MONSID

Technical Brief

Model-Based Off-Nominal State Identification and Detection for Autonomous Fault Management

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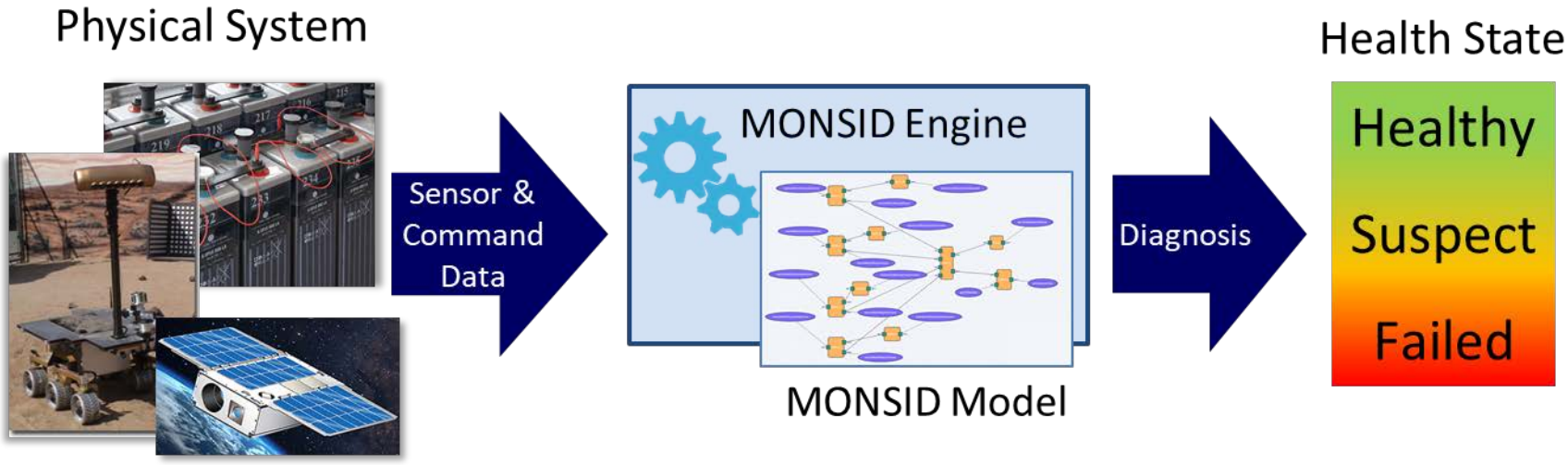
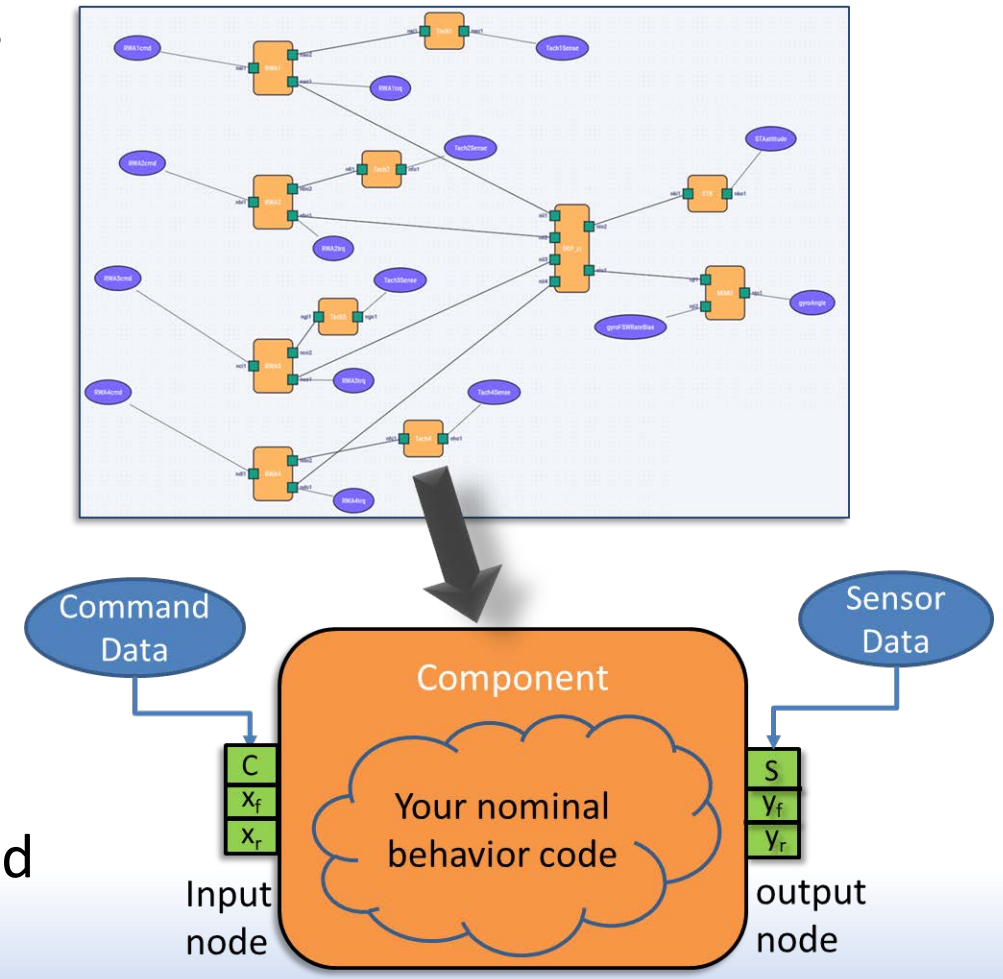
MONSID Fault Management: Technology Overview



