Concept and Autonomy Considerations for Goal-based Mission Continuation on-board Interplanetary Spacecraft.

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Objectives: Goal-based Mission Continuation.

- reliably ensure mission operability by exception handling on-board,
- respond quickly & effectively to unanticipated events
- ensure safe & high-performance operation for increased science return by achieving less safe mode events,
- reduce mission operational cost
- decrease ground operator's workload.


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Spezifikation für die Anwendung einer kognitiven Recovery Unit an Bord einer interplanetaren Raumsonde

1. Zweck

Die Spezifikation beinhaltet den Vorschlag mehrerer, aufeinander aufbauender Anwendungsfälle und Testszenarien mit ansteigendem Komplexitätsgrad für die Anwendung einer innovativen, kognitiven Recovery Unit für Raumfahrzeuge.

Anschließend wird die entworfenen Simulationsumgebung und Architektur zur Umsetzung der beschriebenen Anwendungsfälle kurz dargestellt.

2. Anwendungsfälle

Alle im Folgenden diskutierten Anwendungsfälle folgen Abbildung 1, welche die Fundamentalziele der Mission bzw. des Raumfahrzeugs aufzeigt.

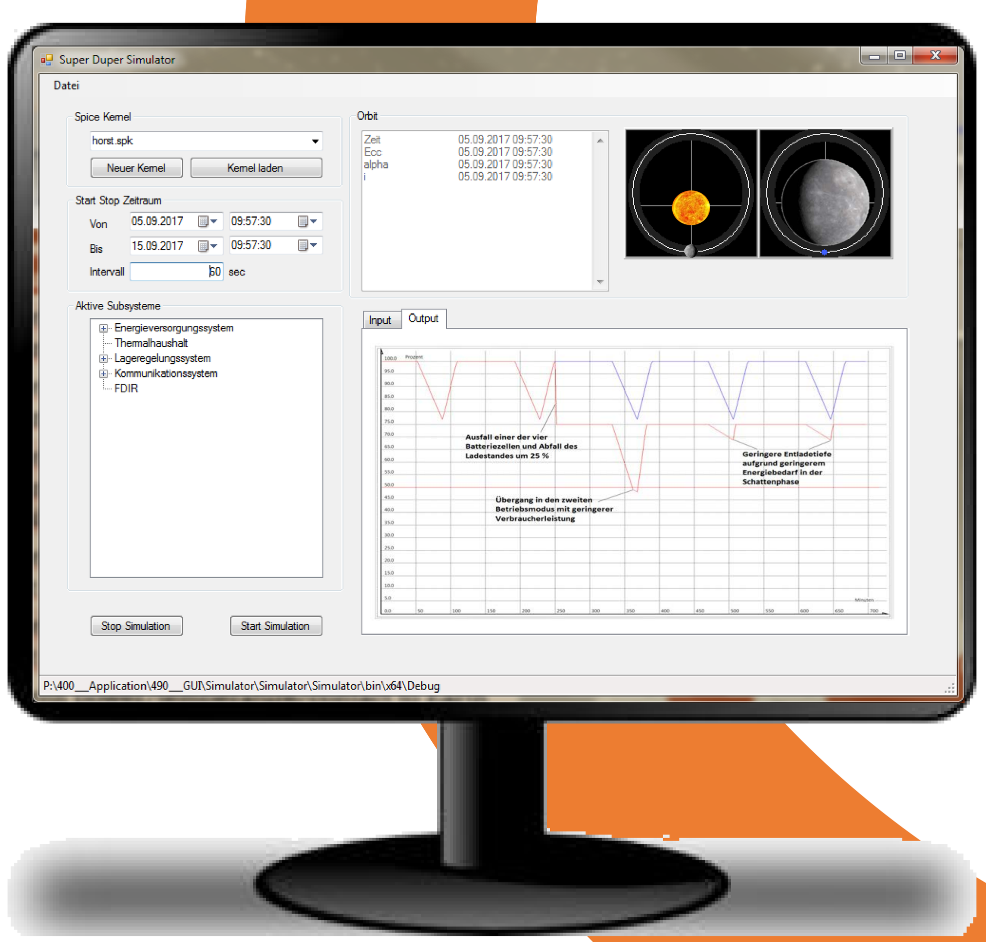
Zusätzlich zur Anwendung kommt

Tabelle 2-1: Betriebsmodi und vorab festgelegte Werte für jeweiligen Leistungsbedarf.

	Betriebsmodus	Leistungsbedarf	Kommentar
1	Nominal	1000 W	Nennleistungsbedarf, wenn keine besonderen Anforderungen an das Raumfahrzeug gestellt werden
2	Minimal	600 W	Leistungsbedarf sichert Überleben der Raumsonde
3	Wissenschaft	1800 W	Leistungsbedarf zum Betrieb wissenschaftlicher Nutzlast
4	Kommunikation	2000 W	Leistungsbedarf zur Datenübertragung von und zur Bodenstation

Simulator.

