MONSID®
Technical Briefing

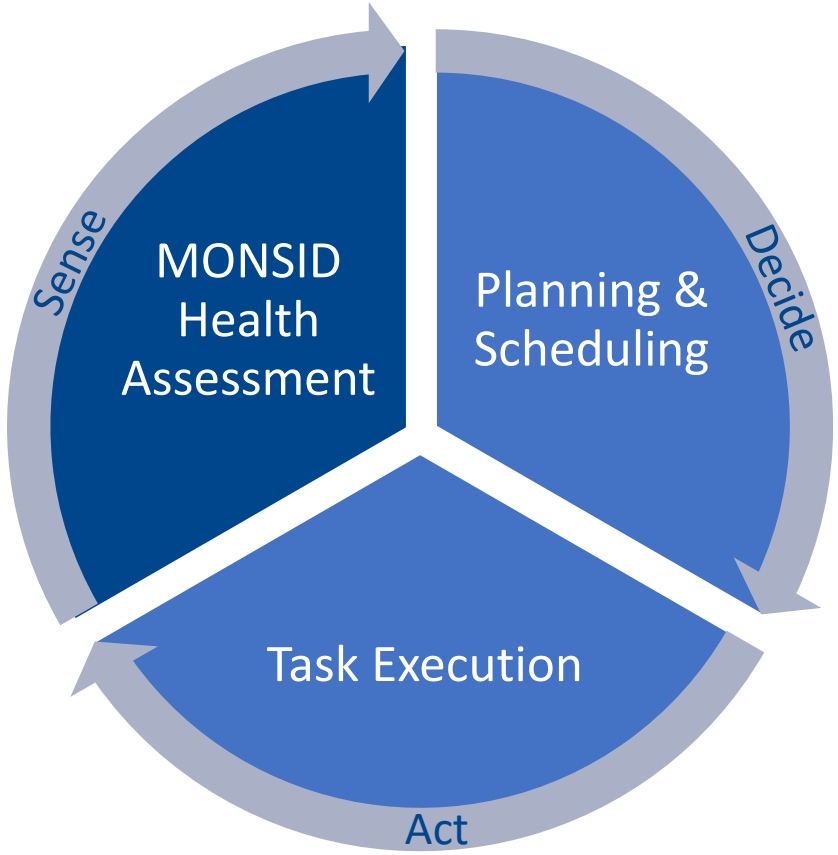
July 2023

okean solutions

Health Assessment - The Big Picture

System Health Assessment is critical to system operations

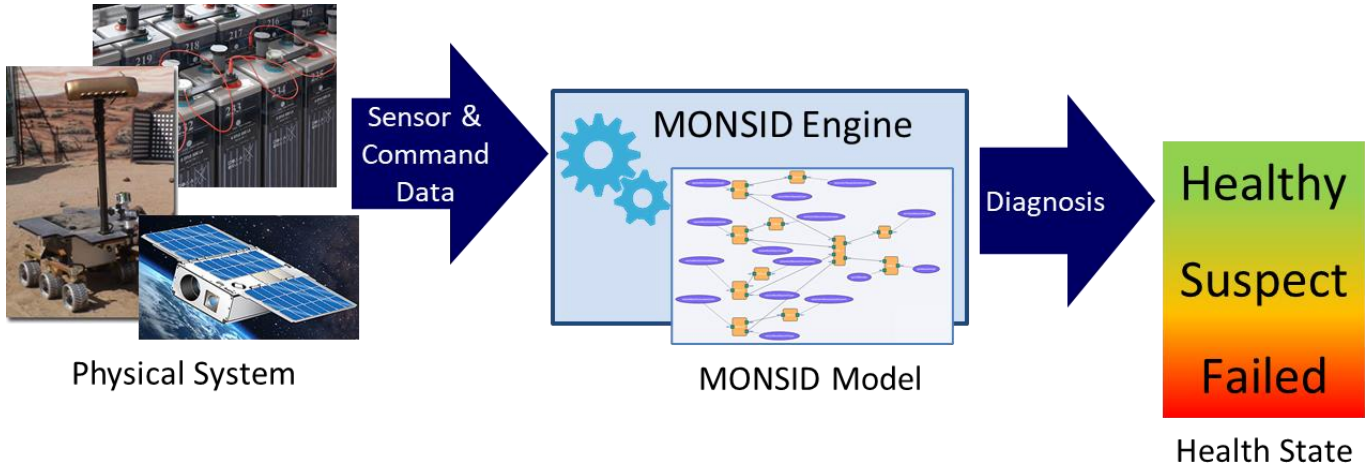
- A key part of Sense Decide Act for mission operations
- Enables onboard resource management: replan in the face of opportunities or threats
- Enables targeted responses and autonomous recovery: operate through failures
- Enables improved decision making for human operators



