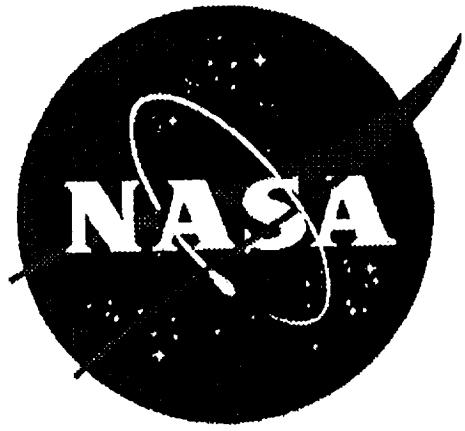
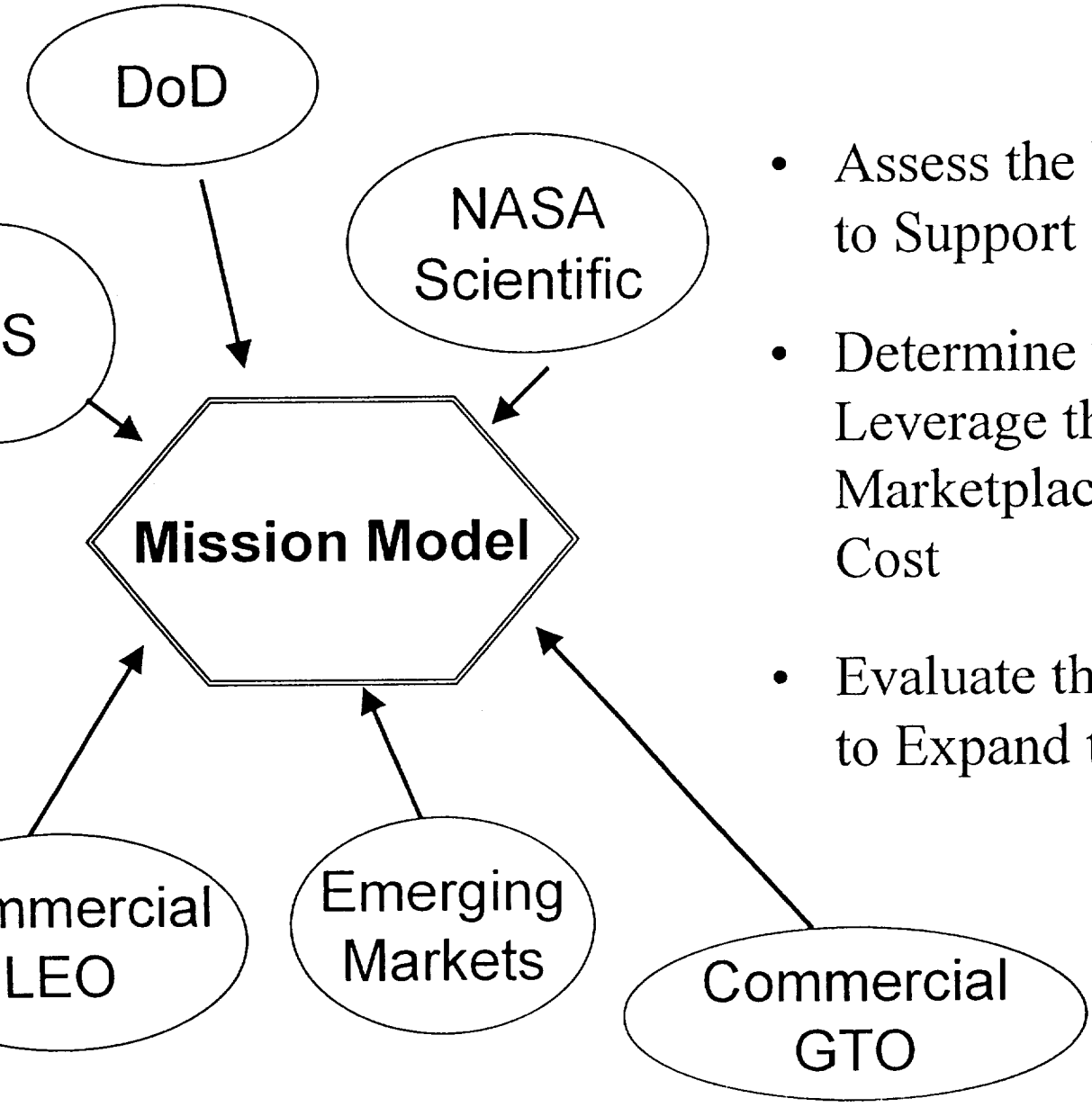


Reusable Launch Vehicle (RLV) Mission/Market Model

Frank A. (Andy) Prince
NASA/Marshall Space Flight Center
Engineering Cost Office

Mission Model



- Assess the Vehicle's Capab to Support ISS Servicing
- Determine the Potential to Leverage the Commercial Marketplace to Reduce NA Cost
- Evaluate the Vehicle's Abi to Expand the Space Econo

Mission Model Methodology

Data Sources

- ISS: JSC and LaRC Studies
- NASA Science: Architecture Study Guidelines and the National Mission Model
- DoD: National Mission Model
- Commercial LEO: FAA Associated Administrator for Commercial Space Transportation
- Commercial GTO: COMSTAC Report
- Emerging Markets: Commercial Space Transportation Study (CSTS)

