

## IAC-08-D2.4.5

# Is the World Ready for High-Speed Intercontinental Package Delivery (Yet)?

Version A

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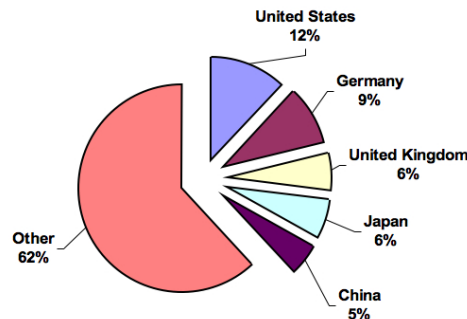
- Ultra-Fast Point-to-Point (PTP) cargo delivery is often discussed, **but lacks the semi-rigorous market assessment** of other emerging markets such as suborbital space tourism
  - Consider for comparison, the market studies of sub-orbital space tourism by Collins, Futron/Zogby, and others. No such data exists for high-speed PTP
- Private investors will be required to make this new capability a reality, **and those investors will be convinced by the revenue potential**, not by the technological solutions (“If you built it, they will come” won’t be a sufficient position)
- So, our study is attempting to contribute some rigor to the discussion of fast-package delivery markets, with particular concentration on intercontinental service, and we are hopeful that additional discussions follow from these preliminary results



## Introduction

- **31.7 million tonnes of worldwide air freight exported in 2001**
  - U.S. exports alone valued at \$251B in 2001
- **Top destinations include North America, Europe/UK, Asia/China, Japan**
- **Top service providers include FedEx Express, UPS, EAT, TNT, DHL**
- **FedEx Express (FedEx's air services)**
  - \$20.7B revenue in 2007
    - By type: \$17.3B from packages, \$3.4B from freight
    - By destination: \$7.3B international, \$13.4B domestic US
  - Average revenue per package is \$51 USD for international packages
  - Revenue for scheduled services dominates non-schedule/on-demand services

### Top Ranking Export Countries (2007)

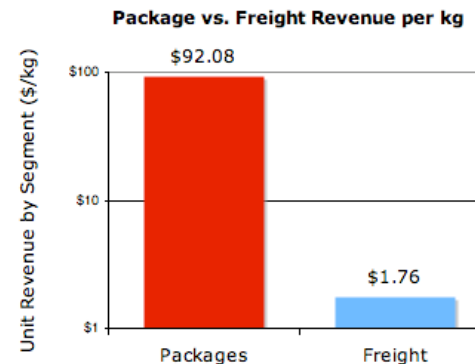
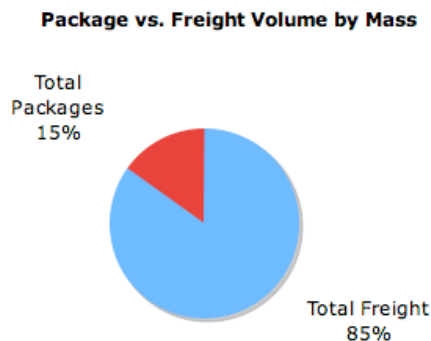


### Busiest Cargo Airports (by departed mass, 2007)

Rank	Airport	Million Tons Cargo
1	Memphis	3.6
2	Hong Kong	3.4
3	Anchorage	2.6
4	Tokyo	2.3
5	Seoul	2.1
6	Frankfurt	2.0
7	Los Angeles	1.9
8	Shanghai	1.8

## **The Potential Market**

- **Air cargo market is typically divided into two categories**
  - **Air Freight**
    - Larger items (greater than 70 kg per item)
    - Outsized or odd sized shipments, time-critical parts, palletized cargo
  - **Air Packages (aka Express Packages)**
    - Standardized envelopes and shipper-supplied boxes
    - Consumer goods, documents, electronics, pharmaceuticals
    - Category is defined as less than 70 kg, but typical packages are less than 0.6 kg and 45 cm x 30 cm x 10 cm
- **FedEx Express data (international business only, 2006)**
  - Packages: 400,000 int'l priority packages shipped per day (~180 tonnes/day)
  - Freight: 1,675 tonnes of int'l freight per day
  - Revenue: \$6.1B from int'l packages, \$1.2B from int'l freight



