A Suggestion to Address CAIB's Recommendations Regarding Future Spaceplanes
(HyTASP Version)

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Preface

- All quotations are from the CAIB Report, Vol. I, August 2003.

Content

- Background
- CAIB’s design philosophy
- A vehicle concept to follow this philosophy

Motivation

- “The loss of *Columbia* and her crew represents a turning point, calling for a renewed public policy debate and commitment regarding human space exploration.” (p. 6)

A Look Ahead: Objective

- “The objective…is for this country to maintain a human presence in space, but with enhanced safety of flight.” (p. 207)

“An Inescapable Conclusion” (p. 210)

- *“Because of the risks inherent in the original design of the Space Shuttle, because the design was based in many aspects on now-obsolete technologies, and because the Shuttle is now an aging system but still developmental in character, it is in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit.”* (p. 210-211. Emphasis in original.)

The Shuttle: The Bottom Line

- CAIB believes that by 2010, a successor vehicle for the aging shuttle fleet should be close to readiness, or the shuttles should undergo a rigorous recertification process, that might require very costly improvements or ground the shuttle fleet.

CAIB: A National Vision for Space

- *"The United States needs improved access for humans to Low-Earth orbit as a foundation for whatever directions the nation's space program takes in the future."* (p. 210. Emphasis in original.)
  - "All members of the Board agree that America's future space efforts must include human presence in Earth orbit, and eventually beyond, …" (p. 210)

CAIB on Previous Attempts

- "It is the view of the Board that *the previous attempts to develop a replacement vehicle for the aging Shuttle represent a failure of national leadership*." (p. 211. Emphasis in original.)

Integrated Space Transportation Plan: Potential Changes in Directions

- Pre-STS-107 plans (which are also the current plans) for OSP and NGLT (including Hypersonic pillar of NAI as related to NASA's access to space) should significantly change post-CAIB report.
  - CAIB recommendation: An Orbital Space Plane should not be an interim complement to the Space Shuttle.
- The following approach should be replaced:
  - "… the current NASA strategic plan stresses an approach of investing in 'transformational technologies' that will enable the development of capabilities to serve as 'stepping stones' for whatever path the nation may decide it wants to pursue in space." (p. 210)

Pre-STS-107 & Current Plans: Observations

- **OSP**
  - Alternatives [CRV in 2010 & CTV in 2012 (changed “post-CAIB report” to 2008 and 2010, respectively)]
    - Capsule, a la Apollo, Soyuz, or Shenzhou V
    - Space Plane, a la X-20, Hermes, or Hope
  - Observations
    - Previously discarded or old approaches are reconsidered.
    - Atlas V or Delta IV and 2008 necessitate a simple design and a quick development, respectively.
    - CTV requires man-rated EELVs.
- **NGLT**
  - Alternatives
    - New Rocket RLV (Decision Point: 2009)
    - Hybrid RLV (Decision Point: 2015)
    - Hypersonic RLV (Decision Point: 2020)
  - Observations
    - Two RLVs will not be developed in less than 12 years.
    - 2015 or 2020 as a decision point is too late.

CAIB's Design Philosophy

- "…the nation should give attention to developing a new 'concept of operations' for future activities..." (p. 210)
- "Such a concept…should help…prevent the debate from focusing solely on the design of the next vehicle." (p. 210)
- "The design of the system should give overriding priority to crew safety, …" (p. 211)

Concepts of Operations, Discriminators, and Risk

- Concept of Operations: Defining Factors
  - Mission Requirements
  - Propulsion Concepts
    - Rocket-like operations
    - Aircraft-like operations
- Operations
  - Mission Preparation and Planning
  - Ground Processing
  - Flight Operations
- Concept of Operations: Discriminators
  - Safety
  - Reliability
  - Affordability
- "… the risk is not distributed evenly over the course of the flight. It is greater by far at the beginning and end than during the middle." (p. 207)

