



CIRA GN&C Technologies for Hypersonic Flights

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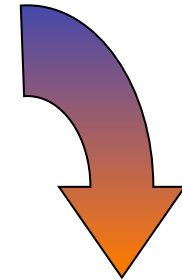
Needs & Challenges in GN&C Hypersonic Technologies

- Low Flexibility
- High Risk Flight
- Long Turnaround



- High Flexibility
- Low Risk Flight
- Short Turnaround

Needs



Today

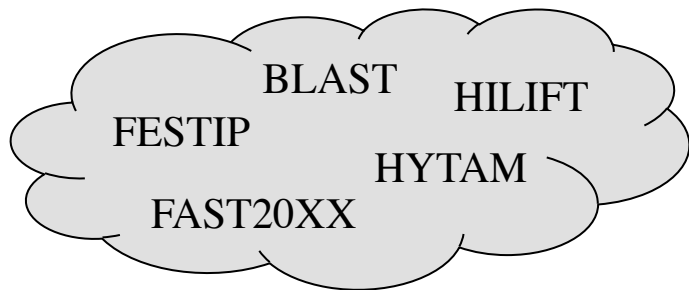
Tomorrow

Challenges



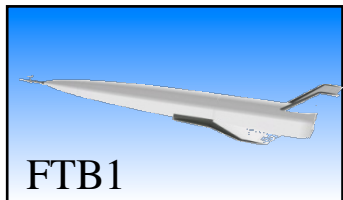
- On-Line Adaptive GN&C
- Increase Modelling Accuracy
- Increase GN&C Fault Tolerance
- Reduce GN&C Development Time

TRL = NASA Technology Readiness Level



Terminal Area Energy Management Phase

Orbital Phase



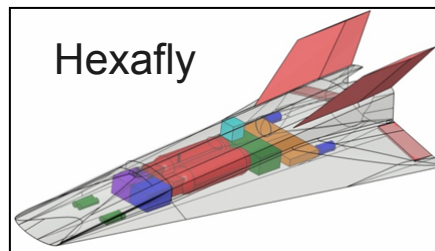
Flight mechanics, GNC, SW, Avionics

RCT Control System

Hypersonic GNC Technologies (TRL5)



Hypersonic Phase



Flight mechanics, GNC, SW, Avionics

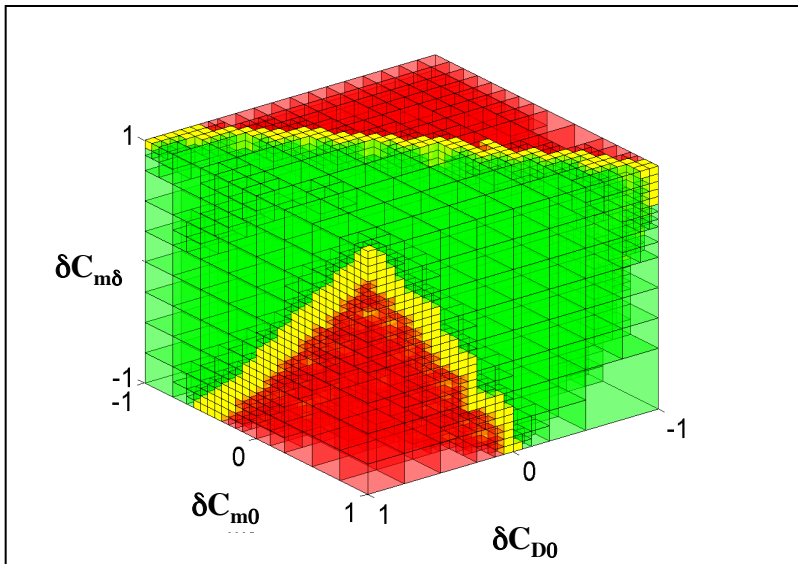
Manned/Unmanned Aeronautic Technology Development



