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

Presentation to Administrator Bolden

John Skratt
The Aerospace Corporation

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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**

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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***

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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

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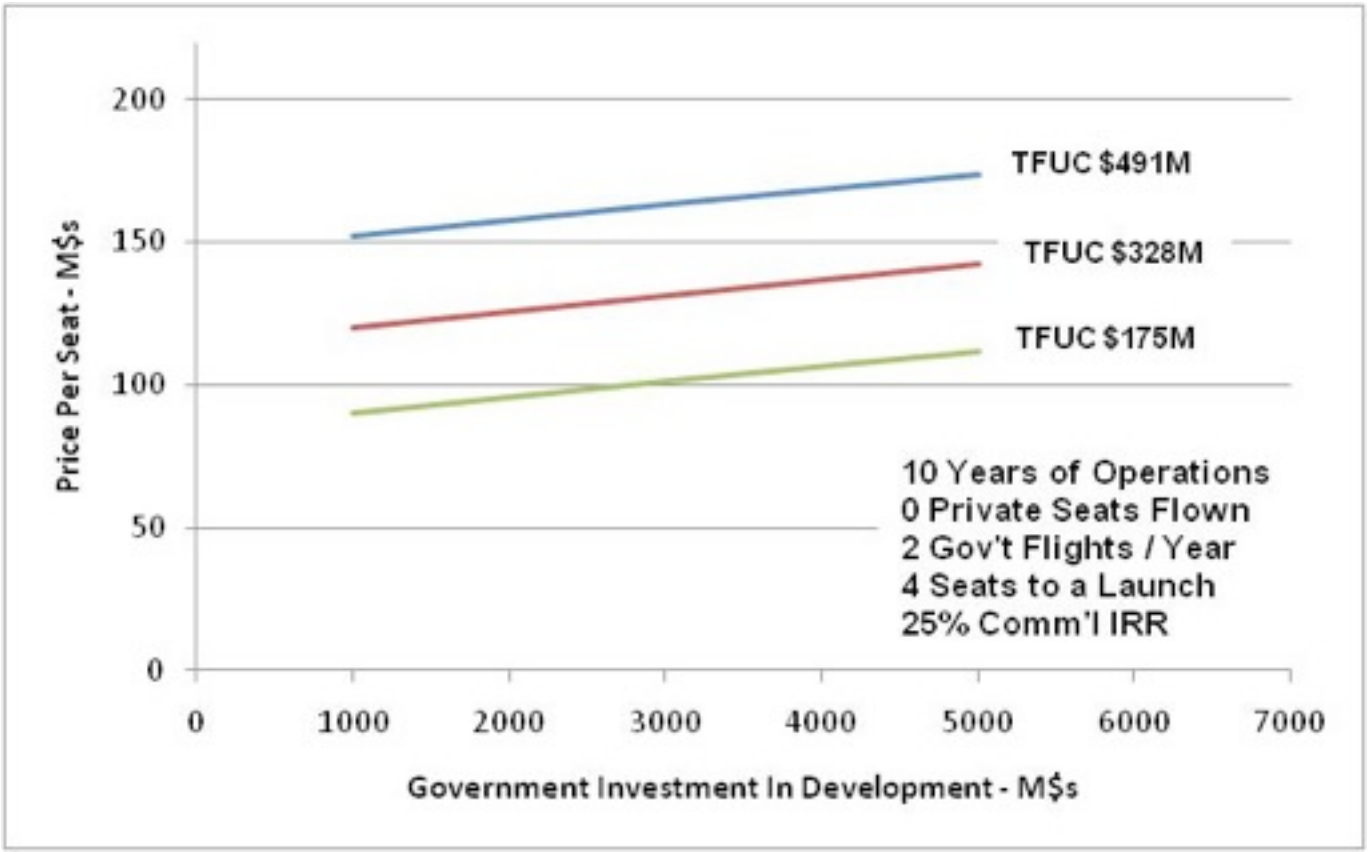
Price Per Seat to NASA for Commercial Crew