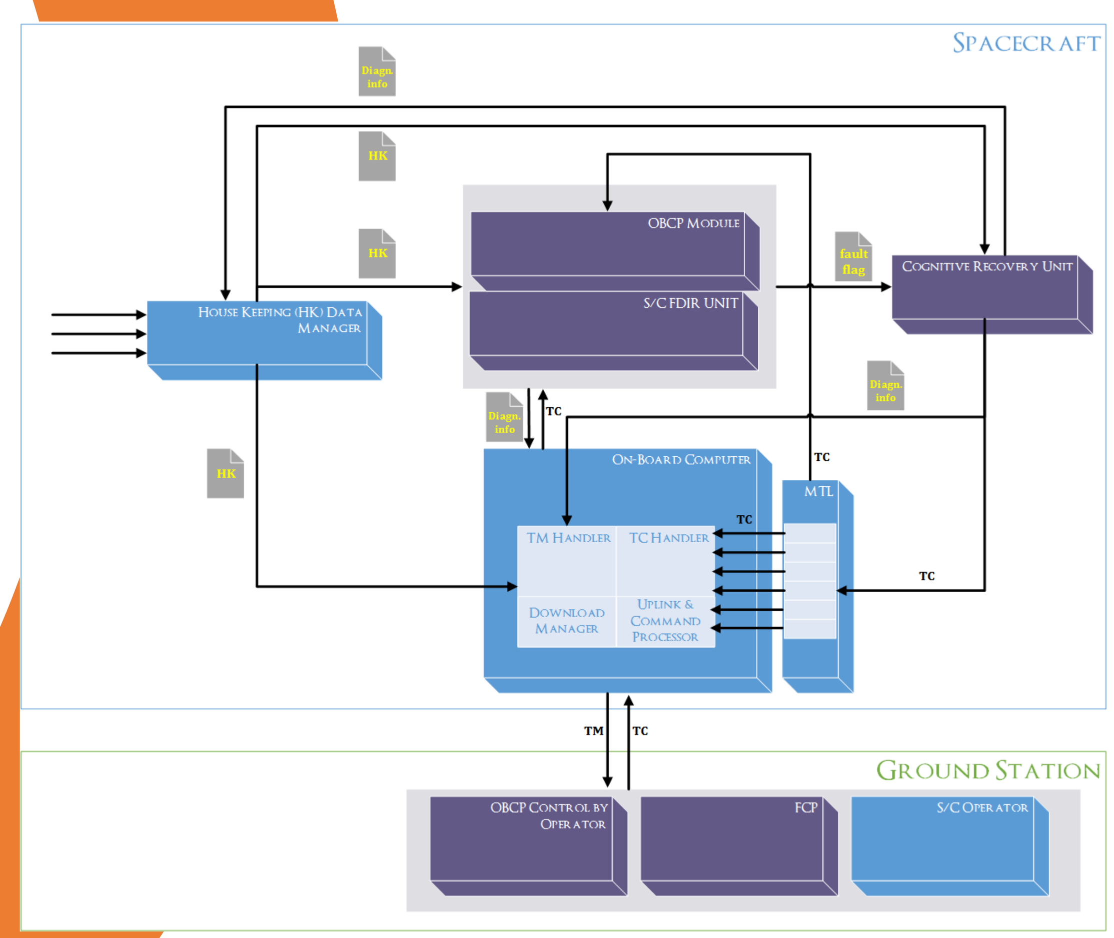
- Matlab based system simulation with SPICE orbit mechanics implementation
- Simulation control via C# graphical user interface for system simulation, control and fault injection
- Generations and exchange of HouseKeeping Data Packages & Telecommands



Innovative Concepts: Literature Review.

Fuzzy logic	Analytical model-based FDI	(dynamic) bayesian networks	D-S-evidence theory	Neural networks	Cognitive automation
	MEX thruster fault identification[1]		FD[3]		Guidance of cooperative UAV[4]
FD in S/C power s/s[10]	Remote agent experiment on-board DS-1[5]	FD in SSHM of small satellites[6]			Cognitive UAV guidance[8]
SMART -FDIR[7]		FD in power s/s[9]			Management of aircraft propulsion s/s[11]
	ESA's advanced FDIR study[2]				
Attitude & flight control for re-entry vehicle X-38[15,24]	FD in GNC s/s of re-entry vehicle[13]	Mars rover system level FDIR[14]		FD in AOCS s/s[22,23]	
AOCS s/s control[16]					
AOCS s/s (GEO stationkeeping, R&D, instr. pointing)[17,18]			Landing site selection[21]		
Landing site selection[20,21]		Landing site selection[19]			

Recovery Architecture.



Autonomy Considerations.

- Combination of traditional, well-proven FDIR methods on-board with innovative, advanced recovery mechanisms on system level.
- Implementation of a centralized knowledge base about the system, its operational capabilities and impact of environmental interaction
- Context sensitive reaction in case of unexpected faults and failures according to mission goals
- On-board architecture: additional independent cognitive recovery unit.
- Development process definition for integration into space systems engineering process.

Test Setup.