Flight Mechanics Analysis and GNC Development Tools

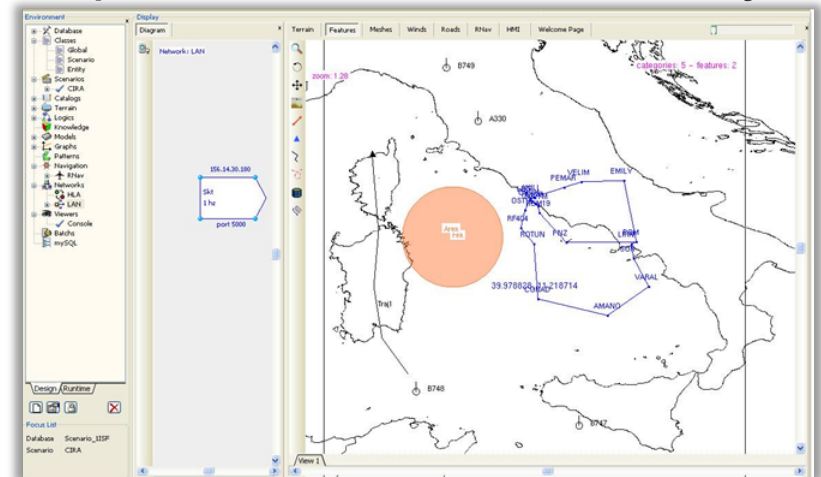
Tools dedicated to mission analysis and efficient, accurate and reliable implementation, verification and validation of GN&C algorithms for Space

- Detailed vehicle non-linear simulation accounting uncertainties and failures
- Innovative Tools for GNC analysis supporting multi-disciplinary optimization



Mission Feasibility in Aerodynamic Uncertainties

Space Vehicle Simulator in ATS Facility



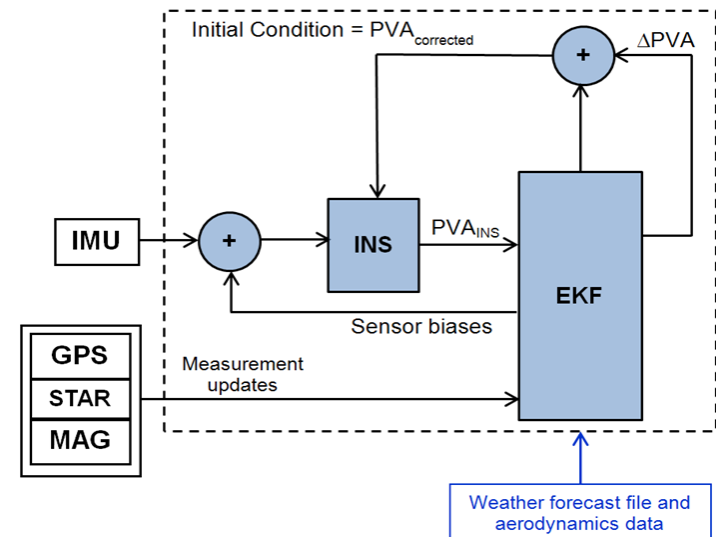
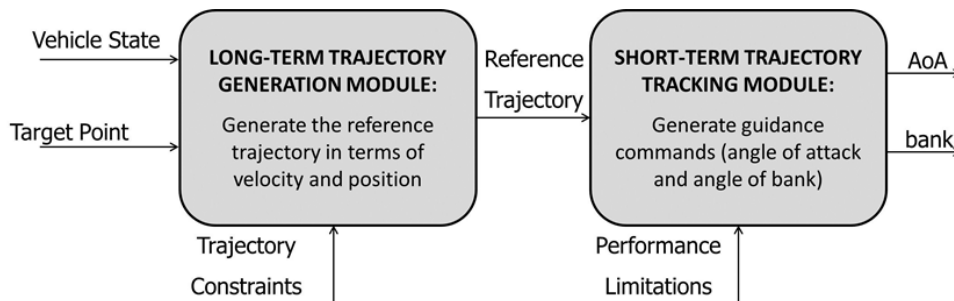
- Automatic generation of documentation, test cases and results and SW code
- Proprietary Post Flight Analysis and Model Identification Tools
- Dedicated HIL Testing Facilities integrated in ATS Real Time Simulators

Guidance & Navigation Algorithms

Technologies dedicated to reliable execution of a flexible and robust Hypersonic or Re-entry flight with high final state precision