For the values shown Price per Seat varies Between $90M and $175M

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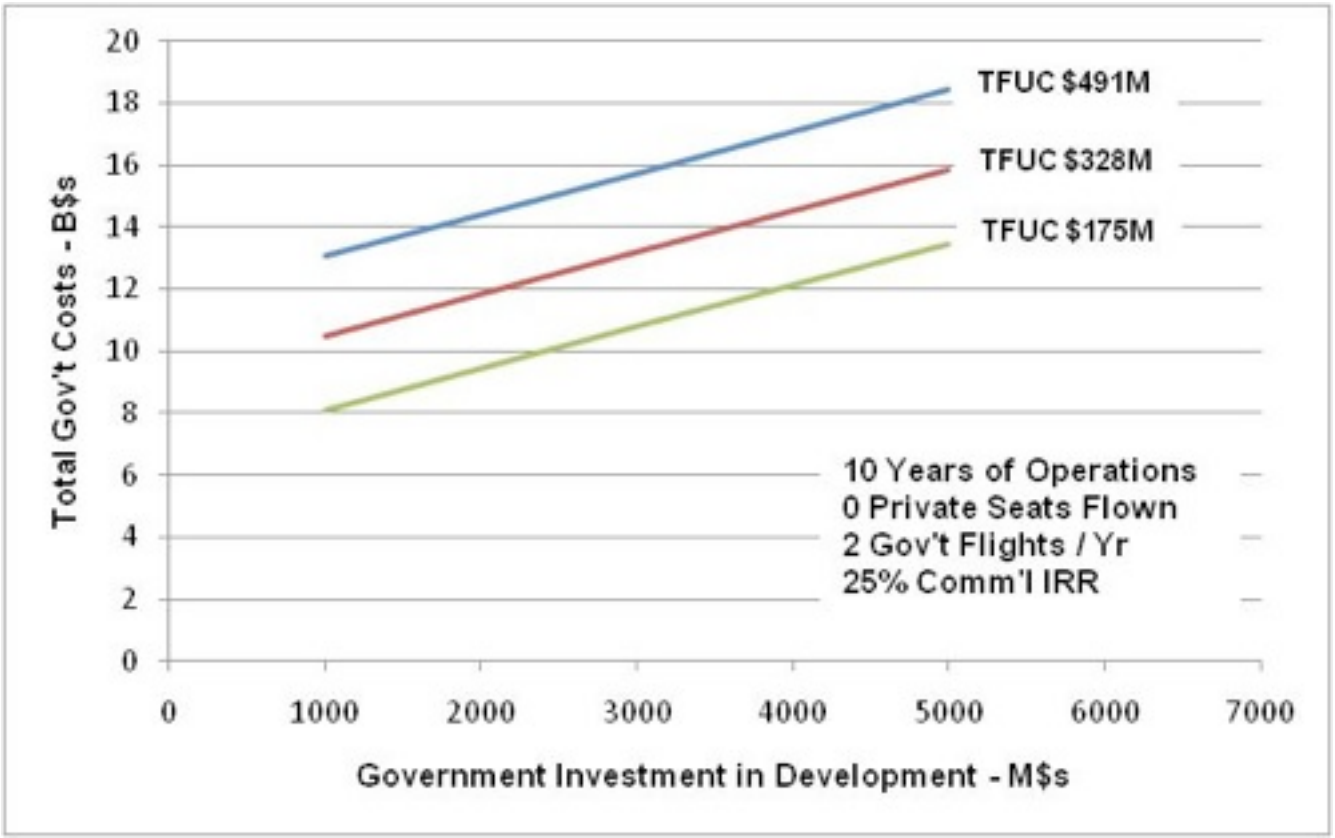
Total Cost to NASA for Commercial Crew



For the values shown total cost to NASA varies between $8 and $19B with operations costing between $7B and $13B