## Package vs. Freight Comparisons

1. Consider only the **express package** market, not the air freight market
  - Higher revenue per kg for packages and better cargo form factor
2. Consider only the **intercontinental** market (transoceanic routes)
  - Long range is more likely to benefit from a faster aircraft
3. Consider only **scheduled** service (i.e. daily service)
  - On-demand market is too small
  - Scheduled service can more easily integrate into existing distribution networks (collect at end of day, fly to distant hub, distribute daily packages at destination)
4. Assume new facilities can be built if needed, and that coastal areas are preferred where practical to serve as regional spaceport hubs
  - New infrastructure will logically be government supported and funded
  - Land overflight issues will exist for hypersonic systems
5. Currently ignore a range of issues such as customs, regulatory and political influences, actual implementation of the associated ground segment
6. Consider the **fast package market in isolation** from the passenger or even the suborbital tourism markets
  - Given the risk of flying humans, it is likely that the cargo market will be first
7. **Service goal is to improve intercontinental package delivery by one business day** earlier than currently available scheduled services (note for some east-to-west routes, this means offering same-day service!)

## Key Assumptions



- Tier 1 Cities (7). Chosen as the initial study set based on current express package market sizes.
- Tier 2 Cities (3). Emerging regions that would be best candidates to expand the delivery network.
- Tier 3 Cities (3). Additional regions to result in more global capabilities.

## Selected City Pairs

Default Time Values (24 hr clock)		Start City Collection Time (hrs)		End City Dist. Time (hrs)	
Start City Time Value	1700	Cologne	3	Cologne	3
End City Time Value	800	London	4	London	4
		Los Angeles	5	Los Angeles	5
		New York	4	New York	4
		Shanghai	3	Shanghai	3
		Hong Kong	3	Hong Kong	3
		Tokyo	3	Tokyo	3

	Start City	End City	Start City Time Value	End City Time Value (same day)	Great Circle Distance (km)	Start City Collection Time (hours)	End City Distribution Time (hours)	Time Zone difference (positive if destination is ahead)	Travel Time 1 day	Travel Time Target day	Travel 1 Speed (km/h)	Travel Speed for Target Day (km/h)	Target Delivery Day (relative to origin)
Cologne, London, Los Angeles, New York - Forward 1 hour	Cologne	Hong Kong	1700	800	9345	3	3	6	3	3	3115	3115	1
	Cologne	Tokyo	1700	800	9359	3	3	7	2	2	4680	4680	1
	Cologne	Shanghai	1700	800	8880	3	3	6	3	3	2960	2960	1
	Cologne	New York	1200	1700	6069	3	4	-6	28	4	217	1517	0
	Cologne	Los Angeles	1200	1700	9177	3	5	-9	30	6	306	1530	0
	Hong Kong	London	1200	1700	9740	3	4	-7	29	5	336	1948	0
	Hong Kong	Cologne	1700	800	9345	3	3	-6	15	15	623	623	1
	Hong Kong	Los Angeles	1700	1700	11640	3	5	-15	31	7	375	1663	0
	London	Hong Kong	1700	1200	9740	4	3	7	5	5	1948	1948	1
	London	Tokyo	1700	1200	9585	4	3	8	4	4	2396	2396	1
	London	Shanghai	1700	1200	9216	4	3	7	5	5	1843	1843	1
	London	New York	1200	1700	5585	4	4	-5	26	2	215	2793	0
	London	Los Angeles	1200	1700	8781	4	5	-8	28	4	314	2195	0
	Los Angeles	Hong Kong	1700	800	11640	5	3	15	-8	16	0	728	2
	Los Angeles	Tokyo	1500	1700	8815	5	3	16	2	2	4408	4408	1
	Los Angeles	Shanghai	1700	800	10440	5	3	15	-8	16	0	653	2
	Los Angeles	London	1700	1500	8781	5	4	8	5	5	1756	1756	1
	Los Angeles	Cologne	1700	1500	9177	5	3	9	5	5	1835	1835	1
	New York	Tokyo	1700	1700	10878	4	3	13	4	4	2720	2720	1
	New York	Shanghai	1700	800	11888	4	3	12	-4	20	0	594	2
	New York	London	1700	800	5585	4	4	5	2	2	2793	2793	1
	New York	Cologne	1700	800	6069	4	3	6	2	2	3035	3035	1
	Shanghai	London	1700	800	9216	3	4	-7	15	15	614	614	1
	Shanghai	Cologne	1700	800	8880	3	3	-6	15	15	592	592	1
	Shanghai	Los Angeles	1700	1500	10440	3	5	-15	29	5	360	2088	0
	Shanghai	New York	1700	1700	11888	3	4	-12	29	5	410	2378	0
	Tokyo	Cologne	1700	800	9359	3	3	-7	16	16	585	585	1
	Tokyo	London	1700	800	9585	3	4	-8	16	16	599	599	1
	Tokyo	New York	1700	1500	10878	3	4	-13	28	4	389	2720	0
	Tokyo	Los Angeles	1700	1200	8815	3	5	-16	27	3	326	2938	0