Test Environment

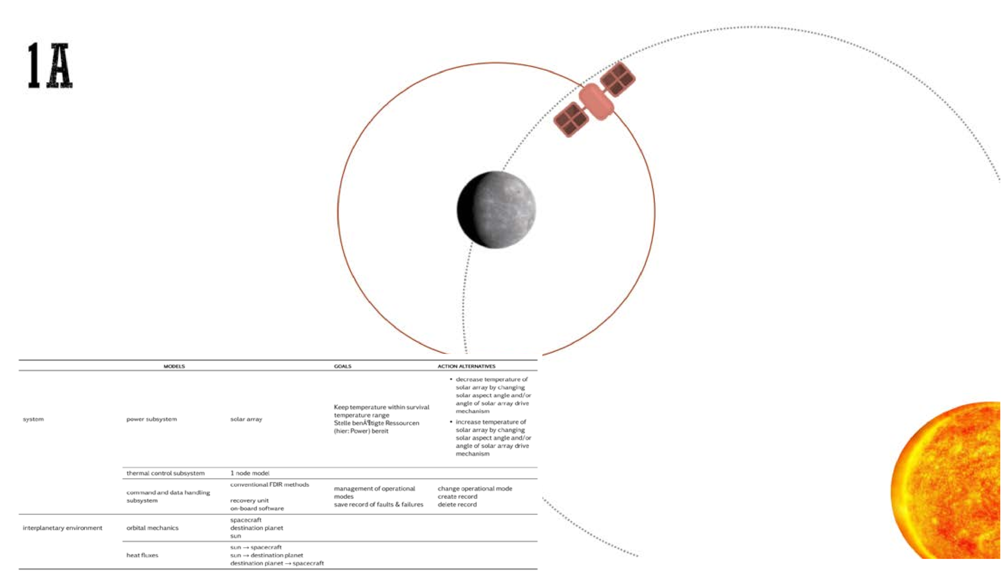
- Simulator with GUI for fault injection & control
- Cognitive Recovery unit with knowledge about system properties, mission goals and action alternatives

Test Strategy

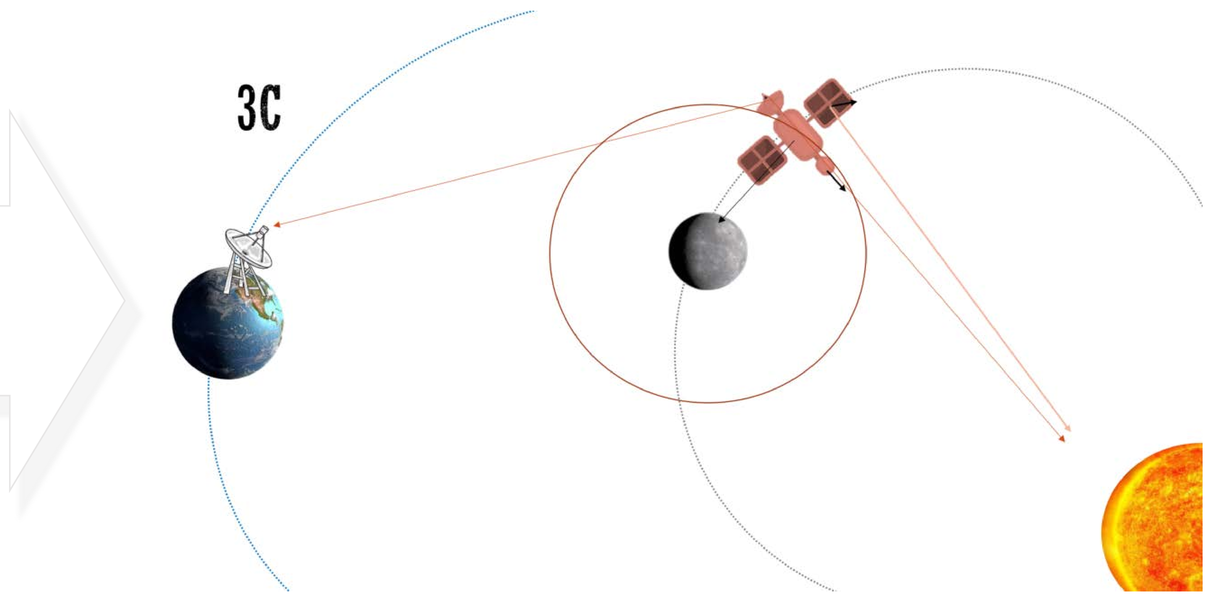
- 3 use cases covering 7 test scenarios from single faults to multiple failures and conflicting subsystem goals
- Composed modularly with increasing system complexity

1a	Orbit with power/temperature conflict of solar array
1b	Orbit with power/temperature cpnflict of solar array and rechargable battery
2a	Orbit with power/temperature conflict of solar array and fault „SADM stuck"
2b	Orbit with power/temperature conflict of solar array and fault „SADM stuck" incl. geometrical constraints
3a	Orbit with power/temperature/contact to Earth conflict
3b	Orbit with power/temperature/contact to Earth conflict and fault „SADM stuck"
3c	Orbit with power/temperature/contact to Earth conflict and fault „SADM stuck" incl. economic considerations

1A



3C



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