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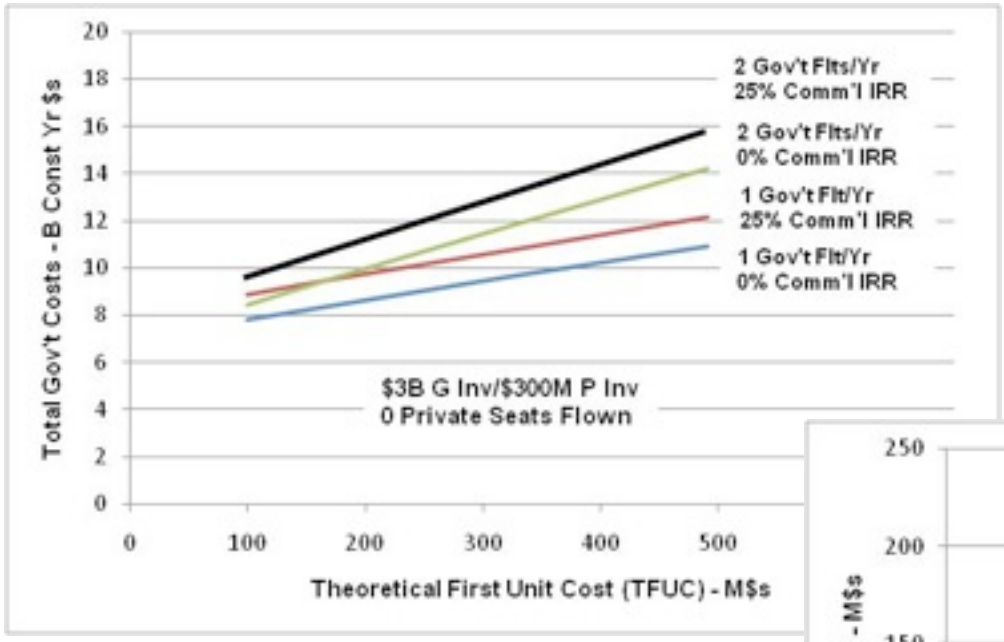
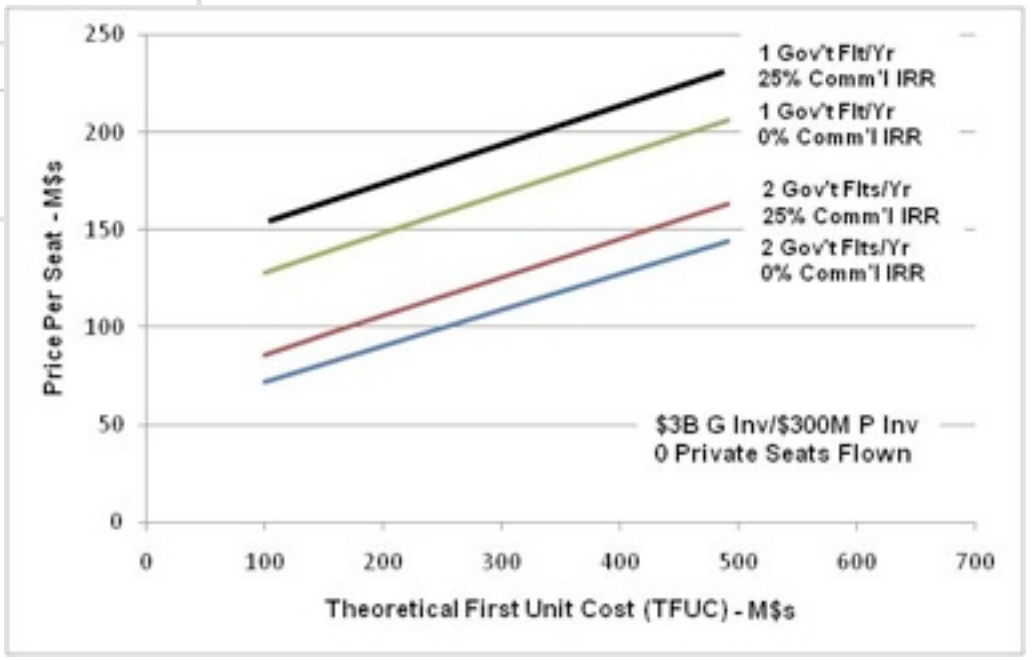
NASA Total Cost and Price Per Seat Sensitivities





Total cost is substantially higher for two providers each supplying one flight annually compared to one provider supplying two flights annually

