WHAT'S THE COMMON PROBE STUDY?

- NASA study to determine if probe designs can be standardized, to what extent, with what compromises, and with what cost savings
- Atmospheric probe designs share many similar attributes
- Aeroshell design and probe geometry
- Instruments: mass spectrometers, atmosphere structure sensors

Study scope:
- NASA Centers: Ames, Goddard, Langley, and JPL
- Targets: Venus, Jupiter, Saturn, Uranus, and Neptune
- No sample-return (separate study)
- Draws from recent probe studies and current/new technology advancements
- Addresses common aeroshell and descent vehicle design, size, and instrument suite

Questions to answer:
- Can a single common probe be designed for all targets? (E.g., extreme heating and g-load at Jupiter and high pressure at Venus?)
- If not, how many designs are needed to accommodate all targets? Can many of the components be made common?
- What are the cost savings for any such commonality?
- What is the compromise/penalty to standardize? Does it limit mission science? What volume and mass constraints are imposed on mission?

KEY CHALLENGE:

- Low arrival velocity (to reduce probe entry speed)

TARGETS:

- Venus

23 Mar 2036

21 Mar 2043

3 Nov 2034

CURRENT PLAN:

- V = 9.0 km/s

21 Feb 2031

17 Dec 2032

Center Divert ΔV = 29 m/s

Probe Entry at Neptune 21 Aug 2034

V = 21.1 km/s

Total Deterministic ΔV = 14 m/s

Values shown for 50-g solution

TARGETS:

- Venus

20 Dec 2024

14 May 2034

80

Parameters

FPA:

- 18.5 RJ

Design a flyby trajectory for the carrier spacecraft that accommodates the carrier and descent vehicle design, size, and instrument suite

And studies in atmospheric probe designs (to match desired probe entry latitude)

Δ

Long flight times

Scenarios:

- FPA: -16.0°, -23.0°
- Peak g-load: 50, 150 (respectively)
- Key challenge: Distance from Earth and Sun
- Long flight times

HYPERBOLIC APPROACH

- An single interplanetary trajectory may provide a wide variety of entry conditions
- Available hyperbolic approach solutions gets narrowed down by entry conditions (e.g. entry flight path angle, altitude, latitude, etc.)—possibly to a unique solution

OBJECTIVES OF THE INTERPLANETARY TRAJECTORY DESIGN

- Design interplanetary trajectories for plausible future probe mission scenarios to Venus, Jupiter, Saturn, Uranus, and Neptune
- Multiple design objectives:
  - Low ΔV
  - Low flight time
  - Low arrival velocity (to reduce probe entry speed)
  - Low arrival declination (to match desired probe entry latitude)
  - Provide atmospheric entry conditions for a variety of entry flight path angles
- Design a flyby trajectory for the carrier spacecraft that accommodates the carrier probe communications link

CARRIER-PROBE COMMUNICATION LINK

- Distance within:
  - Giant planets: ~100,000 km
  - Venus: ~14,000 km
  - Probe to carrier aspect angle:
  - Giant planets: 30°
  - Venus: “50”
- Maintain link for:
  - Giant planets: ~2 hr
  - Venus: 0.5 hr
  - Probe oriented radir
  - Probe fixed at entry point and moves with rotation of atmosphere
  - Probe release prior to atmospheric entry
  - Giant planets: 60 days
  - Venus: 4 days

JUPITER TRAJECTORY DESIGN

- Entry altitude of 450 km
- Entry at equator
- Different from Galileo’s 67°N entry
- Slower relative velocity if heading eastward
- Scenarios:
  - FPA: -4.10°, -4.47°, -5.31°, -6.5°
  - Peak g-load: 70, 100, 150, 200 (respectively)
  -Key challenge: High entry speeds
  - Due to Jupiter’s immense gravity
  - Insensitive to arrival V∞ (for V∞ < 10 km/s)

NOTE: All g-load values shown for 50-g solution

SATURN TRAJECTORY DESIGN

- Entry altitude of 150 km
- Entry at equator
- Slower entry with eastward heading
- Scenarios:
  - FPA: -11.88°, -24.98°
  - Peak g-load: 50, 150 (respectively)
  - Key challenges: Ring avoidance and entry speed
  - Carrier flies through F-G ring gap for these solutions

NOTE: All g-load values shown for 50-g solution

VENUS TRAJECTORY DESIGN

- Entry altitude of 175 km
- Entry at 3.53°N latitude, 64.70°W longitude
- Scenarios:
  - FPA: -9.0°, -16.12°
  - Peak g-load: 50, 150 (respectively)
  - Key challenge: Required planet rotation with super-rotating atmosphere
  - Targeted longitude has large impact on trajectory due to slow rotation

NOTE: All g-load values shown for 50-g solution

VENUS TRAJECTORY DESIGN

- Entry at 150 km
- Entry at 3.53°N latitude, 64.70°W longitude
- Scenarios:
  - FPA: -9.0°, -16.12°
  - Peak g-load: 50, 150 (respectively)
  - Key challenge: Required planet rotation with super-rotating atmosphere
  - Targeted longitude has large impact on trajectory due to slow rotation

NOTE: All g-load values shown for 50-g solution

NEPTUNE TRAJECTORY DESIGN

- Entry altitude of 1500 km
- Entry at equator
- Scenarios:
  - FPA: 16.5°, 35.0°
- Peak g-load: 50, 200 (respectively)
- Key challenge: Distance from Earth and Sun, 98° axial tilt
- Long flight times
- Higher entry speeds (heading transverse to atmosphere)
- Probe in atmosphere moves transverse to carrier spacecraft—presents comm-link challenge

NOTE: All g-load values shown for 50-g solution

NEPTUNE TRAJECTORY DESIGN

- Entry at equator
- Scenarios:
  - FPA: 16.5°, 35.0°
  - Peak g-load: 50, 200 (respectively)
- Key challenge: Distance from Earth and Sun, 98° axial tilt
- Long flight times
- Higher entry speeds (heading transverse to atmosphere)
- Probe in atmosphere moves transverse to carrier spacecraft—presents comm-link challenge

NOTE: All g-load values shown for 50-g solution

Jupiter Gravity-Assist Trajectory

- Probe-Com Link: 50-g

Venus-Earth-Jupiter Gravity-Assist Trajectory

- Probe-Com Link: 50-g

Venus-Earth-Gravity-Assist Trajectory

- Probe-Com Link: 50-g

Direct-to-Neptune Transfer

- Probe-Com Link: 50-g