MONSID provides continuous health assessment on board or remotely

What is MONSID?

Model-Based Off Nominal State Identification and Detection



MONSID consists of:

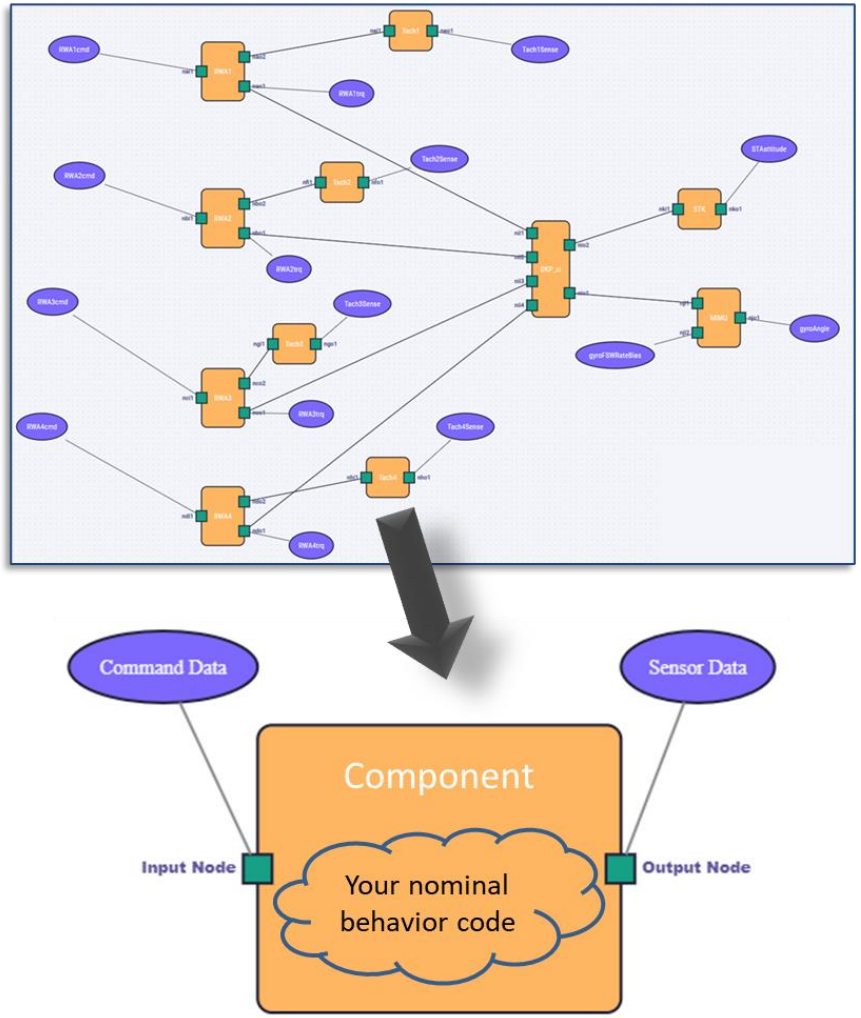
- Diagnostic Engine (application independent)
- Model capturing nominal system behavior (application specific, network of hardware components)

- Sensor and Command data are inputs to MONSID Model
  - Inputs are propagated through model
  - Utilizes Constraint Suspension technique to detect and isolate faults