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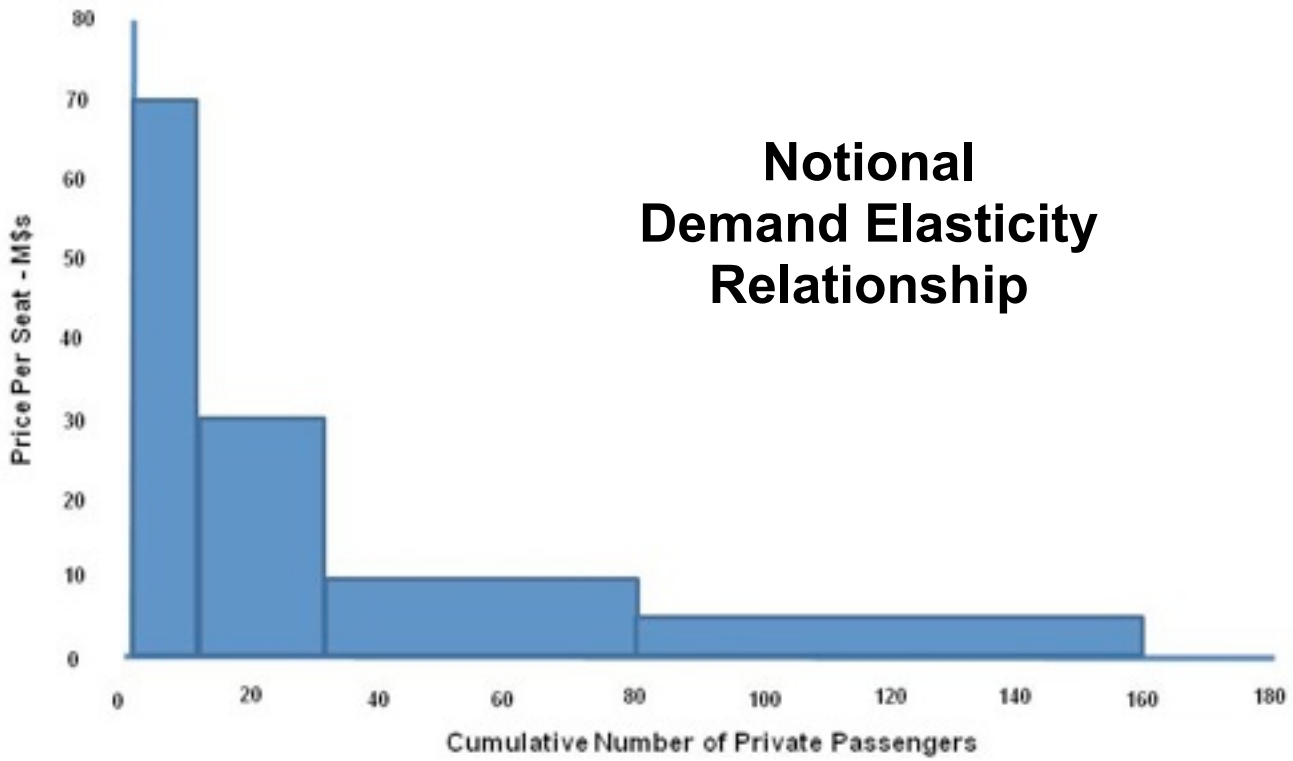
Modeling Demand Elasticity for Private Passengers