## GHoST Calculator (Tier 1 Cities, 4,000 km min, 12,000 km max)

- **What is the daily market and what is the expected price for an incremental improvement in shipping times (i.e. one day sooner than current capabilities based on subsonic aircraft)?**
  - **We recognize that good answers to these questions require sound market studies, a luxury we don't have at this time**
- **Best estimates are used as a point-of-departure**

### **Daily volume for the baseline set of 7 city pairs and their local regions**

FedEx Average Daily International Package Volume	= 400,000 packages/day
Divide by FedEx Market Share	= 21%
Multiply by Percentage of Current Earliest AM Service Customers	= 5%
Multiply by Percentage of Current Customers to Adopt New Service	= 80%
Multiply by Percentage of Overall Market Served by Tier 1 Network	= 40%
Multiply by Average Package Mass	= ~0.45 kg/package
Total Daily Volume Estimate	= 13,840 kg per day (about 460 kg per flight)

## **Simple Market Volume Estimate**

- Customers would be expected to pay a premium for speed, but what is a reasonable premium?
  - A more complex analysis would recognize that different routes have different premiums and that there is a relationship between price and expected volume
- Lacking a true market study, we again provide best estimates as a point of departure

### Estimated Price for Fast-package Service

High - Price of On-demand/Next Flight Service	= ~\$1,050/kg
Alt High - 10X Over FedEx Avg. Pkg. Revenue	= ~\$1,100'kg
Low - 150% of the cost of Earliest AM delivery	= ~\$400/kg
Total Price Estimate	= ~\$800/kg

Service	Route	Price
FedEx Int'l Priority (10:30 AM delivery)	NYC - Brussels	\$53
FedEx Int'l First (8:30 AM delivery)	NYC - Brussels	\$98
FedEx Int'l Next Flight (next pax jet)	NYC - Brussels	\$365
FedEx Int'l Priority (10:30 AM delivery)	LA - Tokyo	\$52
FedEx Int'l Next Flight (next pax jet)	LA - Tokyo	\$476
UPS Worldwide Expedited (typ. one day deferred)	NYC - Cologne	\$104
UPS Worldwide Saver (end of day delivery)	NYC - Cologne	\$110
UPS Worldwide Express (10:30 AM delivery)	NYC - Cologne	\$114
UPS World Wide Express+ (9:00 AM delivery)	NYC - Cologne	\$168

