NASA SPLICE Project: Developing the Next Generation Hazard Detection System

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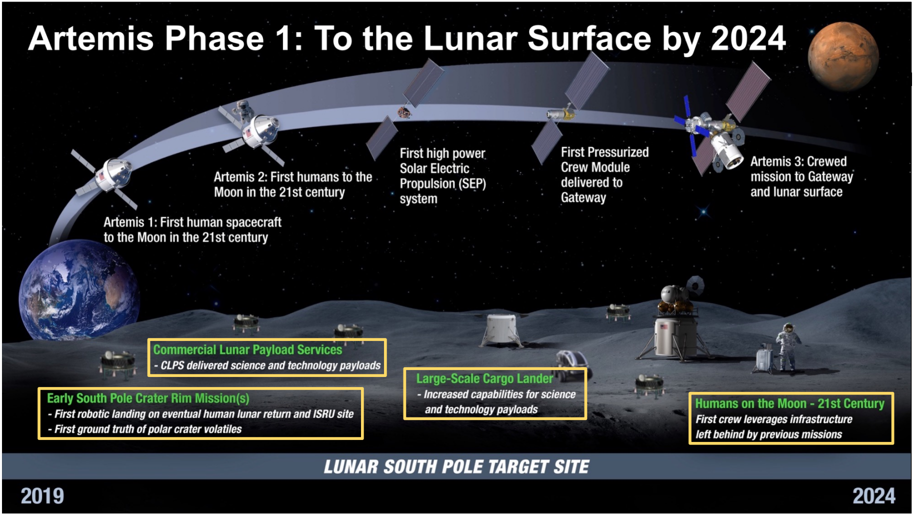
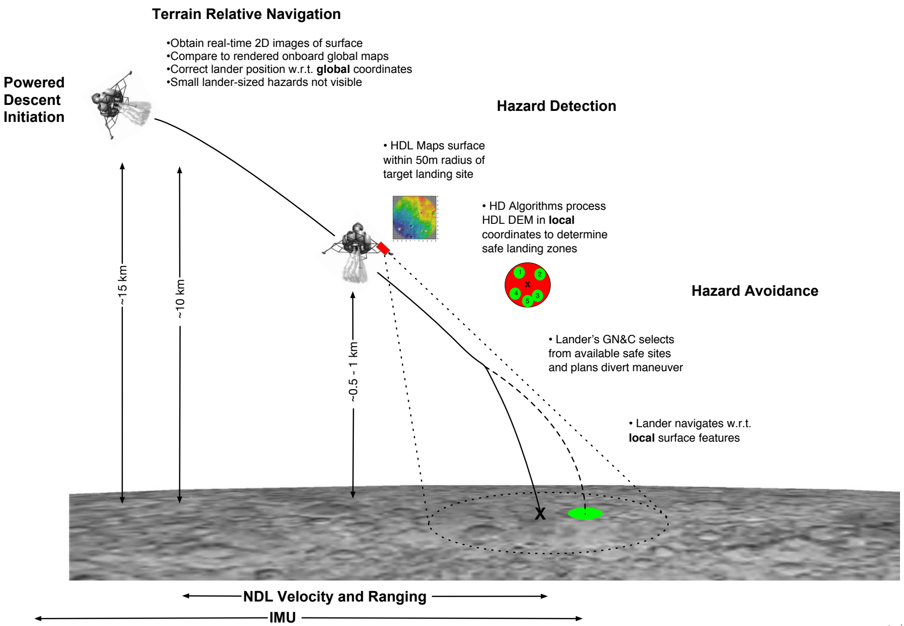
Overview

NASA's Lunar Program



Precision Landing & Hazard Avoidance ConOps



SPLICE Project

SPLICE: Safe & Precise Landing - Integrated Capabilities Evolution

- SPLICE is GN&C technology for precision landing
  - Components can be flown as an integrated payload or separately
  - High-fidelity hardware-in-the-loop simulation environments
  - Concept of Operations studies to derive requirements for various sensors during different flight phases
  - Flight tests planned for testing sub-components on various platforms