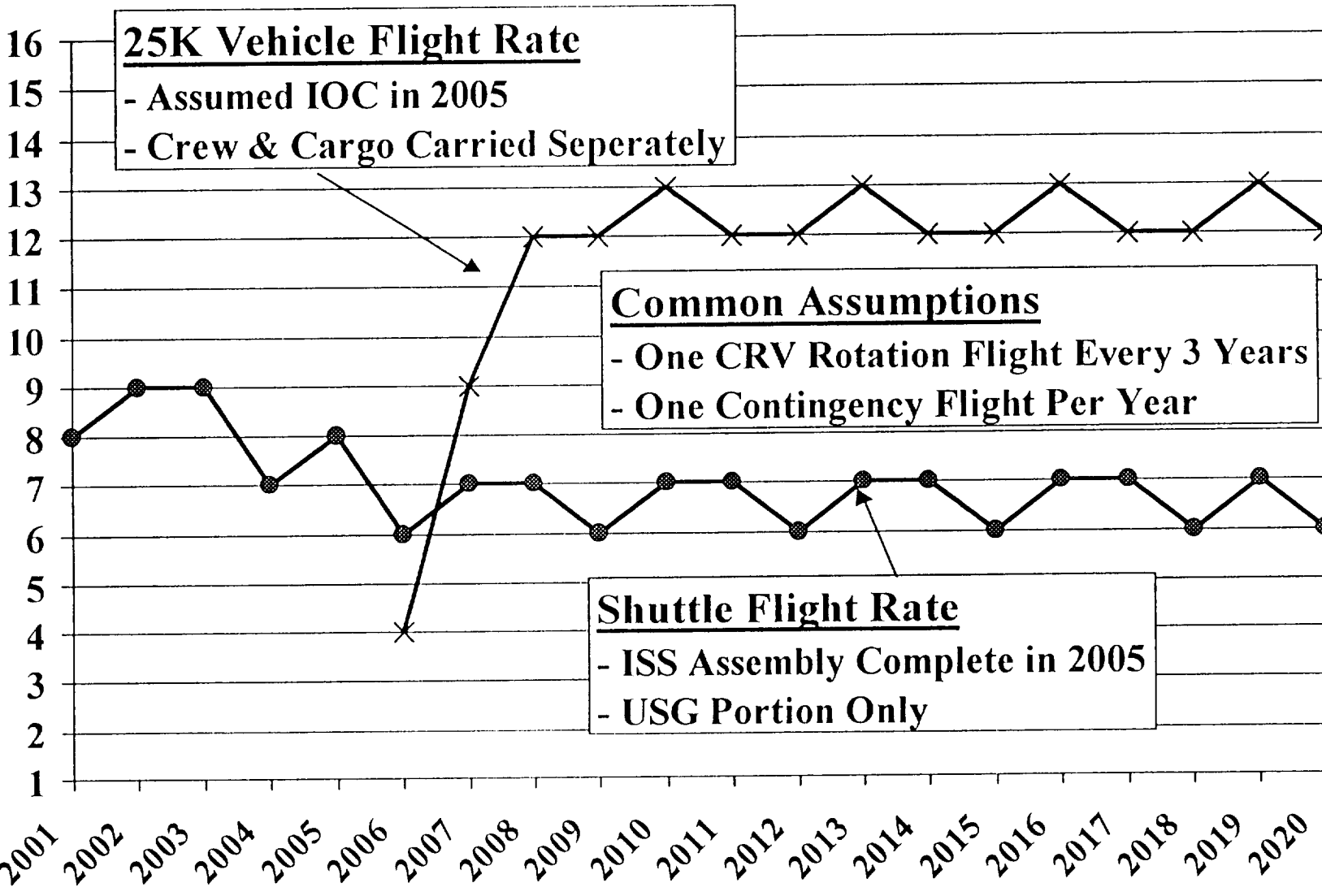
Payload Classification

- Two Classes of ISS Servicing
  - Shuttle or Shuttle Equivalent
  - 25K lbs to ISS
- National Mission Model Approach used for NASA Science and DoD Missions
- Commercial LEO Classifications same as FAA
- All GTO Missions (Commercial and USG) Classified Consistent with COMSTAC

Multiple Manifesting

- No Multiple Manifesting of NASA Scientific or DoD LEO Payloads
- Multiple Manifesting of Commercial LEO Missions Built into Source Material
- GTO Payloads Multiple Manifested in Market Analysis Model

ISS Servicing Mission Models



NASA Scientific Mission Model

all:
EX +
a-Lite

Architecture Study Mission Model

National Mission Mode

ar	LEO Vehicle Classification			GTO Vehicle Class
	Small	Medium	Heavy	ILV
	< 4,000 lbs	4,000 - 22,400 lbs	> 22,400 lbs	4000 - 9000 lbs
01	1	5	0	0
02	1	2	0	2
03	1	7	0	2
04	1	3	0	0
05	3	8	0	0
06	1	4	0	1
07	1	7	0	0
08	1	6	0	1
09	1	5	1	0
10	1	4	0	0
11	1	5	1	*1*
12	1	5	0	*0*
13	1	3	0	*0*
14	1	5	0	*1*
15	1	4	0	*0*
16	1	3	0	*0*
17	1	4	0	*1*
18	1	4	0	*0*
19	1	3	0	*0*
20	1	5	0	*1*

Medium:
Medium +
Med-Lite
TBD

Estimated as a Repeat of 2008, 2009 & 2010

Bantam Flights Not Inc

DoD Mission Model

	LEO Vehicle Classification			GTO Vehicle Classification	
	Small	Medium	Heavy	ILV	HLV
r	<4,000 lbs	4,000 - 22,400 lbs	> 22,400 lbs	4000 - 9000 lbs	> 9000 lbs
1	0	7	2	1	1
2	0	12	2	2	1
3	1	7	1	1	0
4	1	8	1	2	0
5	0	8	0	2	0
6	1	9	1	1	0
7	0	7	0	2	0
8	1	6	1	2	0
9	0	6	1	2	0
0	0	5	0	2	0
1	*1*	*6*	*1*	*2*	*0*
2	*0*	*6*	*1*	*2*	*0*
3	*0*	*5*	*0*	*2*	*0*
4	*1*	*6*	*1*	*2*	*0*
5	*0*	*6*	*1*	*2*	*0*
6	*0*	*5*	*0*	*2*	*0*
7	*1*	*6*	*1*	*2*	*0*
8	*0*	*6*	*1*	*2*	*0*
9	*0*	*5*	*0*	*2*	*0*
0	*1*	*6*	*1*	*2*	*0*

Estimated a Repeat of 2008, 2009 & 2010

om the DoD National Mission Model (NMM)