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

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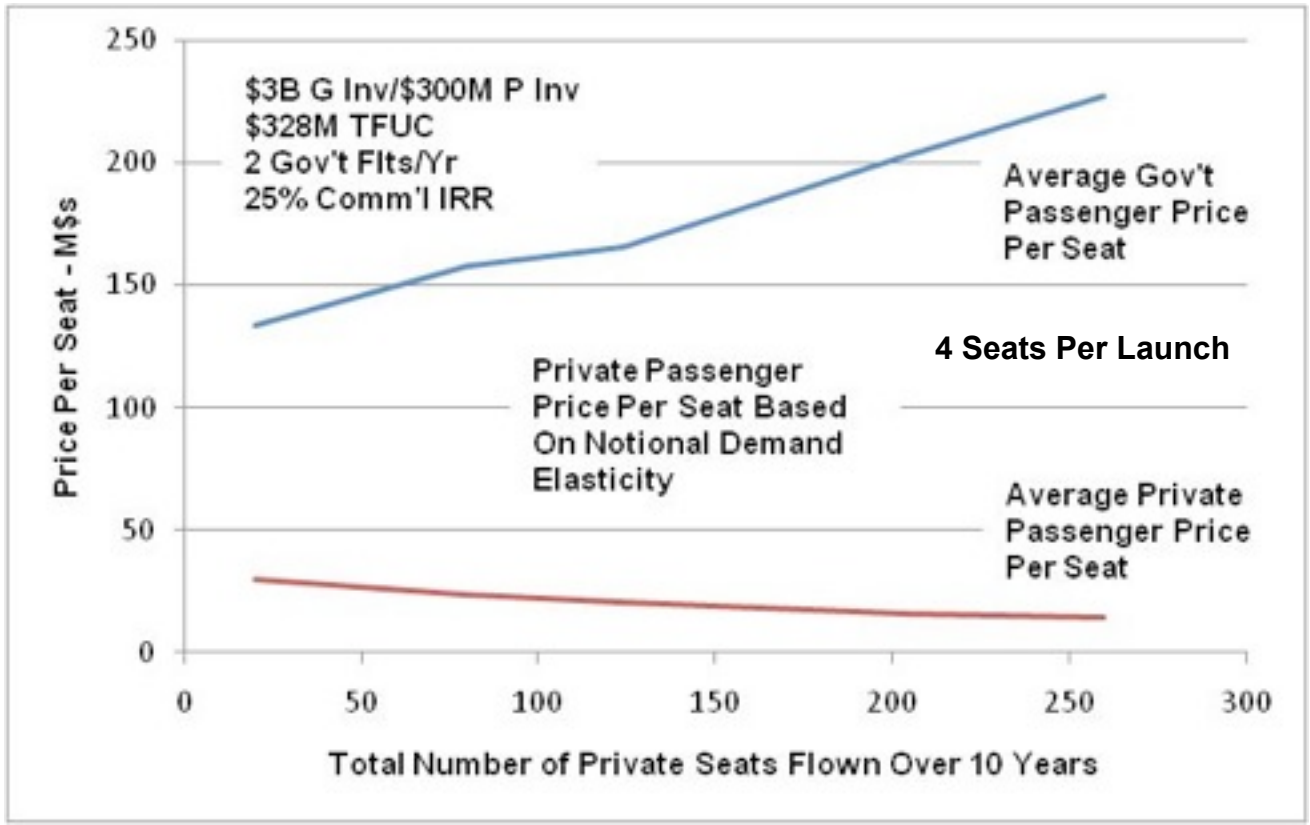
Implications of Modeling Demand Elasticity for Private Passengers



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

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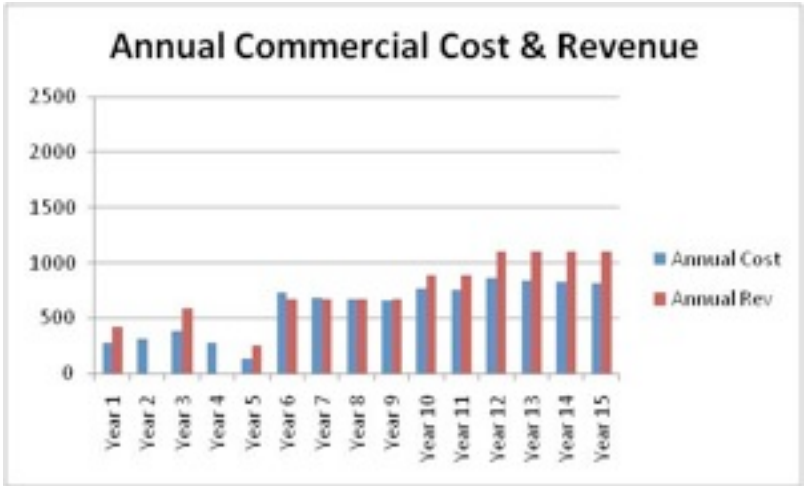
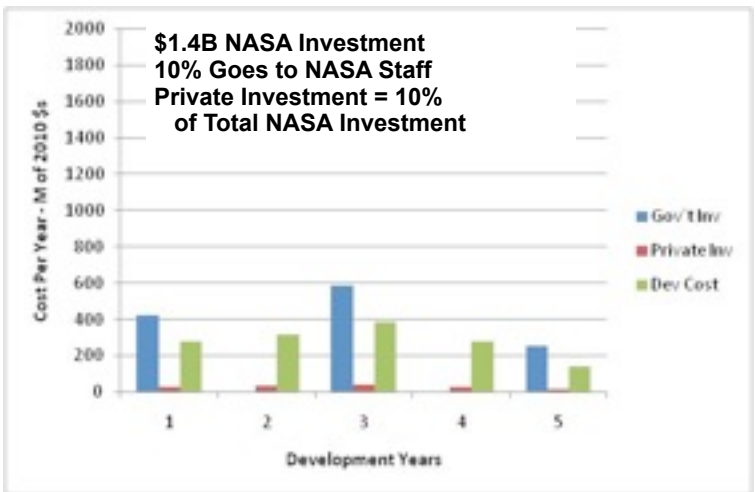
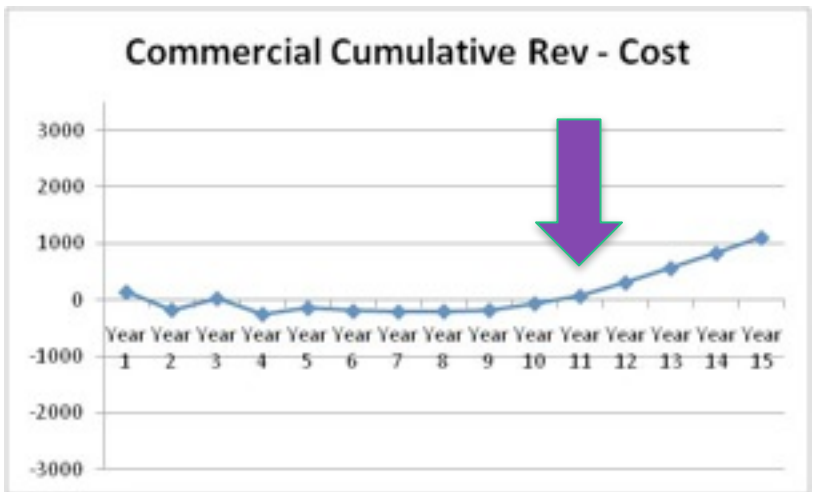
Details Of A Case That "Closes" With Soyuz

