



## Unique Challenges of Deep Space Missions



- **Extreme Distance**
  - Communications performance scales as  $1/R^2$
  - Communicating with an Outer Planet mission to Neptune, Pluto is *~10 billion* times harder than with a commercial GEO satellite
- **Long Round Trip Light Times**
  - Onboard autonomy required in order to close decision loops faster than a round trip light time
  - Rapid response to in situ environments and conditions
- **Wide Range of Environments**
  - Challenging thermal, radiation, shock requirements
  - Fault-tolerant hardware and software
- **Unique Navigation Scenarios**
  - Small body ops, gravity assist trajectories, aerocapture/aerobraking, SEP, libration point missions, formation flying,
- **High Launch Cost per Unit Payload Mass**
  - Drives need for low mass, low power flight systems