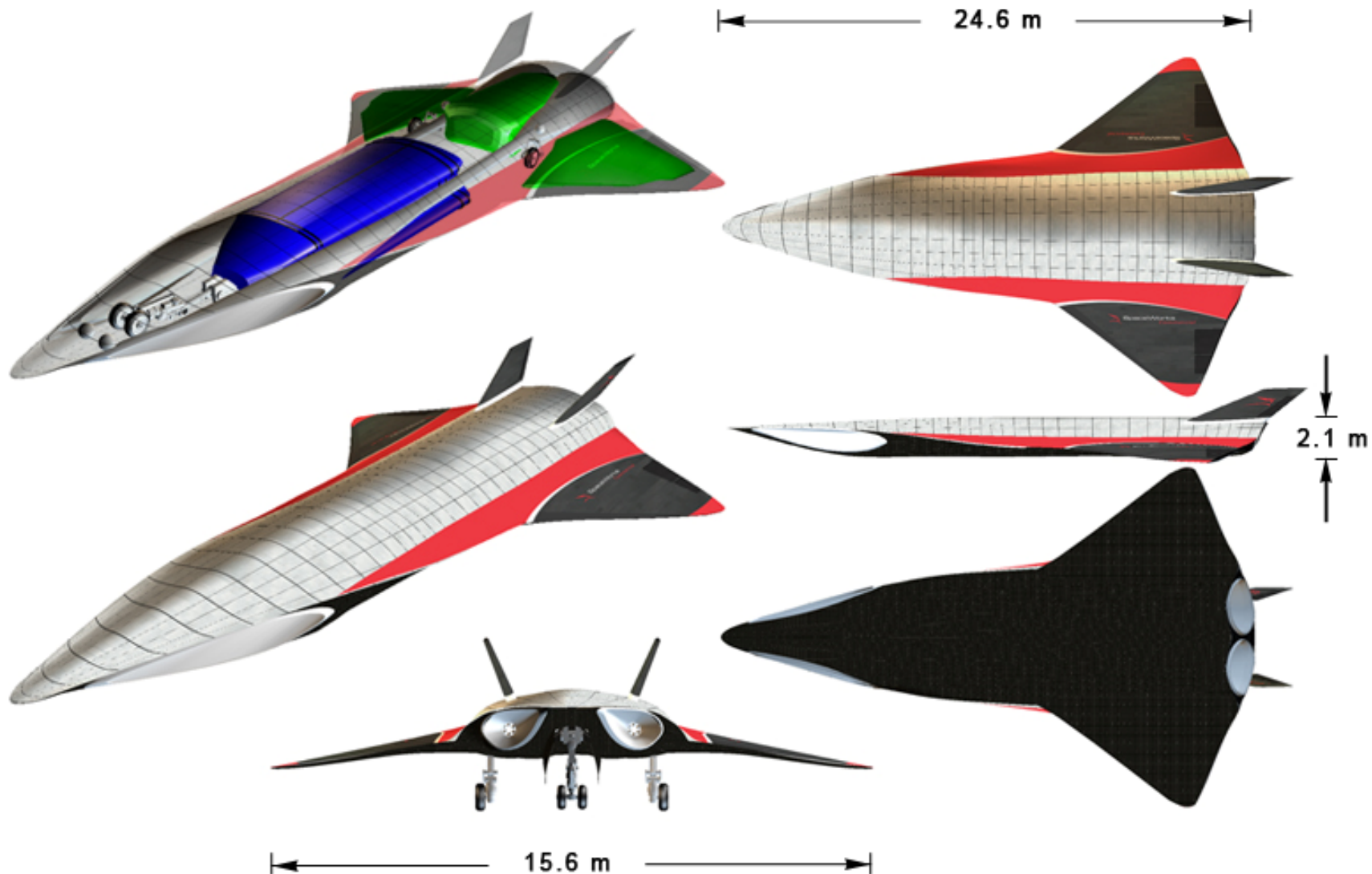
\* - prices for a **0.6 kg** medium box (July 2008)

## Simple Market Price Estimate

- **From our analysis and assumptions, we can begin to formulate some basic requirements for a flight vehicle to serve this market**
  - **Cargo mass and density from expected daily volume and package size**
  - **Flight time, speed, and range from GHoST flight routes and one-day improvement service target**
  - **Turnaround time is a derived metric assuming one flight per vehicle per day (to minimize fleet size)**
  - **Note that a 12,000 km range was logical for our chosen Tier 1 network (NYC to Shanghai and LAX to Hong Kong), however true antipodal range (20,000 km) is certainly a design goal to satisfy global coverage aspirations**

Characteristic	Value
Minimum Payload Mass	~ 1000 kg
Payload Density	~ 45 kg/m <sup>3</sup>
Typical Flight Times	< 2 hours for most
Max Flight Range	12,000 km non-stop
Average Flight Speed	> 4,700 km/h
Turnaround Time	< 20 hours