- Long/Short Term Trajectory hard real time generation accounting mission constraints (path/ATS and safety) and vehicle maneuverability
- Adaptive trajectory tracking with Non Linear Model Predictive Control
- Single failure tolerant navigation without HW redundancy (Virtual Sensors)
- High accuracy fusion algorithms with lighter and affordable sensor units

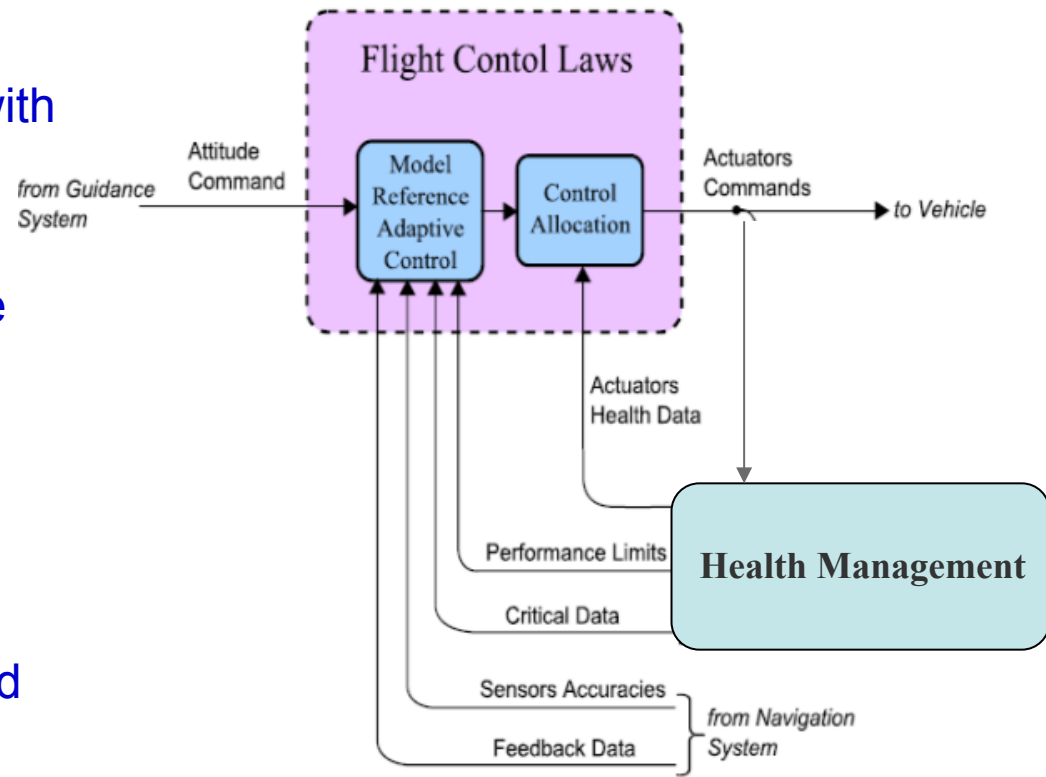
Advanced Guidance & Navigation Architecture for Hypersonics



Control Algorithms

Technologies dedicated to robust space vehicle maneuvering during all phases of flight and even in harsh environment or under failure conditions

- On-Line identification of vehicle limitations
- FDI of sensors and actuators with Stochastic Observers
- Adaptive and reconfigurable control laws for variable vehicle maneuvering capabilities and sensor accuracy variations
- Dynamic Control Allocation for effective use of all available healthy actuation means (Reaction Control Thrusters and Aerodynamic Surfaces) in any flight phase, reducing fuel consumption



Control Architecture with FDI for Hypersonics

- CIRA has been and is involved in several innovative technology developments, demonstration and industrial programs related to GNC for Hypersonic and Re-Entry
- New GNC technology developments also benefits of inner CIRA duality between Aeronautics/Space and Manned/Unmanned
- CIRA GNC and SW development process has been improved and is consistent with current industrial practice, allowing easy and effective integration of proposed technologies in industrial programs, as experience has been already demonstrated
- Some of proposed space technologies are currently being implemented in manned and unmanned aeronautical industrial programs for improving Flight Safety and reducing Pilot Workload in emergency situations



THANK YOU !

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