Investment	$1.4B/ 10%/ 10%
Seats/ Launch	7
NASA Flts/ Yr	2
Total Private Seats	70
Annual Fixed Costs	$400M
Variable Costs	$176M TFUC/ $97M
Failures	None
Gov't Price Per Seat	$48.5M
Total Gov't Cost	$8050M
Private Price / Seat	$30M
Commercial IRR	25%







Means that the Gov't would fly 14 passengers a year to ISS

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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***

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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?

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Notional Human Rating (HR) Approaches

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

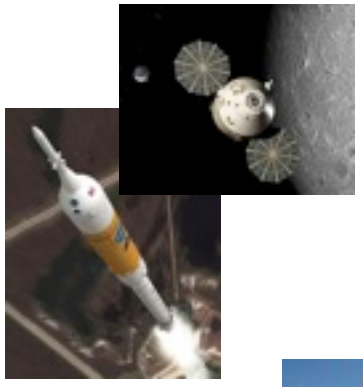
Higher Reliance on Flight Testing / Lower Initial Cost

- **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

More Qual Testing and Gov't Insight / Higher Initial Cost

STS

Saturn V / CM



Ares I/Orion

Planned and Existing Commercial Systems

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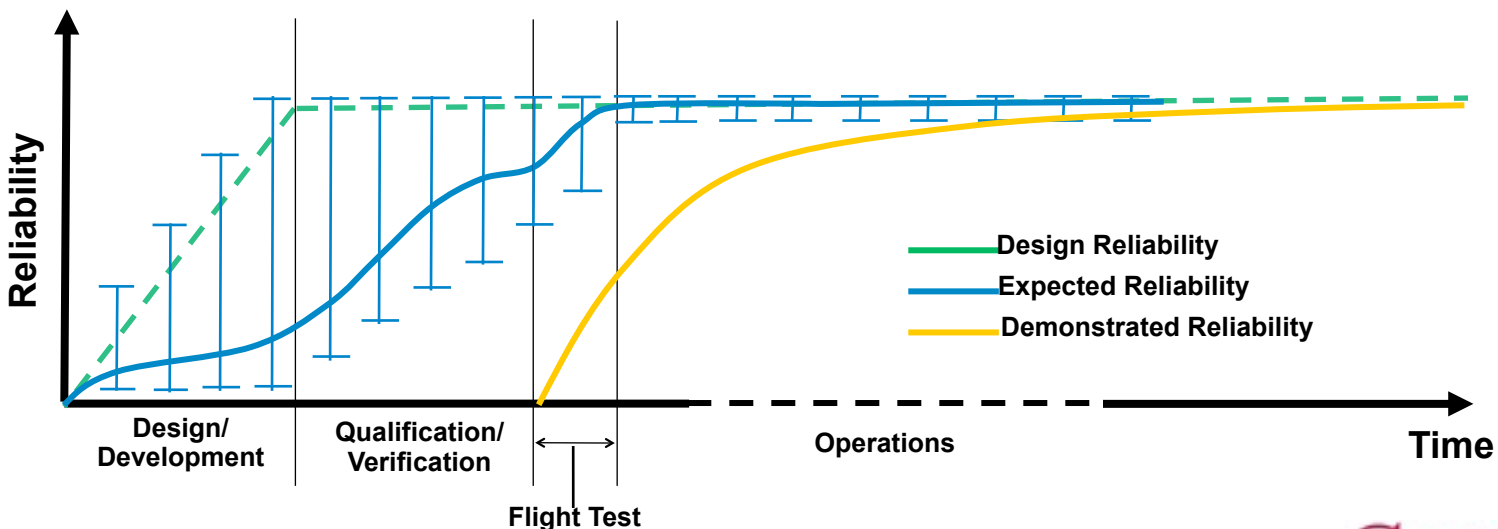
Example of Reliability Evolution for HR4 Approach

