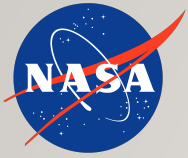


TUTORIAL SESSION I A GUIDE TO THE NASA PYTHON PROGNOSTICS PACKAGES

PHM SOCIETY ANNUAL CONFERENCE, NOVEMBER 29, 2021



FOLLOWING ALONG

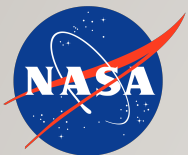
- **Part 1** https://mybinder.org/v2/gh/nasa/prog_models/master/?labpath=tutorial.ipynb
- **Part 2** https://mybinder.org/v2/gh/nasa/prog_algs/master/?labpath=tutorial.ipynb

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

```
pip install prog_algs
```

Documentation can be found here:

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



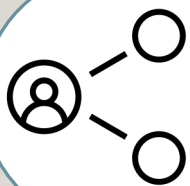
SOFTWARE GOALS



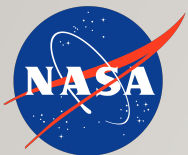
Encourage new PHM researchers



Accelerate prognostics research



Support collaboration and code sharing



Encourage new PHM researchers



Accelerate prognostics research



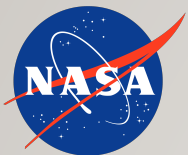
Support collaboration and code sharing

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

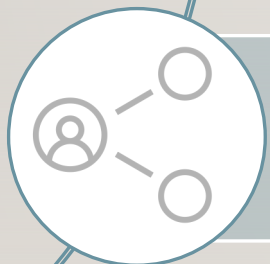




Encourage new PHM researchers



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

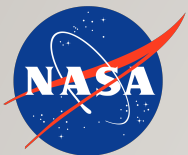
Visualization Tools

New Model Creation

Future Load Estimation

Noise and Uncertainty Analysis

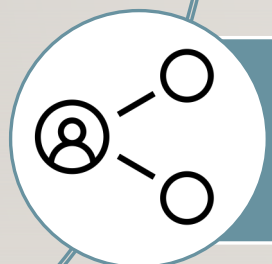




Encourage new PHM researchers



Accelerate prognostics research

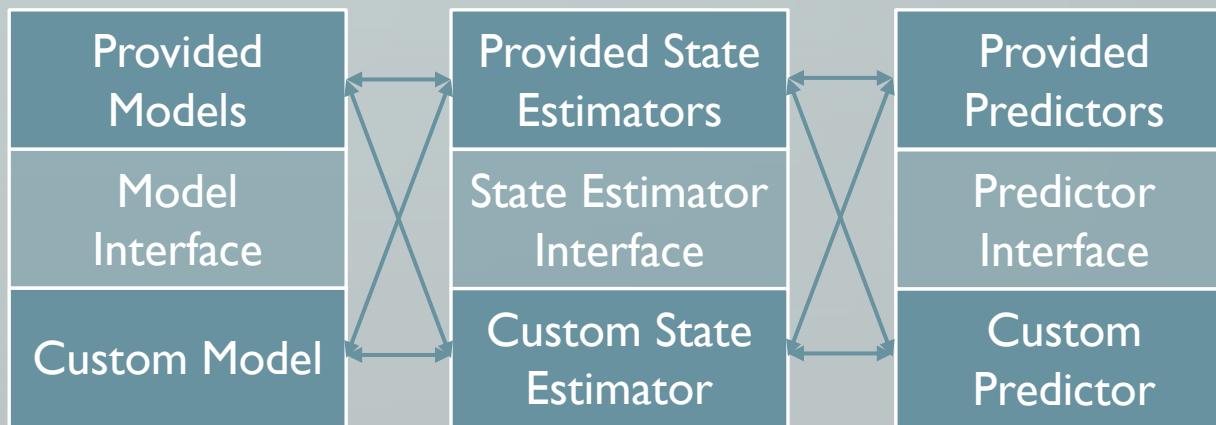


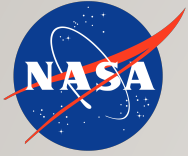
Support collaboration and code sharing

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

Open Source on GitHub repository

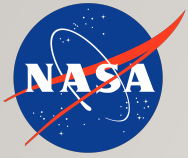
Standard interfaces and formats so users can share new algorithms and models.