- MONSID outputs health state of system components
- Utilizes only nominal behavior – fault models not needed to isolate faults

MONSID Models System Behavior

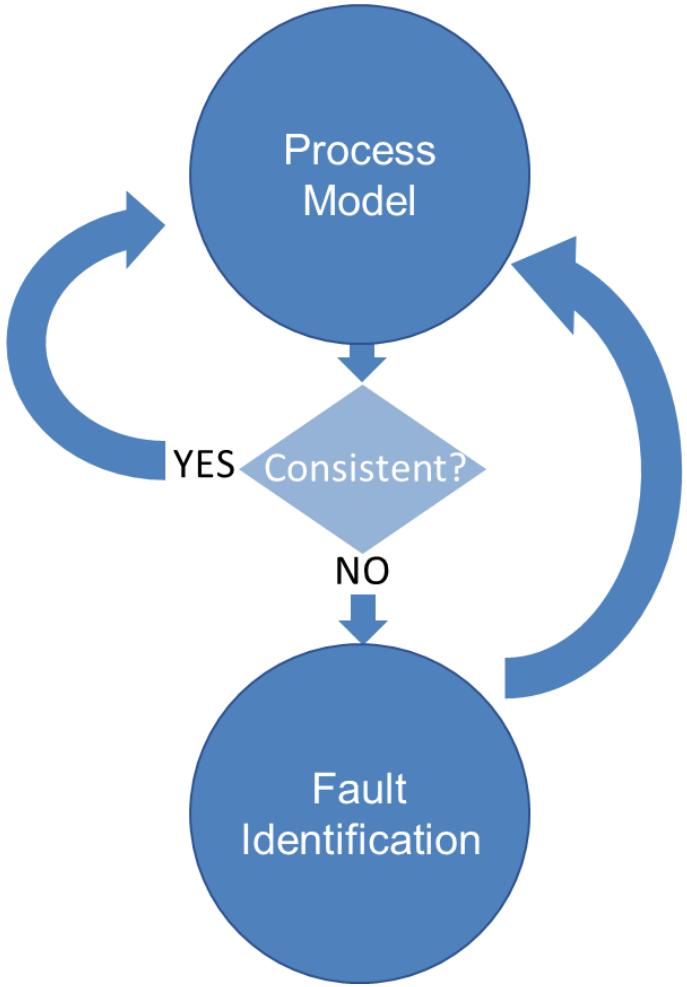
- Components
  - Represent your system's hardware/functions
  - Describe nominal/expected behavior
  - Can be equations, lookups, curve fits, etc.
  - Have input (left) and output (right) nodes – roughly equivalent to functional flow
- Connections
  - Link components together
  - Allow data to propagate through model
- Sensor & Command data
  - Provide inputs to the model from physical system
  - Are compared to modeled values at the nodes