## **PTP Vehicle Design “Requirements”**



## SpaceWorks Commercial Reference PTP Concept

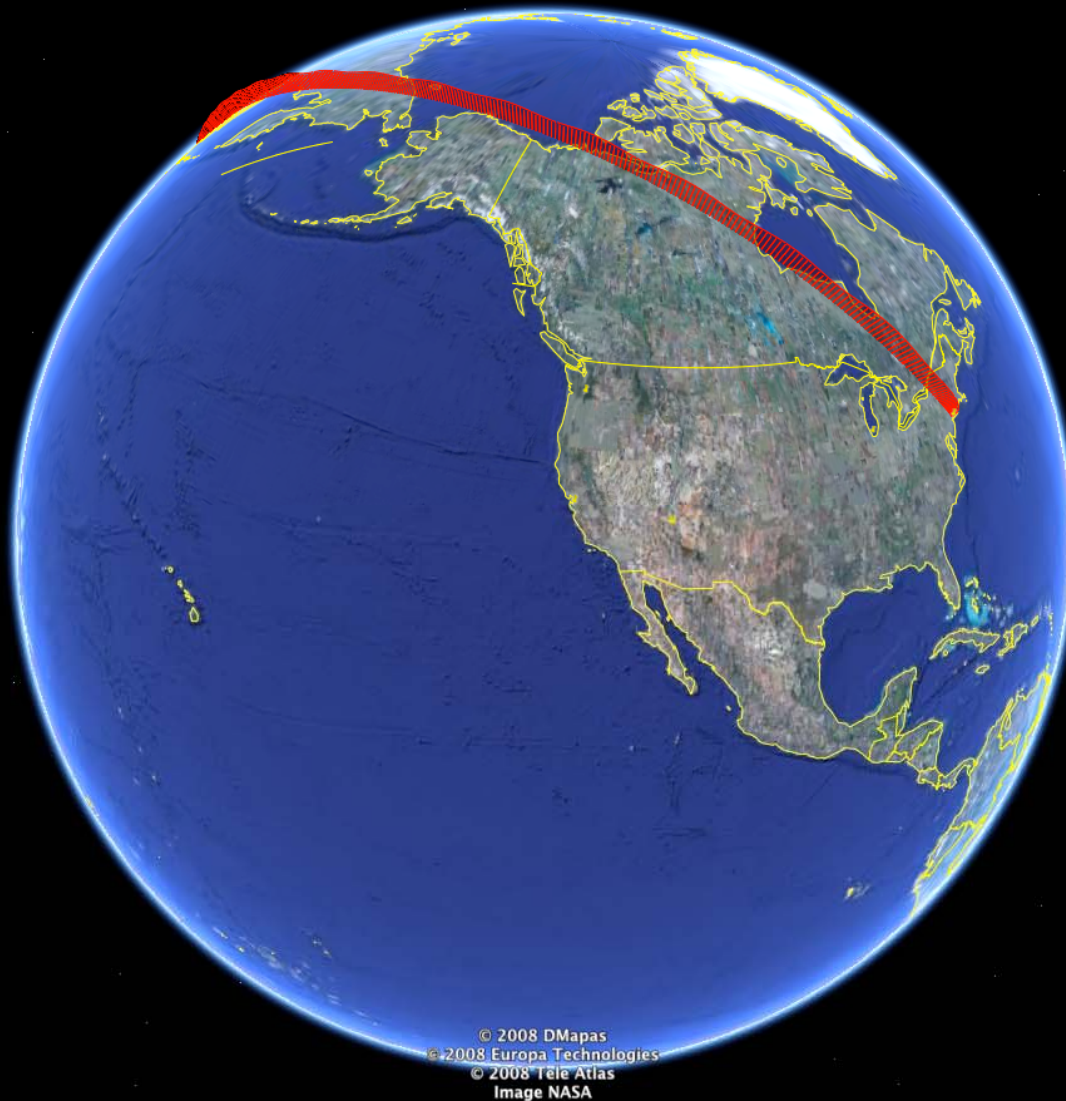
- SpaceWorks' PTP Reference Concept assumes the following technologies:
  - RBCC scram-rocket propulsion (LOX/JP-10)
  - Lightweight MMC structures
  - Remotely-piloted operations
- Synergistic research programs exist in major government-led hypersonic research programs worldwide (e.g. Blackswift, HyFly) leading to an assumption that this concept **could be technically feasible in the next decade or two**
- PTP concept utilizes a periodic / **skipping trajectory** to extend its range
  - Sanger Silbervogel
  - HyperSoar
- Engine cutoff velocity is approximately Mach 18 or less for most cases, and flight times are under 2 hours between all city pairs
- High lift-to-drag ratio ( $L/D \sim 6$ ) **waverider shape** helps extend range, limit g's at the bottom of each skip, and manage peak heating