MM Classes Used for LEO, COMSTAC Classes Used for GTO

COMSTAC
Commercial GTO Mission Model

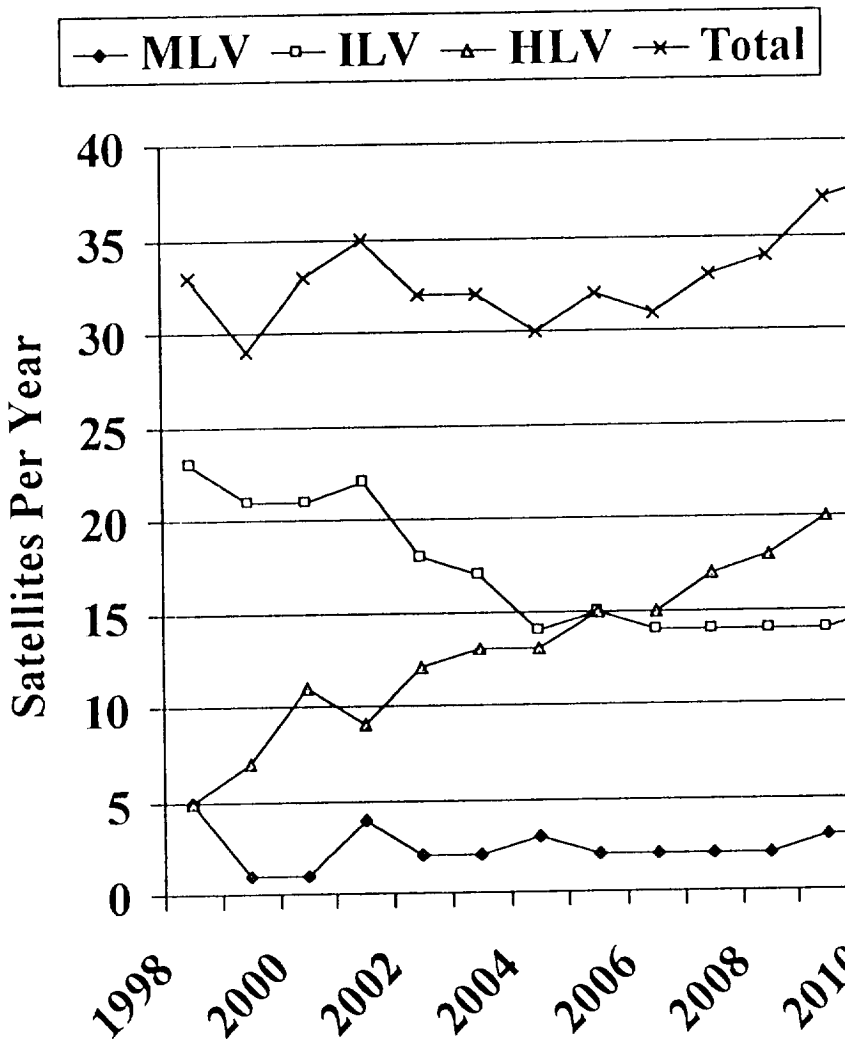
Prepared by an Industry Advisory Group for FAA

Worldwide Commercial GTO Satellite Mission Model

"Addressable Payloads" Open to International Competition

Three Vehicle Classes

- MLV: 2,000 - 4,000 lb.
- ILV: 4,000 - 9,000 lb.
- HLV: >9,000 lb.



FAA LEO Commercial Market Projectio

Commercial LEO Mission Model

epared by the FAA Associate
lministrator for Commercial
ace Transportation (AST)

