The Financial Feasibility and a Reliability Based Acquisition Approach for Commercial Crew

Presentation to Administrator Bolden

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Financial Feasibility Assessment

- Objective:
  - *Research business feasibility of Commercial Crew*
    - Started as internal Aerospace research, picked up by IPCE
  - *Determine preliminary estimates for Business Case variables*
    - Construct a generalized, high level business case model
Summary of Findings

- Given the model we developed and the assumptions we made:
  - *Price Pre Seat for four government passengers per launch and no failures is in excess of $100M in order to make the business case close for most cases studied*
  - *Sensitivities moving away from aggressively low cost forecasts*
Business Case Model Assumptions

- 5 year development and 10 years of operations
- NASA requirement of 2 launches per year
- NASA invests from $1B to $5B in development per provider
- The commercial entity invests 10% of the government’s investment in development
- Range of “unit” variable costs (Launch System, Launch Abort System and Capsule) in terms of theoretical first unit costs (TFUC) from $175M to $491M, taken from internal assessments
- Aggressively low ground system (fixed) costs, starting out at $400M/Yr and modeled as a step function based on the number of
Price Per Seat to NASA for Commercial Crew

For the values shown Price per Seat varies Between $90M and $175M
Total Cost to NASA for Commercial Crew

For the values shown total cost to NASA varies between $8 and $19B with operations costing between $7B and $13B.
NASA Total Cost and Price Per Seat Sensitivities

Total cost is substantially higher for two providers each supplying one flight annually compared to one provider supplying two flights annually.
Modeling Demand Elasticity for Private Passengers

Notional Demand Elasticity Relationship

No one knows what this relationship looks like but we do have evidence of ~$25M for a few flyers who did and $0.25M for many fliers who said they would
Implications of Modeling Demand Elasticity for Private Passengers

To make a business case close for a notional demand elasticity the PPS for private passengers would have to be anywhere from 22% to 6% of the PPS for Gov’t passengers.
Details Of A Case That “Closes” With Soyuz

<table>
<thead>
<tr>
<th>Investment</th>
<th>$1.4B / 10% / 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seats / Launch</td>
<td>7</td>
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<tr>
<td>NASA Flts / Yr</td>
<td>2</td>
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<tr>
<td>Total Private Seats</td>
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<tr>
<td>Annual Fixed Costs</td>
<td>$400M</td>
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<tr>
<td>Variable Costs</td>
<td>$176M TFUC / $97M</td>
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<tr>
<td>Failures</td>
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<tr>
<td>Gov’t Price Per Seat</td>
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<tr>
<td>Total Gov’t Cost</td>
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<tr>
<td>Private Price / Seat</td>
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<tr>
<td>Commercial IRR</td>
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$1.4B NASA Investment
10% Goes to NASA Staff
Private Investment = 10% of Total NASA Investment

Means that the Gov’t would fly 14 passengers a year to ISS
Summary of Financial Feasibility

• Given current assumptions
  – Development + 10 years of operations may cost NASA $10B to $20B for one viable commercial crew provider
  – Domestic commercial crew launch capability may result in prices per seat 2 to 3 times that of foreign based alternative access options
  – Due to the fixed and variable nature of space launch operations 2 viable CC
Questions Raised By The Business Case Analysis

• Reasonableness of low cost / high reliability space transportation systems
  • What are the options for Human Rating?
  • What is the nature of the required test program?
  • What level of reliability is required relative to Shuttle?
• Are there ways to forecast eventual system reliability other than relying on design criteria or waiting for demonstrated reliability?
• What is the impact of failures on demonstrated reliability?
• Given reliability “desirements” what parts of a total Commercial Crew transportation system might be assigned to different levels of Human Rating?
• Does history give us insight into what’s reasonable?
Notional Human Rating (HR) Approaches

Spectrum of Options with Implications on Crew Safety, Time to Domestic Capability and Cost

- **HR4 (Reference Approach):** Full compliance with NASA HR specification, Gov't mission assurance / IV&V along with full ability to direct contractor activities, 3 successful flight tests

- **HR3 (Contemporary NASA Approach):** Minor exemptions from HR4 approach justified through equivalence arguments, Gov't mission assurance / IV&V along with moderate ability to direct contractor activities, 3 successful flight tests

- **HR2 (Hybrid Commercial Approach):** Major exemptions from HR4 approach justified through equivalence arguments, Gov't insight only with some mission assurance / IV&V and minimal ability to direct contractor activities, highly reliant on number of successful flight tests

- **HR1 (Purely Commercial Approach):** Minimal Gov't insight with no mission assurance / IV&V and no ability to direct contractor activities, Gov't completely trusts contractor approach, system reliability solely determined by flight testing
Example of Reliability Evolution for HR4 Approach

- **Design and Development Phase**
  - Design reliability established during this phase
  - Expected reliability very low because very little qualification/verification has occurred
  - High uncertainty in expected reliability
  - No demonstrated reliability

- **Qualification and Verification Phase**
  - Expected reliability grows throughout this phase as qualification and verification steps are completed
  - Uncertainty is reduced throughout this phase
  - No demonstrated reliability

- **Flight Test Phase**
  - Expected reliability approaches design reliability
  - Flight history for demonstrated reliability begins

- **Operations Phase**
  - Expected reliability approximately equal to design reliability
  - Demonstrated reliability approaches Expected reliability over time
Impact on Demonstrated Reliability Growth of

![Graph showing the impact of flight failures on demonstrated reliability growth.](image)

- **Demonstrated Reliability with Flight Failures**
- **Legend**:
  - No Failures
  - 1 Failure
  - 2 Failures
  - 3 Failures
- **Example**: Flight failures on 4th, 25th, and 39th launch attempts
CS Requirement and Allowable LV Reliability

- Multiple LVs have demonstrated reliability that could meet a slightly lower Crew Safety requirement if used with an HR3/HR4 Crew Module and LAS

Demonstrated Reliability of Existing Mature Launch Vehicles
(at 90% Confidence Level)

May be Possible to Achieve CS requirement of 0.990 at 90% CL
Summary of a Reliability Based Acquisition Analysis

• *Completely commercial service is difficult to envision in the near-term given expected CS requirement*

• *LV offers most flexibility for choosing a commercial-like development approach within CC Program*

• *Parallel government / commercial efforts may allow near-term assured domestic capability, as well as “maturation ramp” for longer-term, commercially-provided crew launch services*