- *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*



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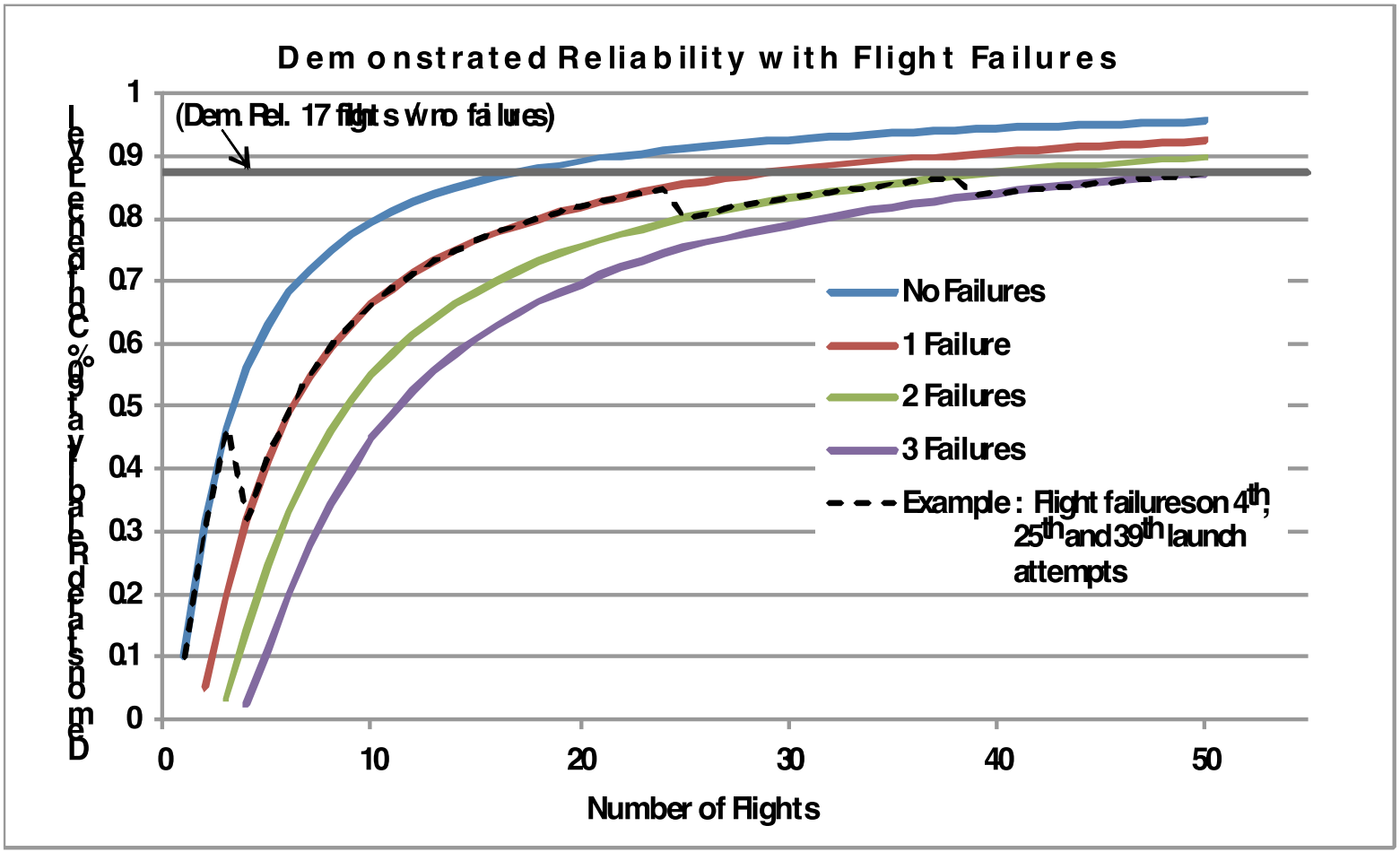
Impact on Demonstrated Reliability Growth of