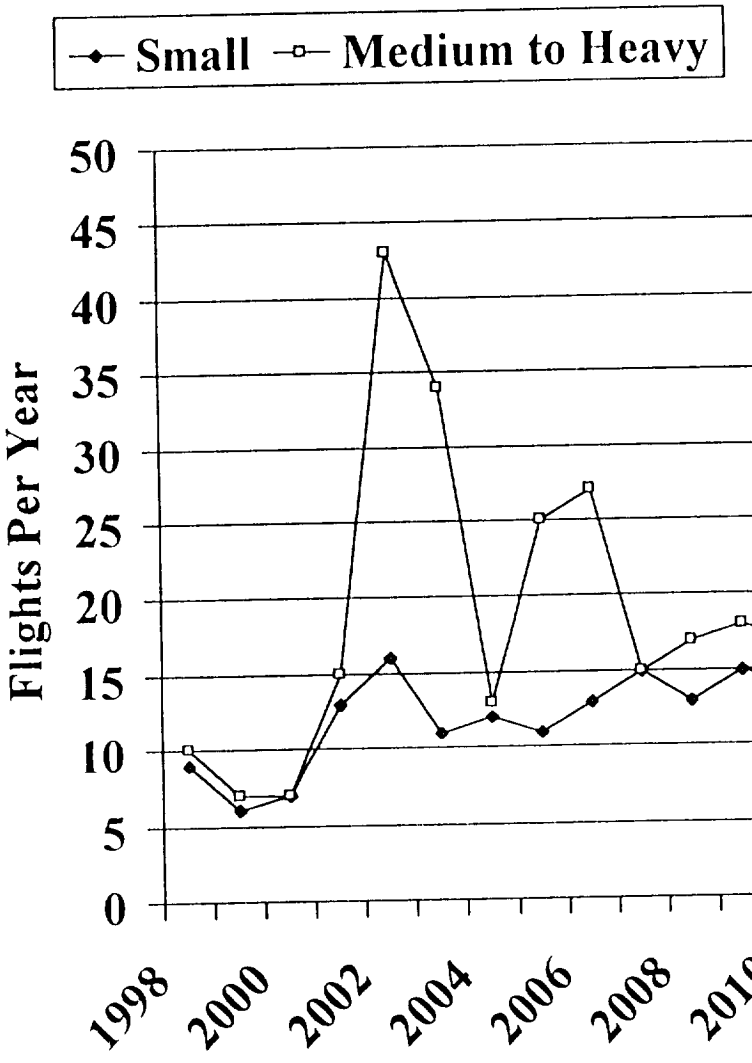
aph Represents Baseline LEO
enario

- Four Big Systems
- Three Little Systems
- Two Broadband Systems

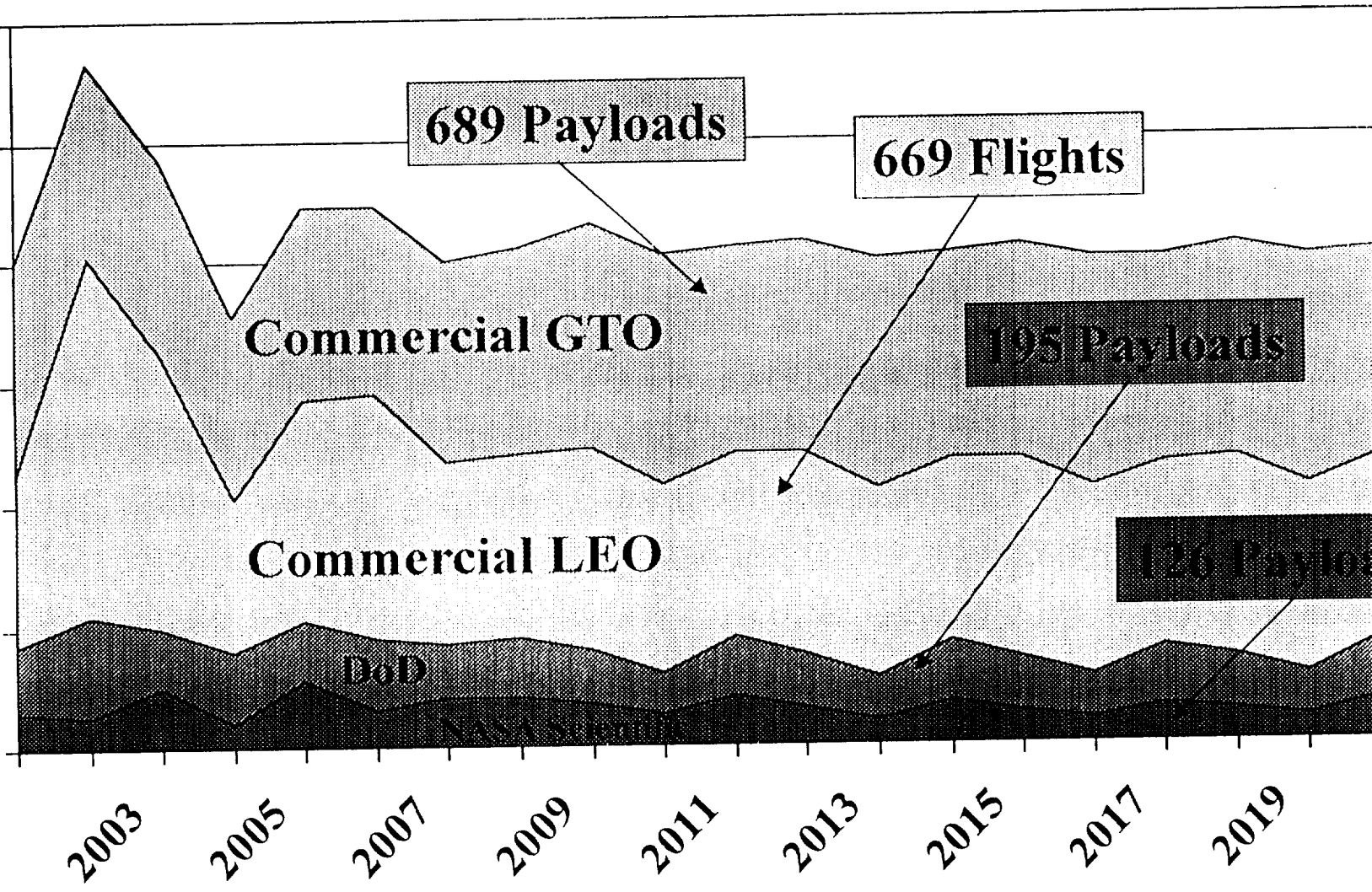
aptures Remote Sensing and
oreign Scientific Missions

wo Launch Vehicle Classes

- Small (<5,000 lb. to LEO)
- Medium to Heavy (>5,000 lb. to LEO)



Commercial Mission Model



Emerging Market

$5000/lb to LEO		
Vehicle	High	Medium
10K	3 Flts	5 Flts
30K	4 Flts	5 Flts
55K	2 Flts	3 Flts
100K	1 Flts	2 Flts

$1000/lb to LEO		
Vehicle	High	Medium
10K	32 Flts	48 Flts
30K	28 Flts	38 Flts
55K	15 Flts	21 Flts
100K	8 Flts	10 Flts

$600/lb to LEO		
Vehicle	High	Medium
10K	54 Flts	81 Flts
30K	43 Flts	82 Flts
55K	41 Flts	70 Flts
100K	25 Flts	41 Flts

$400/lb to LEO		
Vehicle	High	Medium
10K	241 Flts	269 Flts
30K	102 Flts	161 Flts
55K	45 Flts	95 Flts
100K	27 Flts	41 Flts

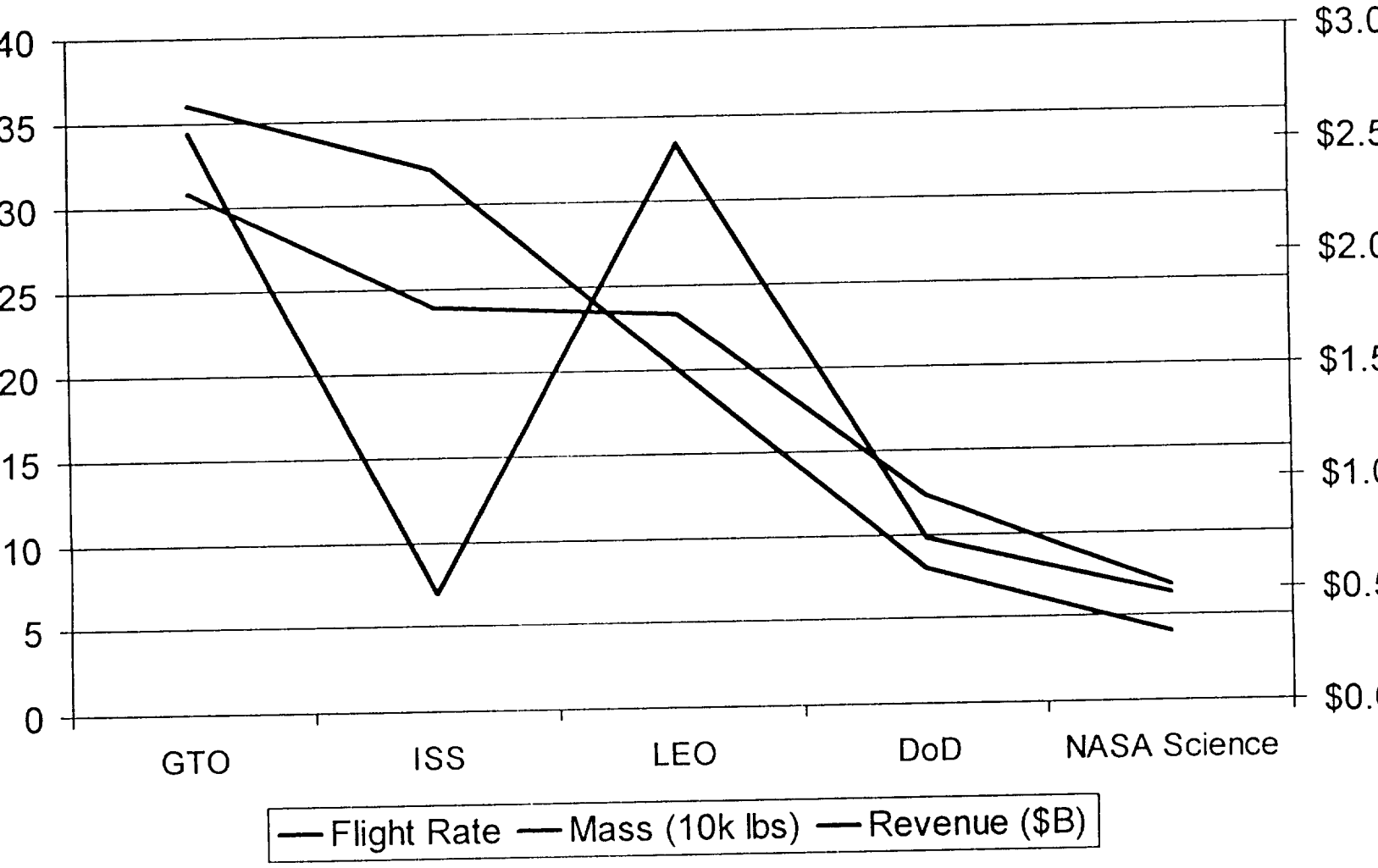
Data from the Commercial Space Transportation Study Final Report