Item	Mass [kg]
Wing Group	9,560 kg
Body Group	3,400 kg
Thermal Protection	1,440 kg
Main Propulsion	6,200 kg
Subsystems	5,400 kg
Mass Growth Margin	<u>4,600 kg</u>
<b>Total Dry Mass</b>	<b>30,600 kg</b>
<b>Max Payload</b>	<b>1,000 kg</b>
LOX	86,420 kg
JP-10 Fuel	35,285 kg
Misc. Residuals	<u>1,435 kg</u>
<b>Total Gross Mass</b>	<b>154,740 kg</b>

## PTP Vehicle Design Characteristics and Technologies



## Sample Periodic Trajectory (London - Tokyo)



## Sample Periodic Trajectory (NYC - Shanghai)

- **Non-recurring Costs (NAFCOM Cost Model)**
  - **Vehicle Airframe Design, Development, Test & Evaluation**
  - **RBCC Engine Design, Development, Test & Evaluation**
  - **Fleet Production (35 airframes, 140 engines)**
  - **Limited Construction of Facilities (CoF) costs (dedicated hangers)**
  - **Assume technology maturation and main infrastructure development costs are borne by local and federal governments**
  
- **Recurring Costs (SpaceWorks Commercial's CABAM tool)**
  - **Labor**
  - **Propellants**
  - **Parts / Spares**
  - **Hull Insurance**
  - **Site Fee (landing fee from local aerospaceports)**
  - **Outsourced Depot maintenance/service costs**
  - **Selling, General & Administrative**

## **Vehicle Cost Estimate Components**

Item	Total
Hardware DDT&E (Airframe)	\$942.0 M
Total Systems Integration	\$559.2 M
Fee/Prog. Support/Cont./Vehicle Int.±	\$1,174.3 M
<b>Total DDT&amp;E (Airframe)</b>	<b>\$2,675.5 M</b>
Hardware DDT&E (Propulsion)	\$737.2 M
Total Systems Integration	\$686.0 M
Fee/Prog. Support/Cont./Vehicle Int.±	\$359.9 M
<b>Total DDT&amp;E (Propulsion)</b>	<b>\$1,783.1 M</b>
<b>Total DDT&amp;E (Airframe + Propulsion)</b>	<b>\$4,458.5 M</b>
Hardware TFU (Airframe)	\$147.2 M
Total Systems Integration	\$55.4 M
Fee/Prog. Support/Cont./Vehicle Int.±	\$105.9 M
<b>Total TFU (Airframe)</b>	<b>\$308.5 M</b>
Hardware TFU. (Propulsion) a	\$8.8 M
Total Systems Integration	\$0.9 M
Fee/Prog. Support/Cont./Vehicle Int.±	\$4.4 M
<b>Total TFU (Propulsion)</b>	<b>\$14.1 M</b>
<b>Total TFU (Airframe + 1 Prop. Unit)</b>	<b>\$322.6 M</b>
<b>Cost to First Vehicle (w/2 Prop. Units)</b>	<b>\$4,794.5 M</b>