- SPLICE partners
  - NASA Centers: JSC, LaRC, GSFC, JPL, AFRC - Flight Ops
  - Industry: Draper, Masten Space Systems, Blue Origin, Astrobotic
  - Academia: University of Washington, Texas A&M University, San Diego State University, 4 Early Career Faculty Awards on related topics

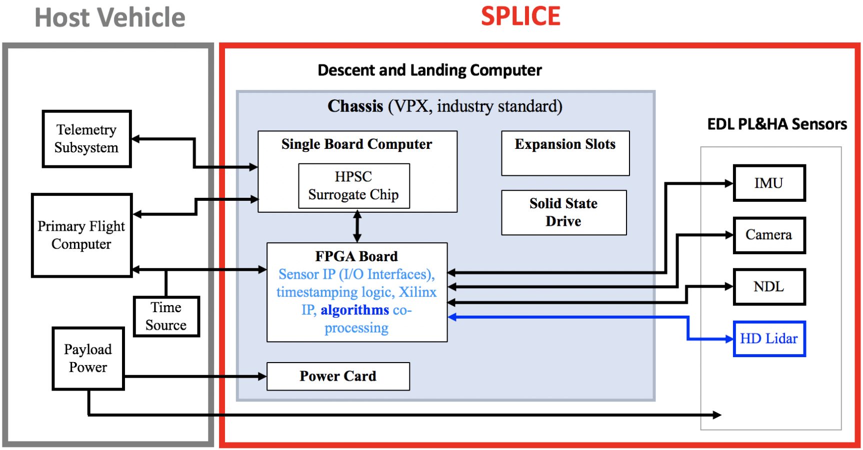
SPLICE Project & NASA's Lunar Programs

- Commercial Lunar Payload Services (CLPS) Program:
  - SPLICE sensors are slated to fly onboard CLPS missions
  - ConOps team is evaluating robotic scale lunar missions for CLPS providers
- Artemis Program:
  - ConOps is evaluating sensor suites for future human lander systems
  - SPLICE team engaged with the Human Lander Systems Program and multiple potential oroviders

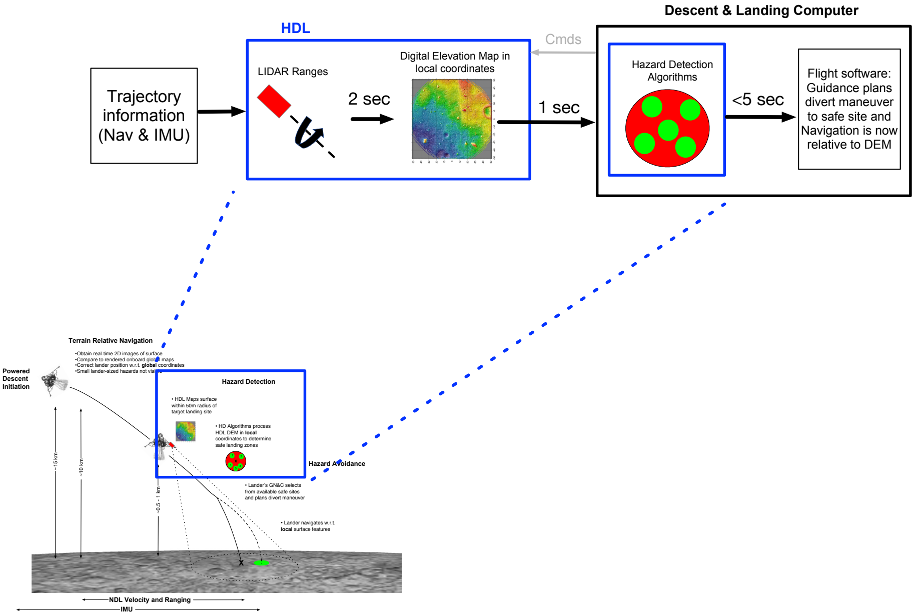
SPLICE PL&HA Technologies

- Sensors
  - Navigation Doppler LIDAR (NDL) for velocity and ranging
  - Hazard Detection LIDAR (HDL) for terrain mapping
  - TRN Camera
- Algorithms
  - Terrain Relative Navigation
  - Hazard detection and safe site selection
  - Trajectory & Navigation filter design to support precision landing
- Avionics
  - Descent and Landing Computer based on the High Performance Space Computing platform
- High-fidelity simulation environments
  - Concept of Operations studies for lander missions
  - Hardware-in-the-loop testbed
- Lab-scale test environment for research-level PL&HA algorithms (under development at JSC)