Preferred Design Concept

- Preferred Concept of Operations
  - Aircraft-like operations
- Preferred Propulsion at Low Speeds for Enhanced Safety and Reliability
  - Turbojets with afterburners
- Preferred Design Approach Considering the Status of Technologies
  - Two-stage-to-orbit (TSTO) spaceplane
    - Airbreathing propulsion on the first stage (booster)
    - Rocket propulsion on the second stage (orbiter)

Outside-the-Sandbox Suggestions

- Crawl before walking; walk before running.
  - First develop the TSTO spaceplane for Mach 6 staging.
  - Then develop the next generation TSTO plane to stage at Mach 10 or 12.
- The preferred “concept of operations” & the “as soon as possible” spaceplane
  - A TSTO spaceplane with a turbine-based combination cycle (a turbojet with afterburner and a dual-mode ramjet) propulsion system on the first stage (booster) and with rocket engines on the second stage (orbiter)
    - One first stage is developed to launch the second stage at Mach 6.
    - Two second stage vehicles are developed:
      - A crew vehicle (circa 2011)
      - A cargo vehicle with or without crew (circa 2013)
- RLVs and EELVs are used, respectively, for small/medium payloads with or without crew and for heavy payloads.

Airbreathing Propulsion: Some Observations

- The turbojet technology is ready up to freestream Mach 3.0+.
- A compelling justification for Mach 4 or 4.5 turbojet is missing for Mach 6 staging. (PW F119, F135 or F136 engines with afterburners or GE F120 engines with afterburners would suffice for a turbine-based combination cycle.)
- Dual-mode ramjets can operate in the Mach number range from 1.5 to 6+.
- Demonstrated ramjets
  - BOMARC
  - D21 drone
  - The Marquardt's flight-weight ramjet was successfully ground tested up to simulated Mach 8 flight condition.
- The ramjet technology is older than the turbojet technology.
- The scramjet technology is increasing less ready as the freestream Mach number is increased from 6 to 15.
- NGLT has not investigated dual-mode ramjets for the ISS mission.
- NAI & NGLT have misused the word "hypersonic."
  - The conceptualized, new rocket RLVs do fly in the hypersonic regime.
  - Correct categories of RLVs: Rocket RLV and Airbreathing-Rocket RLV

Concluding Remarks

- The CAIB's recommendations for the future human space flight and for future spaceplanes will set a new course for the nation.
- Dual-mode ramjets and dual-mode scramjets are, respectively, appropriate for near-term RLVs and for far-term RLVs.
- A TSTO spaceplane, with airbreathing propulsion (turbojets with afterburners and dual-mode ramjets) on the first stage and with rocket propulsion on the second stage, is correct concept in the near term to address the preferred/new concept of operations with safety and reliability being the principal requirements. (The pure ramjet is the threshold.)
- The proposed first stage would be a common vehicle for NASA and DOD, reducing the life-cycle cost for the Nation.
- Need someone like Gen. Bernard Shriever, Adm. Hyman Rickover, Kelly Johnson, or Wernher von Braun to develop the next generation launch vehicle.
- Will & leadership are needed to set & pursue the new course.

References

- Mehta, U. B., “Strategy for Developing Air-Breathing Aerospace Plane,” *Journal of Aircraft*, Vol. 33, No. 2, March–April 1996. Errata in Vol. 33, No. 4, July–August 1996, p. 840. (This paper is an updated and shortened version of “Air-Breathing Aerospace Plane Development Essential: Hypersonic Propulsion Flight Tests (Invited),” *Proceedings of the 2nd European Symposium on Aerothermodynamics for Space Vehicles*, ESTEC, Noordwijk, The Netherlands, November 21–23, 1994, ESA SP-367, February 1995.)
- Mehta, U. B. and Bowles, J. V., "A Two-Stage-to-Orbit Spaceplane Concept With Growth Potential." *Journal of Propulsion and Power*, Vol. 17, No. 6, Nov.-Dec., 2001.

Postscript

- The presented suggestions and observations are solely those of the presenter, and neither reflect the official position of NASA nor constitute an endorsement by NASA.