- MONSID system parts
  - Diagnostic Engine - application independent
  - Model - application specific, captures nominal system behavior
- Sensor and Command data are inputs to MONSID Model
  - Inputs are propagated through the model
  - Utilizes Constraint Suspension technique to detect and ID faults
- MONSID determines healthy/failed state of system

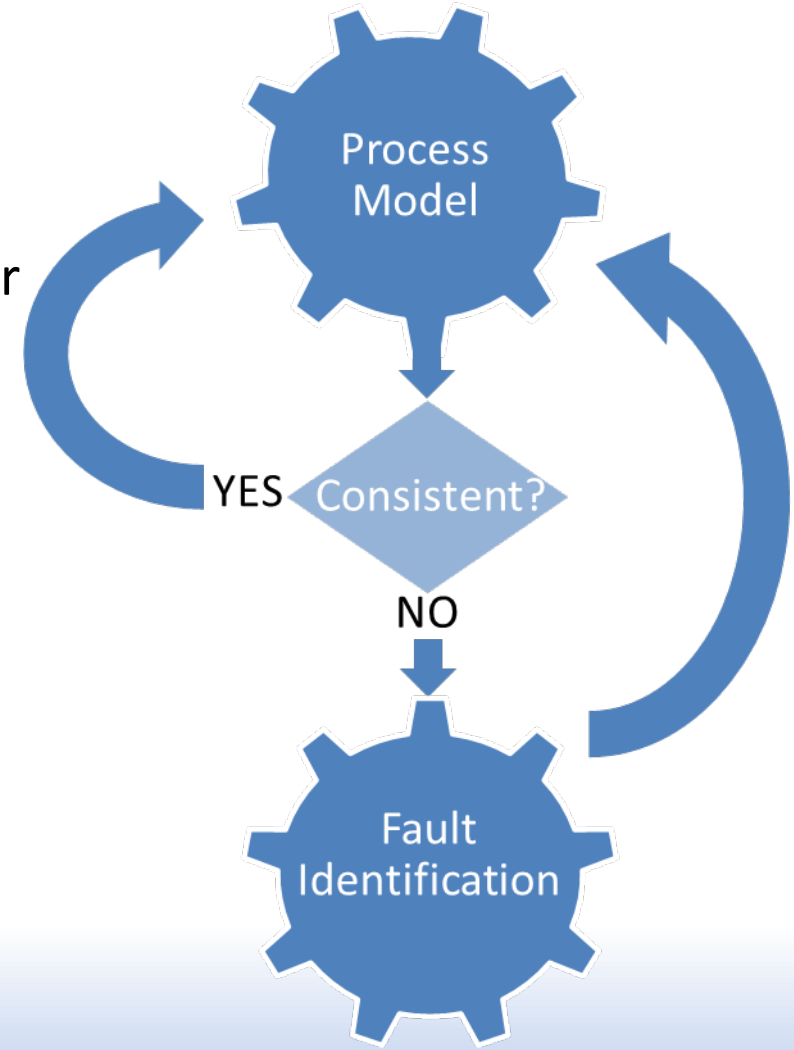
MONSID Models System Behavior

- Interconnected components
  - Represent target system hardware and functions
  - Describe nominal or expected behavior
  - Can be equations, lookups, curve fits, etc.
- Sensor & Command data
  - Provide inputs to the model
  - Are compared to modeled values at the nodes

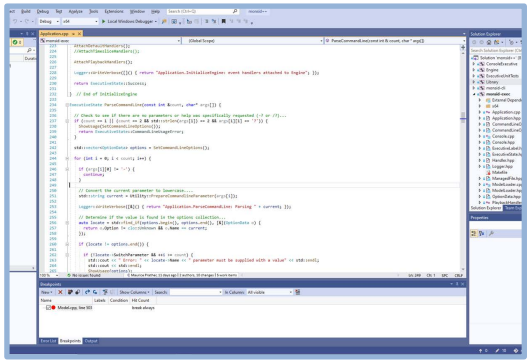


MONSID Engine Evaluates System Health

- Command and sensor data are fed to MONSID Engine
- Engine processes the model at each data slice by comparing the behavior of physical system against model
  - Consistent behavior -> Healthy
  - Inconsistent behavior -> Faulty
- When a fault is detected
  - Engine identifies faulty component or sensor
  - Fault identification is based on a constraint suspension technique (deterministic, iterative algorithm O(n^5) complexity)