Only Known Source of Emerging Market Data (Future Spacelift Requirements Study Confirmed and Repackaged)

Problem with Commercial Market Overlap

Used High Probability Flight Rates to Develop Parametric Model using PPF (Converted from $/lb) and Vehicle LBS to LEO as the Drivers

Mission Model Analysis



Market Analysis Model

Purpose: Estimate Annual Flight Rate for a Conceptual Vehicle

Driven by Vehicle Capability and Price Per Flight (PPF)

Competitive Base: Current and Future ELV's and RLV's

Data on Commercial Launch Vehicle Capabilities and Prices

- International Space Industry Report, 9 November 1998
- AIAA "International Guide to Space Launch Systems," 2nd Edition
- EELV Program Office

Three Market Segments

- ISS Servicing
- Commercial: Today's Commercial GTO and LEO Market plus Unmann USG Missions
- Emerging: New (and Speculative) Business Opportunities

Market Model Inputs and Process

uts
hicle LEO Capability, PPF (by
rket Segment, IOC, Upper Stage
F and Weight, ISS Capability and
nsition Years, Select/Deselect
rket Segment

Model Functions
Market Capture Analysis
Market Penetration
Emerging Market Model
Multiple Manifesting

Model Databases
Mission Model
Commercial Competitors

nomic
ysis

NASA Scientific Flight Rate

Commercial GTO Flight Rate

Commercial LEO Flight Rate

ISS Flight Rate

DoD Flight Ra

Emerging Mark Flight Rate

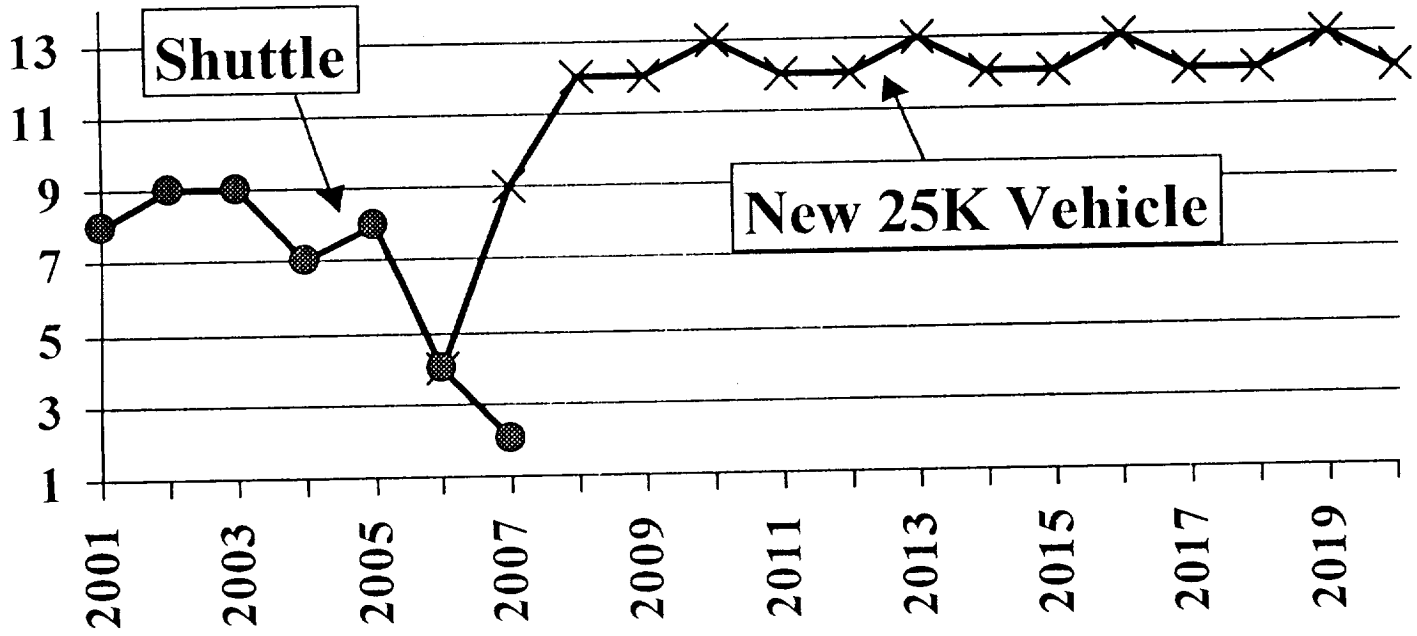
ISS Servicing Market Model

Flight Rates Based on JSC/LaRC Analysis

If the Vehicle is Capable, Assumed to Capture all Flights (PPF Not a Factor)