*Note that our baseline revenue is only \$0.368M per flight*

Cost Item	Per Year Cost <sup>†</sup>	Per Flight Cost <sup>†,‡</sup>
Selling, General, and Administrative Cost (SG&A)	\$306.7 M	\$0.039 M
Site Fee	\$390.0 M	\$0.050 M
Labor	\$306.3 M	\$0.039 M
Line Replacement Unit (LRU)	\$333.7 M	\$0.043 M
Propellant Cost	\$526.1 M	\$0.067 M
Hull/Replacement Insurance	\$298.8 M	\$0.038 M
<b>Direct Recurring</b>	<b>\$2,161.5 M</b>	<b>\$0.277 M</b>
Depot Service Contract	\$361.0 M	\$0.046 M
<b>Direct Recurring with Depot</b>	<b>\$2,522.5 M</b>	<b>\$0.323 M</b>

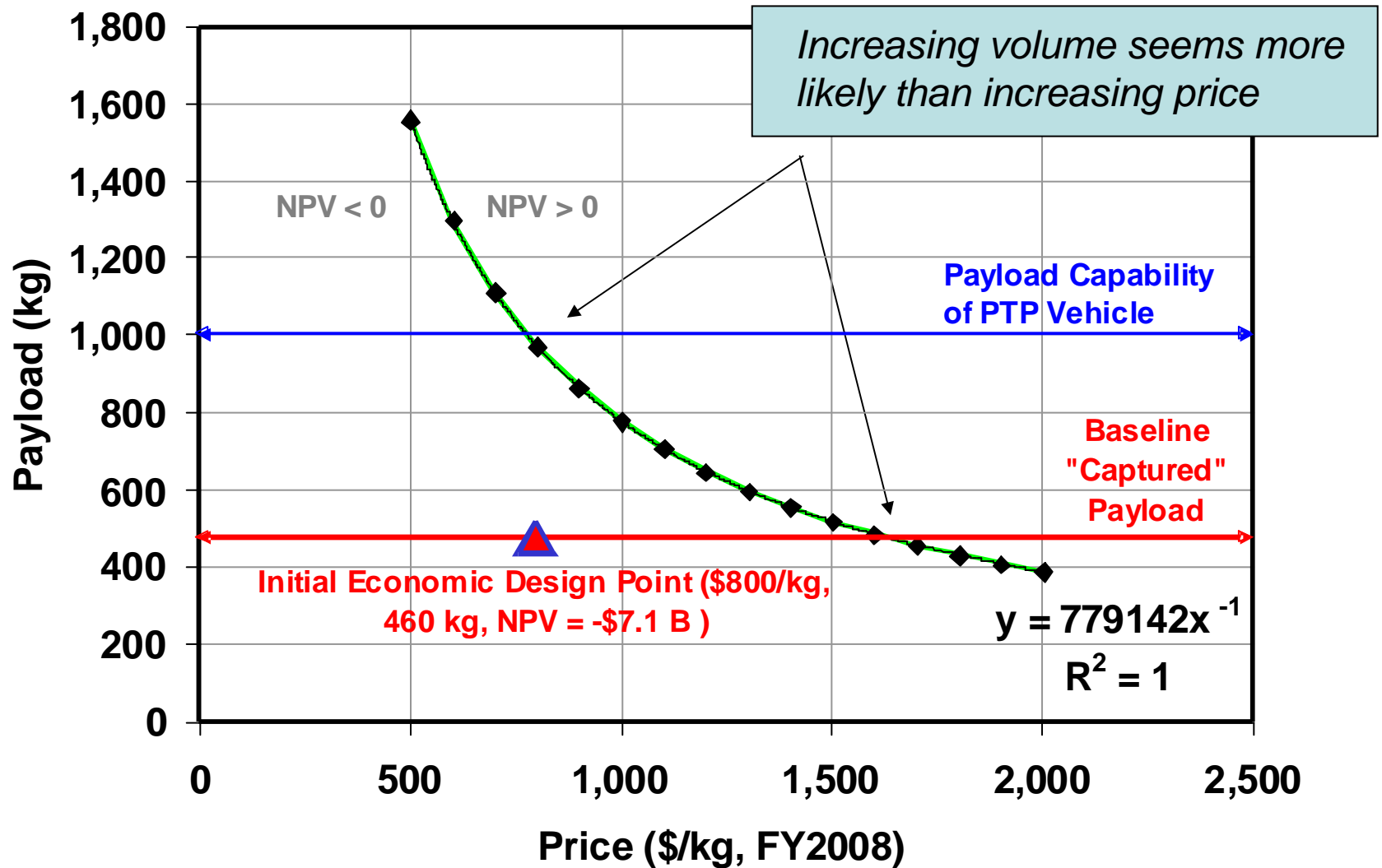
Item	Value
Fiscal Year of Outputs	2008
Program Start Year and Fiscal Year	2014
DDT&E Start Year	2015
Number of Years of DDT&E	3
DDT&E End Year	2017
Number of Years after DDT&E ends when production/acquisition starts	0
Production/Acquisition Start Year	2017
Number of Years of Production/Acquisition	4
Production/Acquisition End Year	2020
Number of Years after Program Start when Facility Development starts	2
Facility Development Start Year	2016
Number of Years of Facility Development	5
Facility Development End Year	2020
IOC (Initial Operating Capability):	2020
Number of Flight Years In Program	20
Program End Year	2030
Number of Years In Program	26