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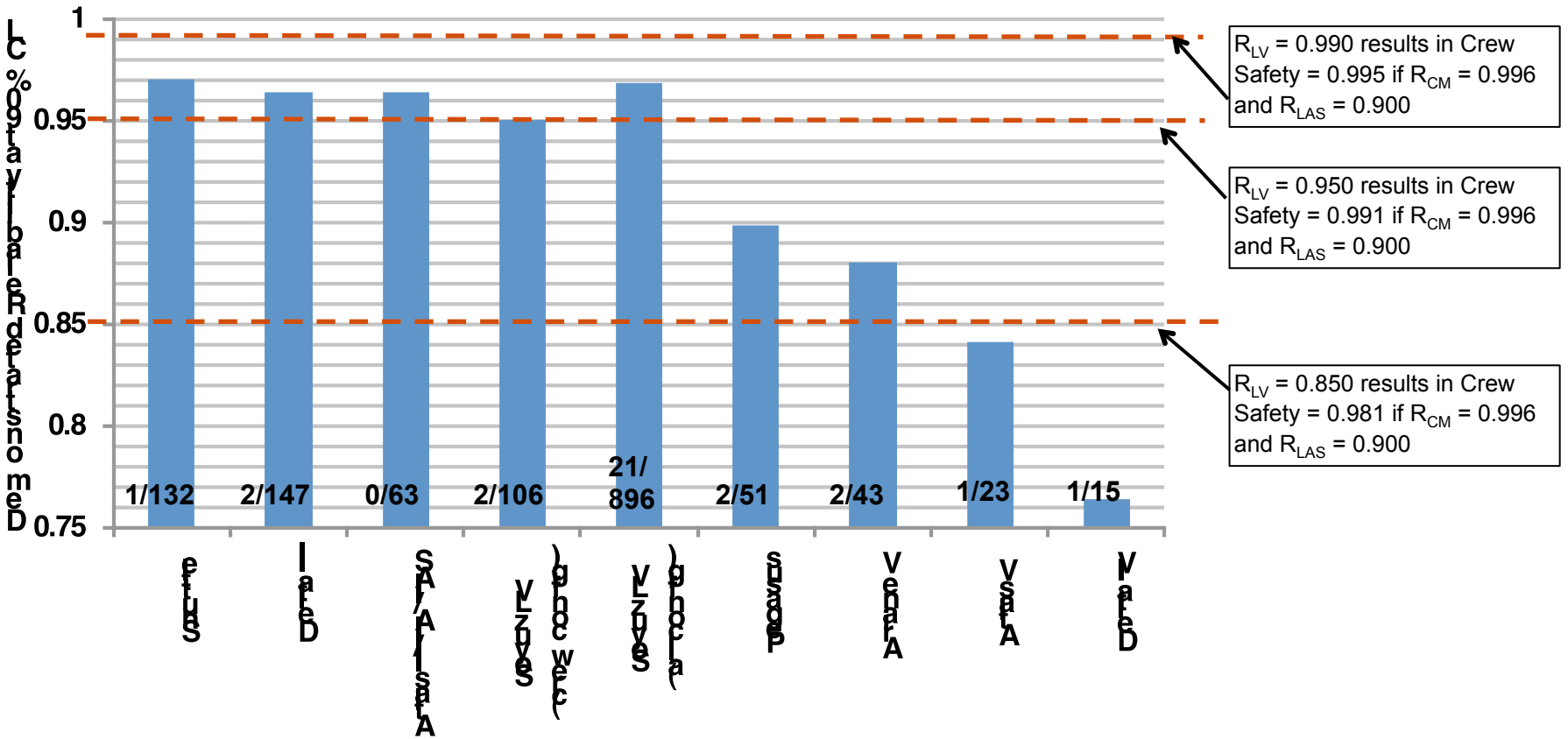
CS Requirement and Allowable LV Reliability

- *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

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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*

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