Transition Rate Assumed to be Linear

IOC Date and Years in Transition can be Varied for Sensitivity Analysis



Commercial Market Model

our Market Segments
- Commercial GTO
- Commercial LEO
- DoD
- NASA Scientific

Inputs:
- LBS to Orbit (LEO & GTO)
- PPF
- Upper Stage Weight and PPF
- IOC

Market Driven by Demand for On-Orbit Services (Communications) and US
Budgets

Currently a Thriving Commercial Market to Supply Launch Services

Any New Vehicle Must Take Market Share from Existing Competitors

Market Capture Model Based on Economic Theory (Oligopoly)

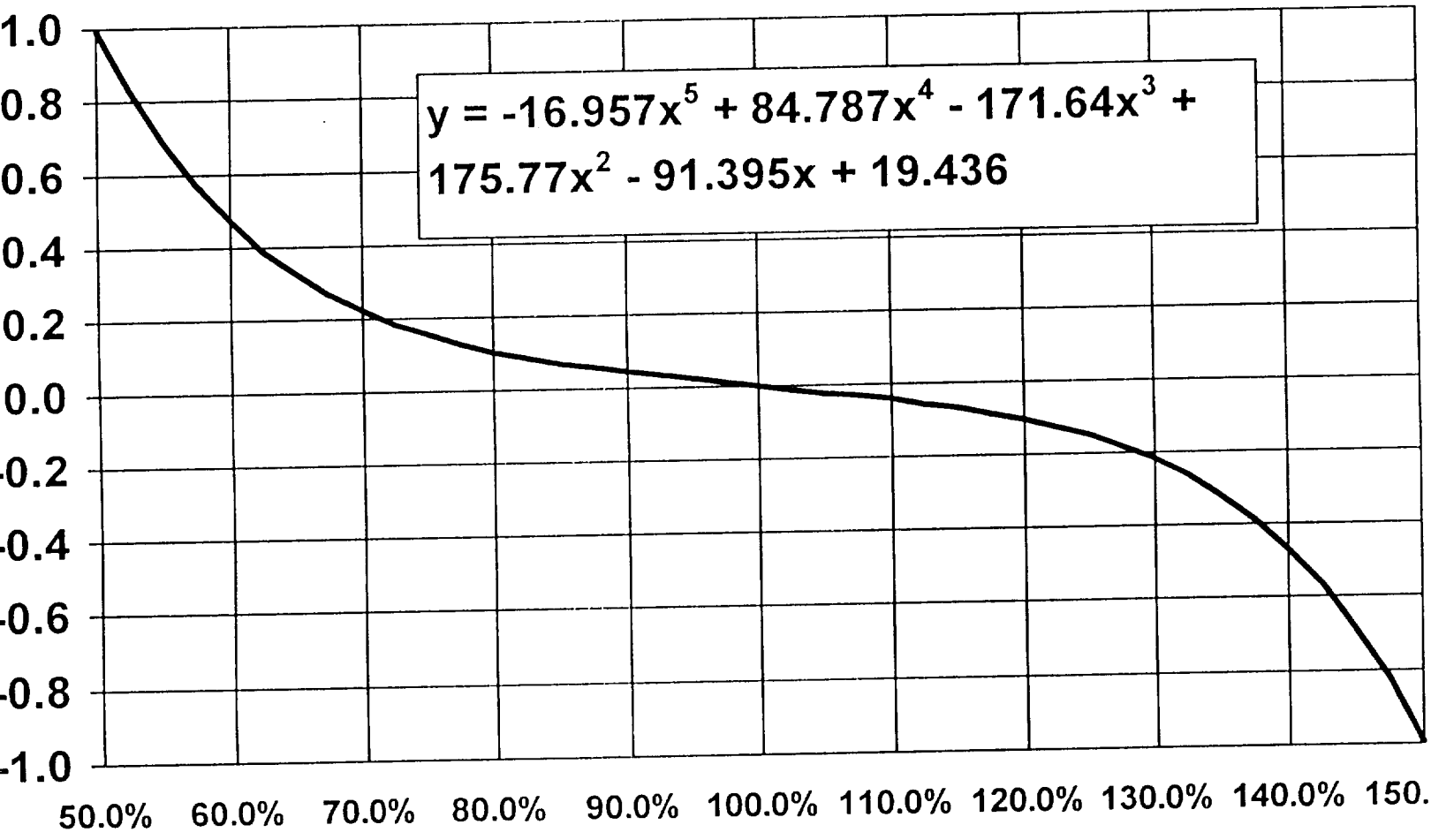
Model Uses Mass to Orbit and Price to Determine Capture; Volume, Reliability, etc. are Not Factored into the Analysis

Commercial Market Model
Competitive Market Segments

cle Class	Weight Range (lbs)	Price per Flight ($M)	Number of Companies	Representative Vehicles
mercial GTO				
edium	2,000 - 4,000 GTO	$36	4	Delta 2, CZ-4B, M-5
ermediate	4,000 - 9,000 GTO	$70	6	Ariane 4, Atlas II, Delta 3, CZ-3A
eavy	> 9,000 GTO	$93	5	Ariane 5, CZ-3B, Proton, Zenit 3SL
mercial LEO				
nall	< 5,000 LEO	$15	10	Athena-1, Pegasus, Start, Kosmos
edium - Heavy	> 5,000 LEO	$66	10	Ariane, Atlas, Delta, H-2A, Soyuz
Government GTO				
edium	2,000 - 4,000 GTO	$46	1	Delta 2
ermediate	4,000 - 9,000 GTO	$78	2	Atlas III, Delta 3, EELV
eavy	> 9,000 GTO	$140	2	EELV Heavy
Government LEO				
mall	500 - 4,000 LEO	$20	4	Athena-1&2, Pegasus, Conestoga
edium	4,000 - 22,400 LEO	$56	4	Atlas II, Delta 3, EELV
eavy	>22,400 LEO	$140	2	EELV Heavy