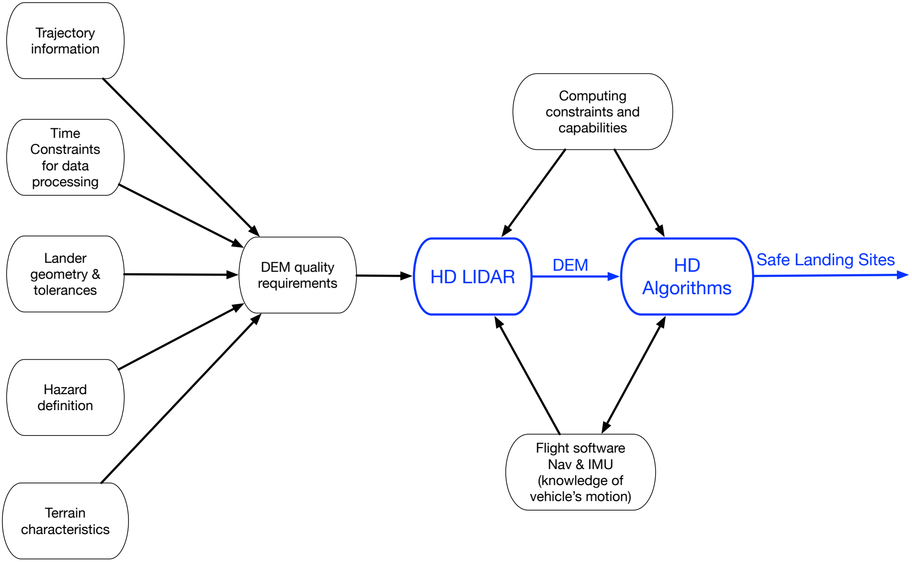
SPLICE Technologies Onboard a Host Vehicle



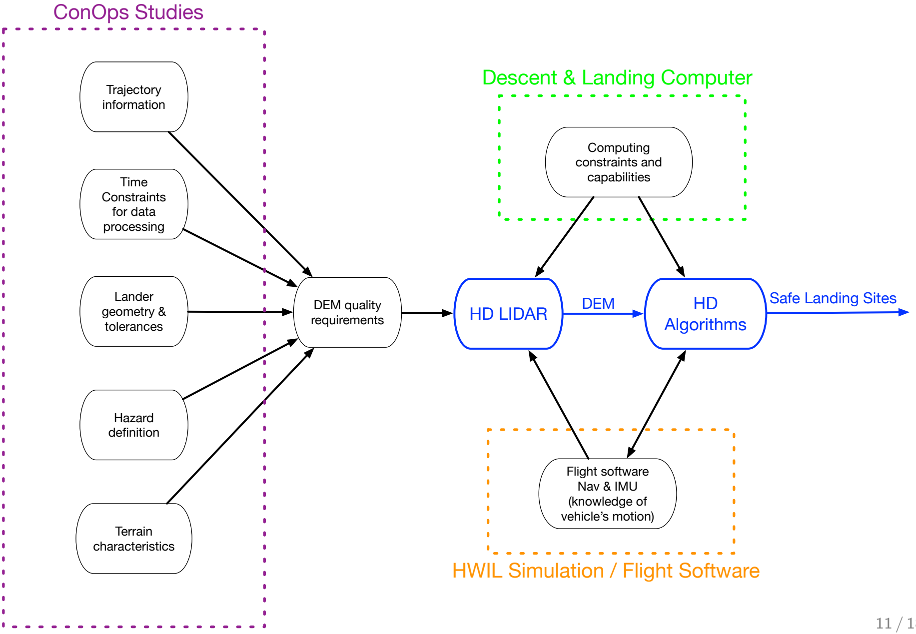
SPLICE Hazard Detection System



SPLICE Hazard Detection System



SPLICE Hazard Detection System



HDL Performance Specifications - ConOps

Derived from ConOps Studies from simulation data for several types of landers and trajectories:

- Slant range to landing target: $500m$
- Slant range angle: 10° off vertical
- Look angle from sensor to landing site: near 10° off vertical
- Vertical velocity: $20m/s$
- Assume HDL is fixed on vehicle and can point to target landing site at the start of the scan

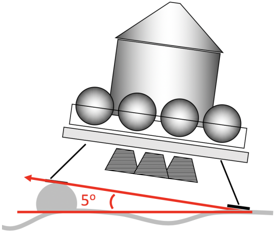
HDL Performance Specifications - DEM

Derived from previous work on Europa Lander sensor:

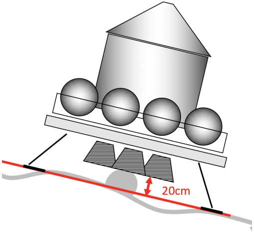
- Map is 100 m diameter circle centered at landing target
- Ground sample distance (resolution): $5cm$
- DEM elevation errors: $5cm,\ 3\sigma$
- DEM generation in approximately 2 seconds

HDL Performance Specifications - Hazards

Hazards definitions derived from previous ALHAT experience and notional lander geometry and sizes:



5° slopes

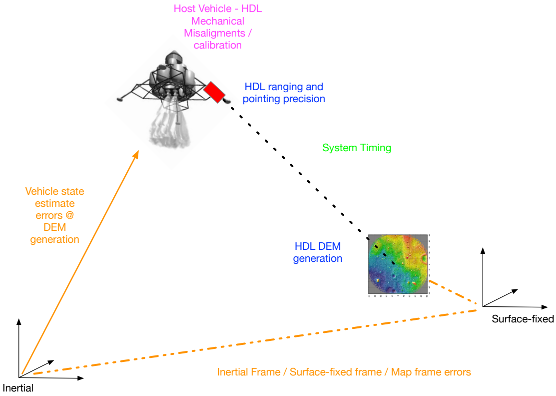


Terrain roughness of 20 cm

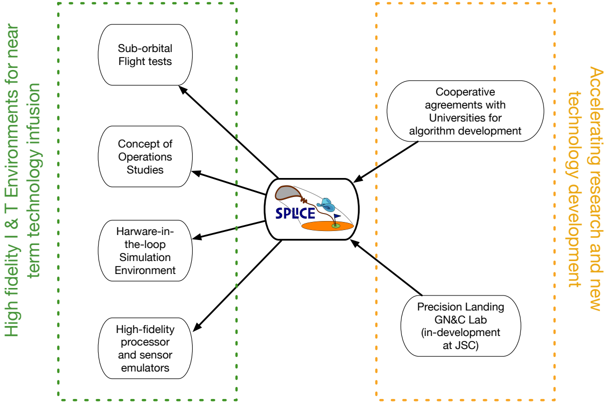
Hazard sizes → requirements for DEM resolution

Hazard Detection System Overall Performance

- Vehicle state knowledge (Nav errors, IMU)
- Host Lander to HDL calibration, misalignments
- HDL (sensor errors)
- DEM generation (vehicle motion and error propagation during map assembly)
- System timing (latencies, offsets)



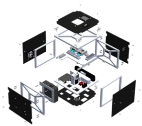
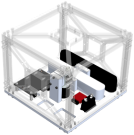
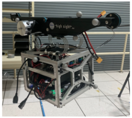
SPLICE Integration & Test Environments



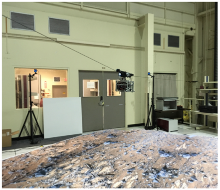
In-development Lab for Testing Emerging Technologies

Through a research collaboration with Texas A&M University, JSC is building a lab for developing and testing future landing GN&C technologies

- Lab-scale sensor package for testing research-level algorithms
- Payload is 100% portable and can be used over any terrain

- Lab has a motion capture system and mock terrain (external truth)



References

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