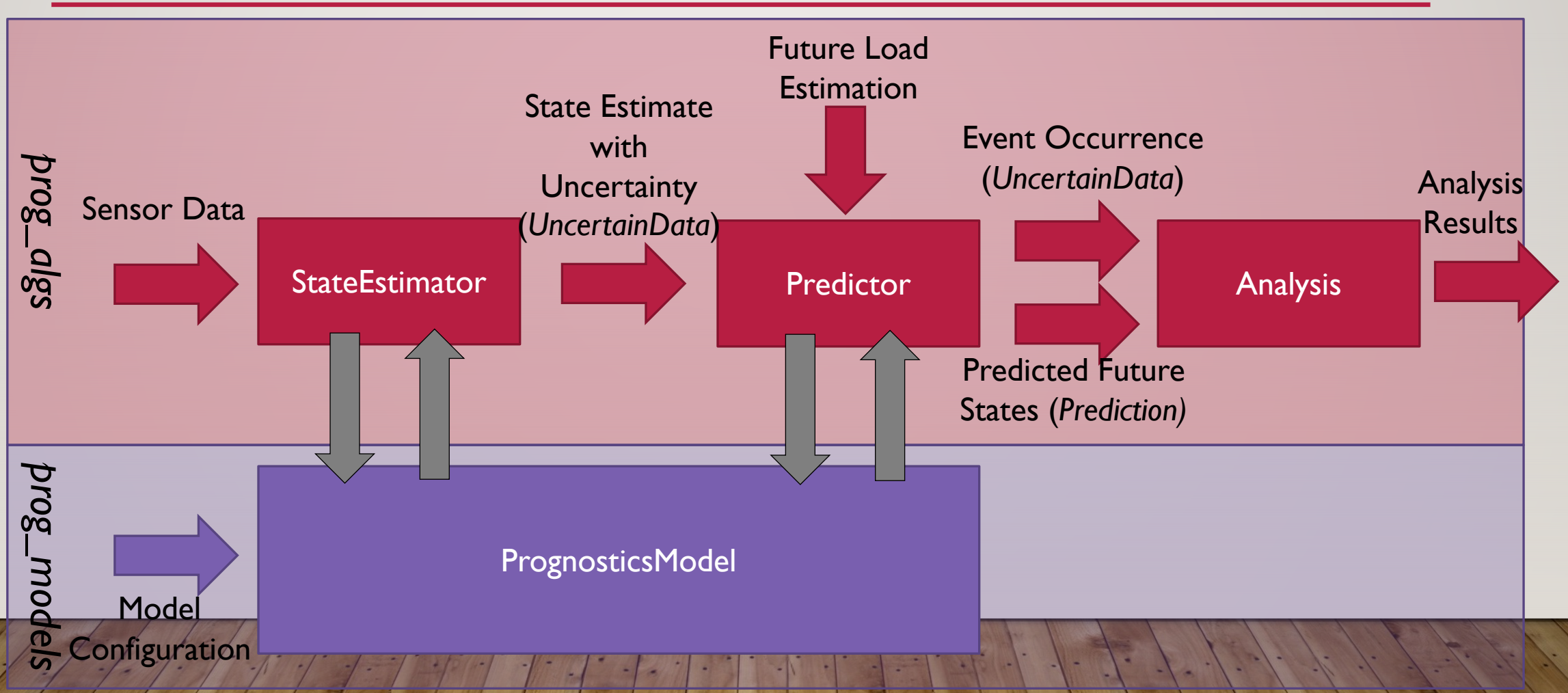
Prognostics: Prediction of (a) future performance and (b) the time of event for one or more events of interest for a system or system of systems

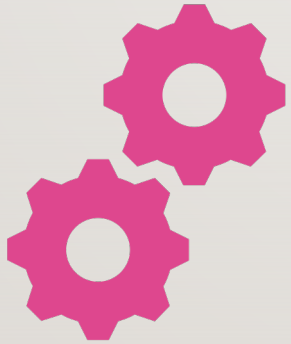
DEFINITIONS

- event: something that can be predicted (e.g., system failure or warning threshold). An event has either occurred or not.
- event state: progress towards an event occurring. Defined as a number where an event state of 0 indicates the event has occurred and 1 indicates no progress towards the event (i.e., fully healthy operation for a failure event). For gradually occurring events (e.g., discharge) the number will progress from 1 to 0 as the event nears. If the event is end of life, event state is frequently called "State of Health" (SOH)
- inputs: control applied to the system being modeled (e.g., current drawn from a battery)
- outputs: measured sensor values from a system (e.g., voltage and temperature of a battery)
- states: Internal parameters (typically hidden states) used to represent the state of the system- can be same as inputs/outputs but do not have to be.

PROGNOSTICS PROCESS



TUTORIALS



prog_models

prog_algs

FUTURE WORK/ WORK IN PROGRESS

prog_models

- Additional models – DC Motor, ESC, etc.
- Battery model extension to include thermal runaway
- Tools for modeling complex system of systems
- Model verification tools
- GPU Support
- Surrogate model generation
- Data-driven model support

prog_algs

- Additional visualization tools
- Additional metrics
- Resource-constrained prognostics approaches
- Diagnostic tools
- Online Parameter Estimation
- Additional State Estimation Algorithms

LOOKING FOR COLLABORATORS ON THIS AND OTHER AREAS
EMAIL: CHRISTOPHER.A.TEUBERT@NASA.GOV

THANK YOU

A big thank you to the members of the Diagnostics and Prognostics group, Prognostics CoE, and our partners at Northrop Grumman for their contributions to this software.

Thank you to past members of the D&P Group for your contributions to the PHM field that were built upon to create this software

A Big thank you to Matteo Corbetta, Katy Jarvis, Chetan Kulkarni, and Jason Watkins for helping with technical issues during tutorial

Also, thank you everyone for attending today's tutorial.

LOOKING FOR COLLABORATORS
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