## Vehicle Cost Estimate Results (FY2008 USD)

- For the baseline case, we used our CABAM (Cost and Business Analysis Module) tool to perform a complete cost flow analysis over the life of the project
  - Utilized an appropriate weighted-average cost of capital for debt
  - Applied taxes in general, but assume a 5-year tax holiday after first revenue
  - Used WACC as discount rate to create a Net Present Value (NPV) estimate
- In the baseline case, **the NPV is severely negative**, indicating insufficient revenue or excessive costs, or both
- So, **for our initial assumptions, this is not an attractive venture economically.** It is unlikely to return value to its investors
- However, given the rough nature of our market volume and price assumptions, **we explored several other options in order to determine the conditions that would make this venture viable**

Item	Value
WACC	15.82%
Payload	460.0 kg
Price	\$800.0/kg
Net Present Value (NPV)	<b>-\$7,691.4 M</b>
DDT&E Cost	\$4,458.5 M
Acquisition Cost	\$10,377.9 M
Facilities Cost	\$1,659.5 M
Recurring Cost	\$29,266.0 M
Financing Cost	\$10,261.7 M
Taxes	\$2,499.0 M
Revenue	\$57,408.0 M
Total Equity Investment	\$10,059.2 M

## Economic Modeling



## Summary Economic Results

- From a **vehicle-design perspective**, a vehicle such as the one envisioned here **could well be technically feasible** in the next decade or two if government-led research in hypersonics is successful and stable
  - Caveat 1: Our PTP concept is just one possible technical solution and we encourage others to design concepts to achieve the requirements. However, achieving safe, routine flights on these routes will likely require a significant investment regardless of the technical approach selected
- However, based on the assumptions made here and the limitations of our study, the **economic business case does not support a new fast package delivery capability** in the next decade or two
  - Caveat 2: If the market turns out to be larger than predicted here, then the case could turn from negative to positive. Increasing the market volume by more than a factor of two (2) at the baseline price will be required. **We recommend a more formal market study to assess this key variable**
  - Caveat 3: Our results did not consider synergies with the emerging suborbital space tourism market, or with alternate implementation strategies such as on-demand service

## Conclusions

- To pursue several of the key recommendations resulting from this initial study and further investigate the size and complexity of the market, **SpaceWorks Commercial is leading the formation of a pre-competitive industry working group** and association of interested parties from government and industry focused on fast-package delivery
- **Sample activities will include:**
  - Bi-monthly telecons with guest speakers (first in November 2008)
  - Informal exchanges of ideas and findings by email and limited-access Google group to post papers, market results, etc.
  - Annual meeting in advance of ISDC or ISTS conferences (dates TBD)
- **Five organizations have agreed to participate to date:**
  - SpaceWorks Commercial, Spaceport Associates, XCOR Aerospace, Rocketplane Global, and the V-prize Foundation
  - Others are welcomed to join!
  - Contact [john.olds@sei.aero](mailto:john.olds@sei.aero)

## **Future Work: FastForward Study Group**

SpaceWorks  
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# SPACEWORKS COMMERCIAL

advancing innovative ideas, solutions, and partnerships for commercial and international space ventures

THE FUTURE IS GO

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