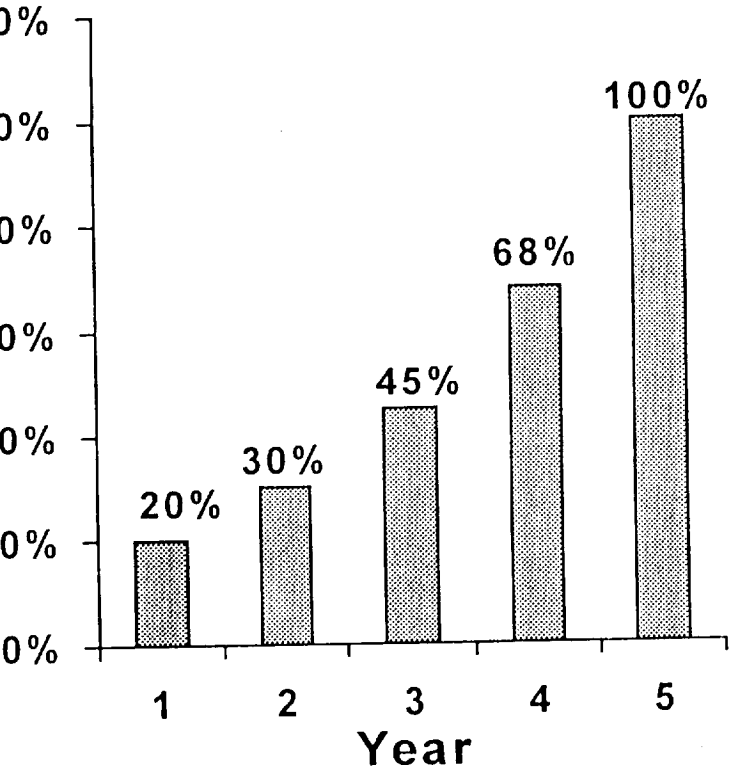
Average Price Per Flight used to Establish Market Equilibrium

Commercial Market Model
Market Capture Function



RLV PPF Relative to Market Equilibrium

Commercial Market Model
Market Penetration Assumption



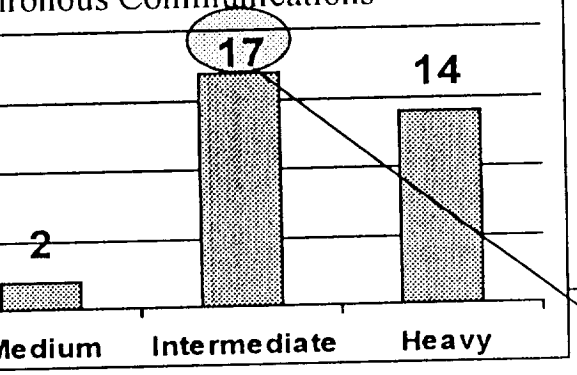
- Assumes 5 Years to Build Custo Base
- Expressed as a Percent of the Maximum Market Share the RL can Capture
- Initial Market Penetration is 20% and Grows at a 50% Rate
- Why? Risk, Existing Business Relationships, "Teething" Pains Existing Satellite Designs
- Also Applied to the Emerging Market

Commercial Market Model
Market Capture Analysis

US Government

Earth Orbit Commercial

hronous Communications



d Projections

US Government GEO/LEO

Low Earth Orbit Commercial

GEO Commercial Communications

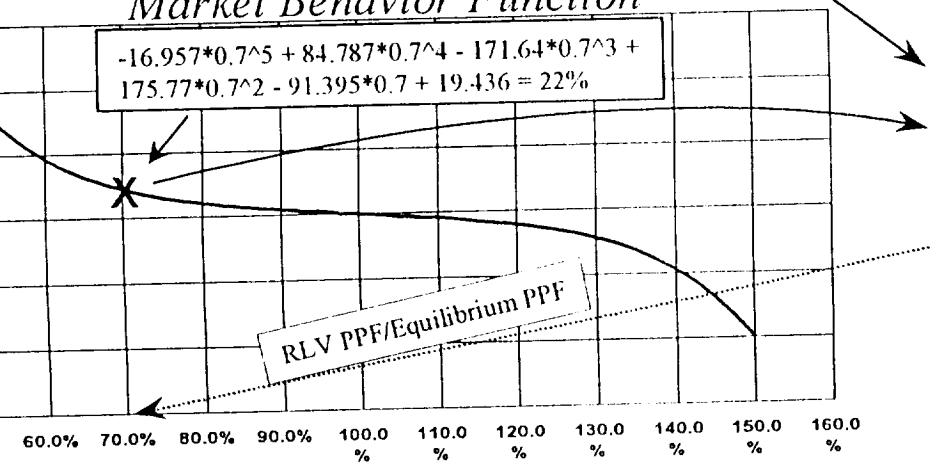
Vehicle Class	Price Per Flight
Medium	$36
Intermediate	$70
Heavy	$93

Competitive Market

If Number of Competitors is 4, Market Share *Per Competitor* At Equilibrium is 1/4 = 25%