PROBLEM DEFINITION

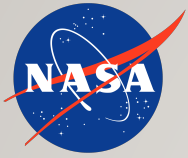
Prognostics: Prediction of when a system will no longer perform its function, i.e., end of life



PROBLEM DEFINITION

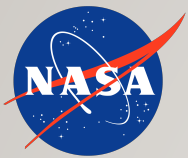
~~Prognostics: Prediction of when a system will no longer perform its function, i.e., end of life~~

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

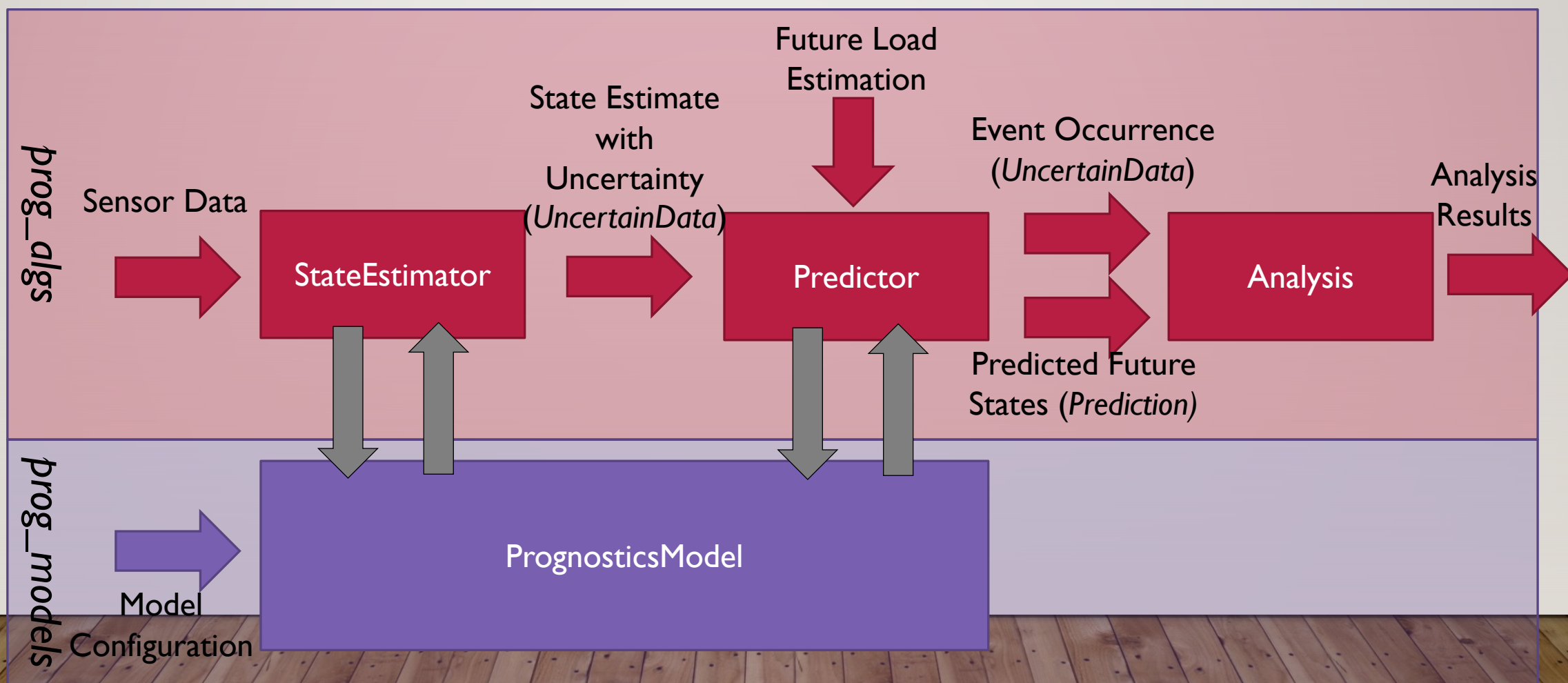


DEFINITIONS

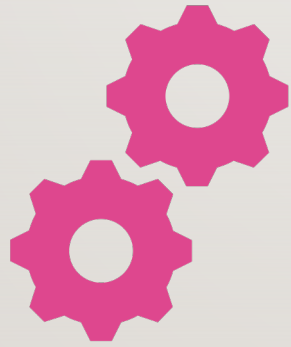
- event: something that can be predicted (e.g., system failure or warning threshold). An event has either occurred or not.
- event state: progress towards an event occurring. Defined as a number where an event state of 0 indicates the event has occurred and 1 indicates no progress towards the event (i.e., 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



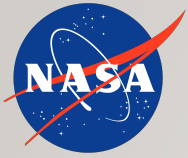
TUTORIAL



prog_models



prog_algs



FUTURE WORK/WORK IN PROGRESS

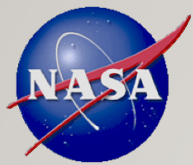
prog_models

- 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



Prognostics CoE

THANK YOU

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

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

LOOKING FOR COLLABORATORS
EMAIL: CHRISTOPHER.A.TEUBERT@NASA.GOV