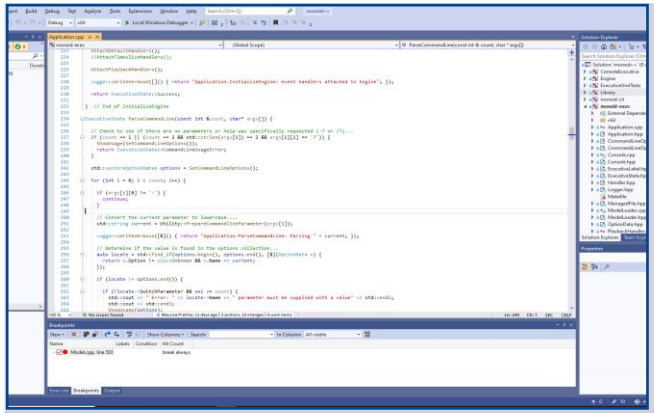
MONSID Engine Evaluates System Behavior

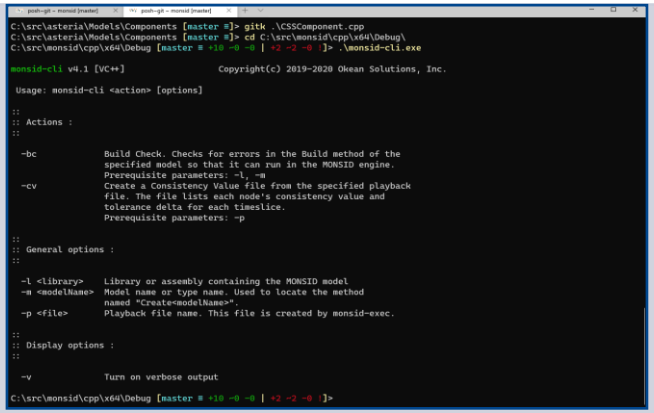
Engine Overview

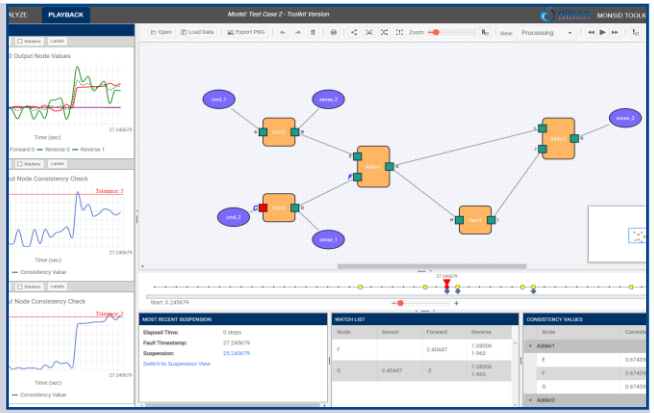
- Command and sensor data are fed to MONSID Engine at each time slice
  - Model processes one or more samples to *establish its initial state*
- Engine processes the model at each data slice
  - Propagates sensor data through model
  - Compares behavior between physical system and model
    - Consistent behavior -> Healthy
    - Inconsistent behavior -> Faulty
- When a fault is detected:
  - Engine analyzes discrepancies to identify faulty component or sensor
  - Identification based on a constraint suspension technique (deterministic, iterative algorithm)



MONSID API and Tool Suite







API

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

Command Line Tools

- MONSID executive
  - CSV processor for MONSID Engine
  - Creates playback files for Toolkit
- MONSID cli
  - Model build checker
  - Post-analysis utilities

Toolkit web app

- Visual model design
- Diagnosis visualization
- Fault window parameter tuning
- Livestream MONSID Engine results
- Analyze fault diagnosis performance using model topology
- Validate model topology

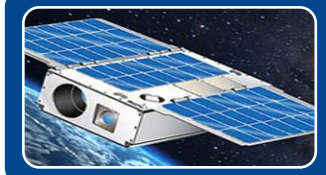
Benefits of MONSID

Model-based Fault Management	Flexible Software Development	Supports Integration and Test	Supports Autonomy
• 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	• **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	• 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	• Can be integrated with Planner/Scheduler • Enables targeted responses to anomalies • **Complementary** to other FM technologies • Can also be used in a ground system for **Operator support and training**

Application Highlights

AFRL Autonomy Test Bed

- Integrated with cFS (publish/subscribe middleware)
- Detected both injected and real hardware faults

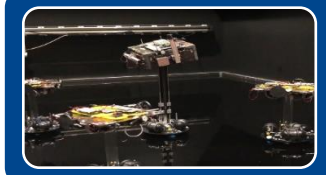


CubeSats

- Lunar Flashlight I&T tool
- ASTERIA – integrated with FSW, tested with ACS flight data

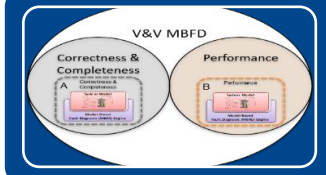
NASA JPL Athena test rover

- 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 using ROS
- Identified injected reaction wheel failures



Technology Development and Studies

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

Contact and Additional Reading

- Contact: monsid@okean.solutions
- For more information, check out the MONSID resources page...
- Find out more about MONSID at MONSID.com...
- Find out more about Okean Solutions at okean.solutions...

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