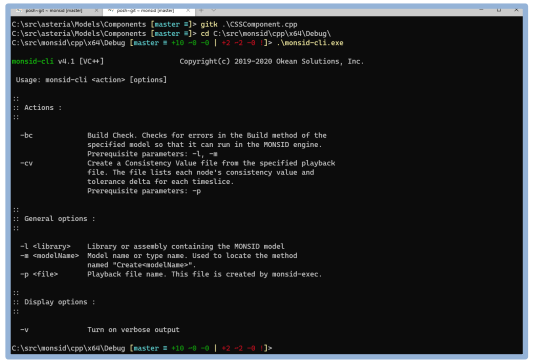


MONSID API and Tool Suite



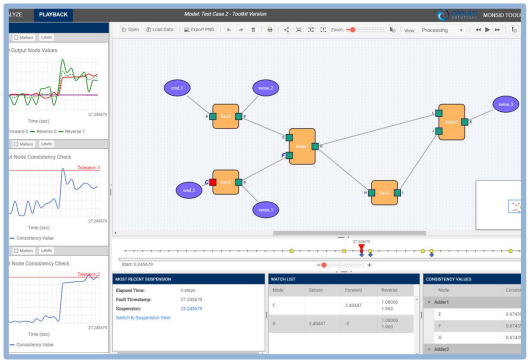
API

- Compact and modular API
- Platform independent
  - C#, C++, C versions available
  - ROS, cFS, F-Prime
- API enables your own tool creation and customizations
- Developer's Guide and code examples



Command Line Tools

- Two tools provided to assist in model development and data analysis
- Model build checker
- Out of the box MONSID executive
  - CSV processor for MONSID Engine
  - Creates playback files for Toolkit



Toolkit Web App

- Visual model design
- Model validation and verification
- Post-run analysis
- Diagnosis visualization
- Analyze fault diagnosis performance using model topology

Benefits of MONSID

Model-based Fault Management

- MONSID engine is reusable, only models change with application
- Potential to diagnose unforeseen faults - fault models not required
- Unlike limit checking, MONSID provides continuous estimate of health state
- Relatively simple models proven effective

Flexible Software Development

- Small footprint, lightweight, minimal RAM requirements for use on single board computers, SOC, MOC, laptops
- Designed for real-time monitoring
- Can be used in conjunction with existing fault response/recovery mechanisms

Supports Integration and Test

- Effective even for sensor-poor systems
- FM design can be started earlier in FM lifecycle
- Uncovers control software and operation errors
- Models validated once, can be used in all phases of project cycle

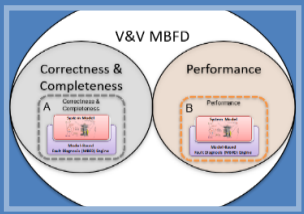
Applications

NASA/JPL Athena test rover

- Found off-nominal behaviors: terrain-induced stalls
- Identified hardware faults: motor stalls, over temp

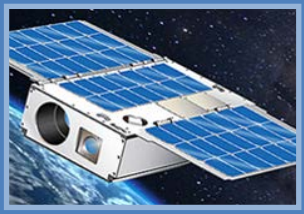
Caltech state of the art test facility

- MONSID implemented on reaction wheel and thruster 6-DOF platforms
- Identified injected reaction wheel failures



Technology Development and Studies

- Part of NASA JPL's Autonomy Framework
- Target system for Model-Based System Assurance techniques



Upcoming…

- CubeSats (ASTERIA, Lunar Flashlight)
- Air Force Research Lab REBEL autonomy testbed

okean solutions

Contact and Additional Reading

Contact

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White papers

MONSID Overview
https://ieeexplore.ieee.org/abstract/document/7500793
https://arc.aiaa.org/doi/10.2514/6.2016-5225

Power System Example
https://ieeexplore.ieee.org/abstract/document/7943835

Findings from Athena Rover Testing
https://ieeexplore.ieee.org/abstract/document/8741923

Model validation, model checking and assurance
https://ieeexplore.ieee.org/document/8396550
https://ieeexplore.ieee.org/abstract/document/8741790

Complexity Analysis
https://ieeexplore.ieee.org/document/8863866

Caltech Autonomous Imaging of an Asteroid using Spacecraft Simulator Video
https://www.youtube.com/watch?v=LfucRFrYdDA