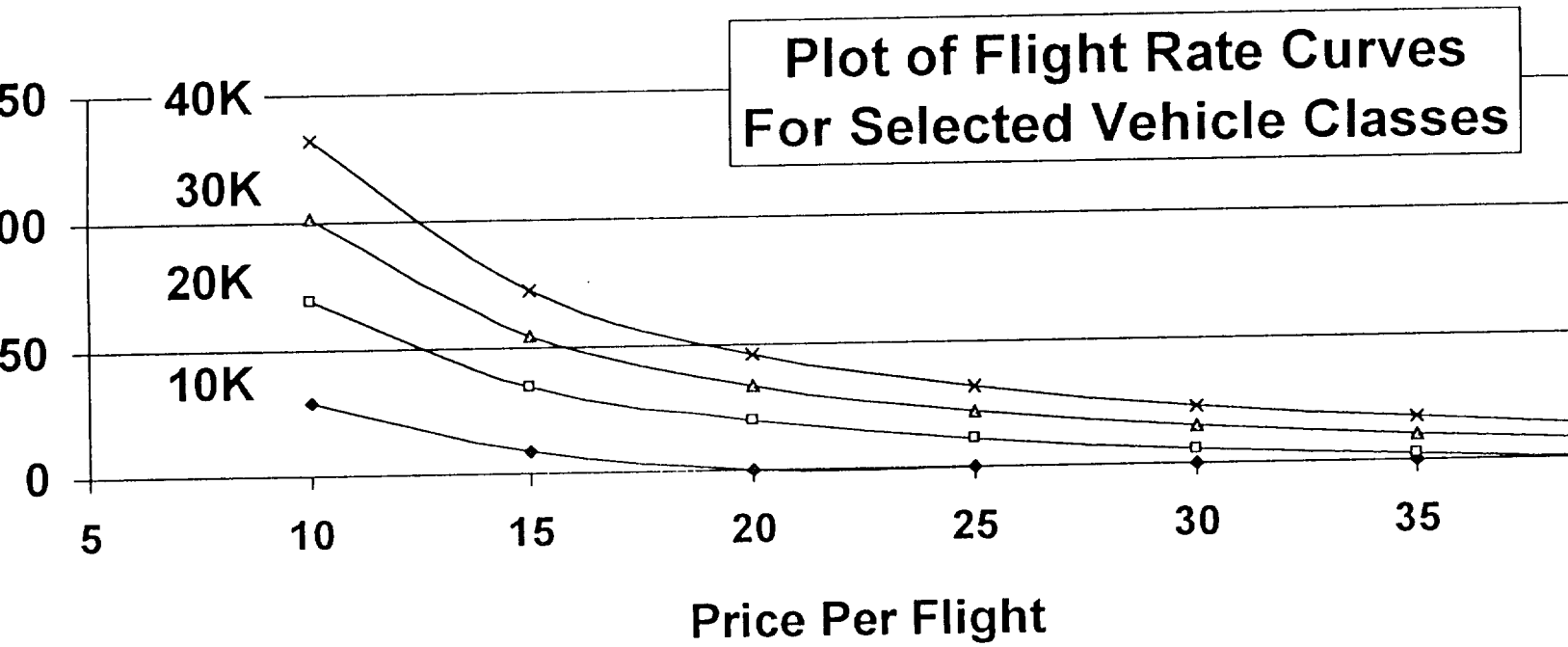
Market Equili Price

Market Behavior Function



The RLV PPF of $50M is Divided by Market Equilibrium PPF ($50/$70= and Input into the Market Behavior Function, the Market Behavior Fun is Added to the Equilibrium Market Share and then Multiplied by the De Projection: 22% + 25% = 47% * 17 Flights Per Year

Emerging Market Model



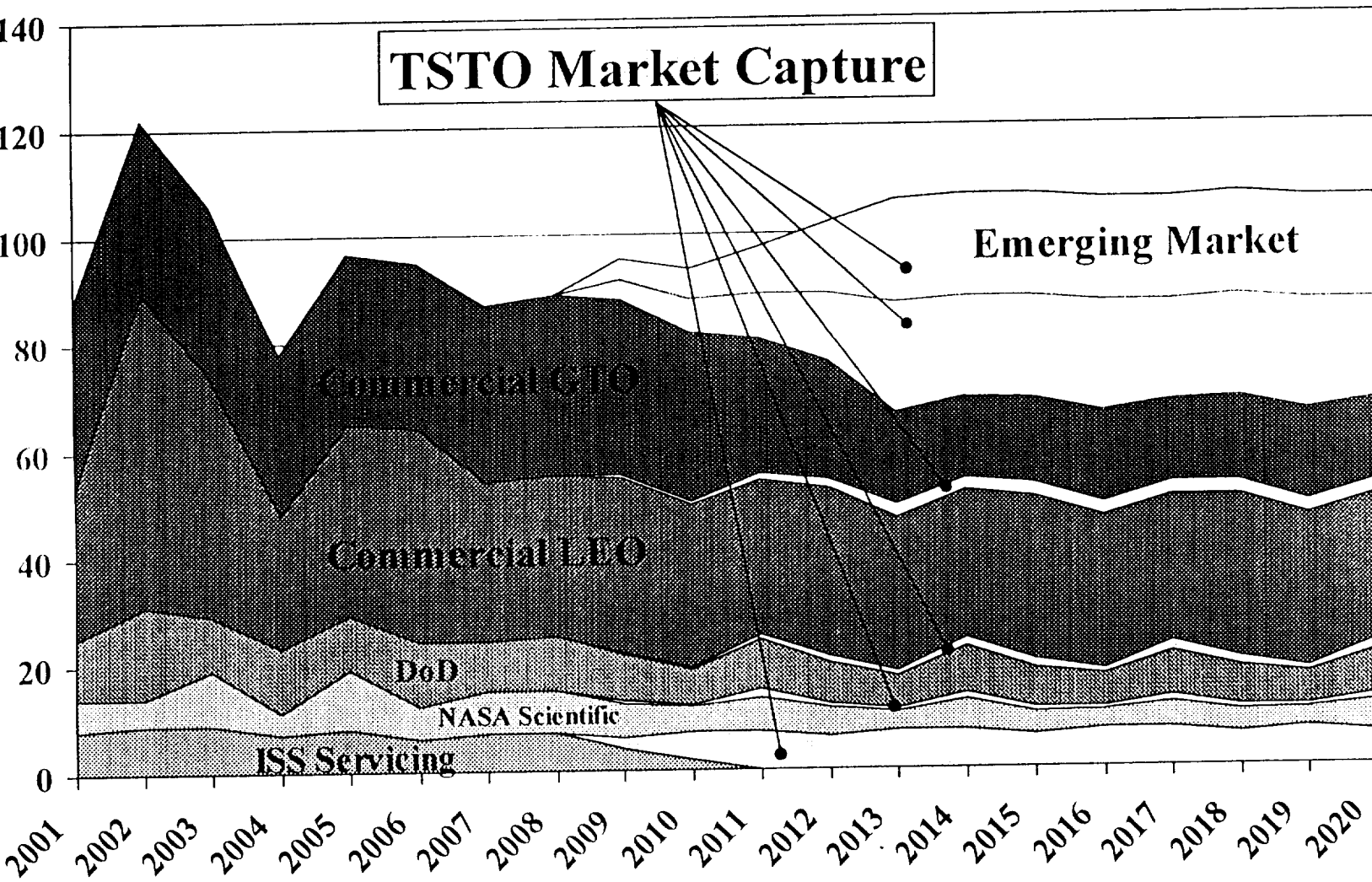
w Business Opportunities Created by a Significant Reduction in the Price to Orbit

sed on an Analysis of CSTS Data, Curve Fitted to Summary Data (Drivers are Weigl
F) with an $R^2 = 0.875$

abling Price ($/lb) can be Adjusted to Reflect a Conservative Bias

sume Vehicles Creating this Market Capture all Flights

Market Capture for a Conceptual TSTO Vehicle



Market Model Sensitivity Analysis

- Mission Model Sensitivity
  - Vary Number of Existing Commercial Flights
- Market Capture Sensitivities
  - Increase or Decrease Effect of the Market Capture Function
  - Vary Equilibrium Price
  - Vary Number of Competitors
- Emerging Model Sensitivities
  - Vary Number of Emerging Flights
  - Change Enabling $/lbs

Sensitivity Analysis
Commercial Market