

**Toho Tenax America, Inc.**  
**November 2012 Presentation to:**  
**FEIPLAR BRAZIL**

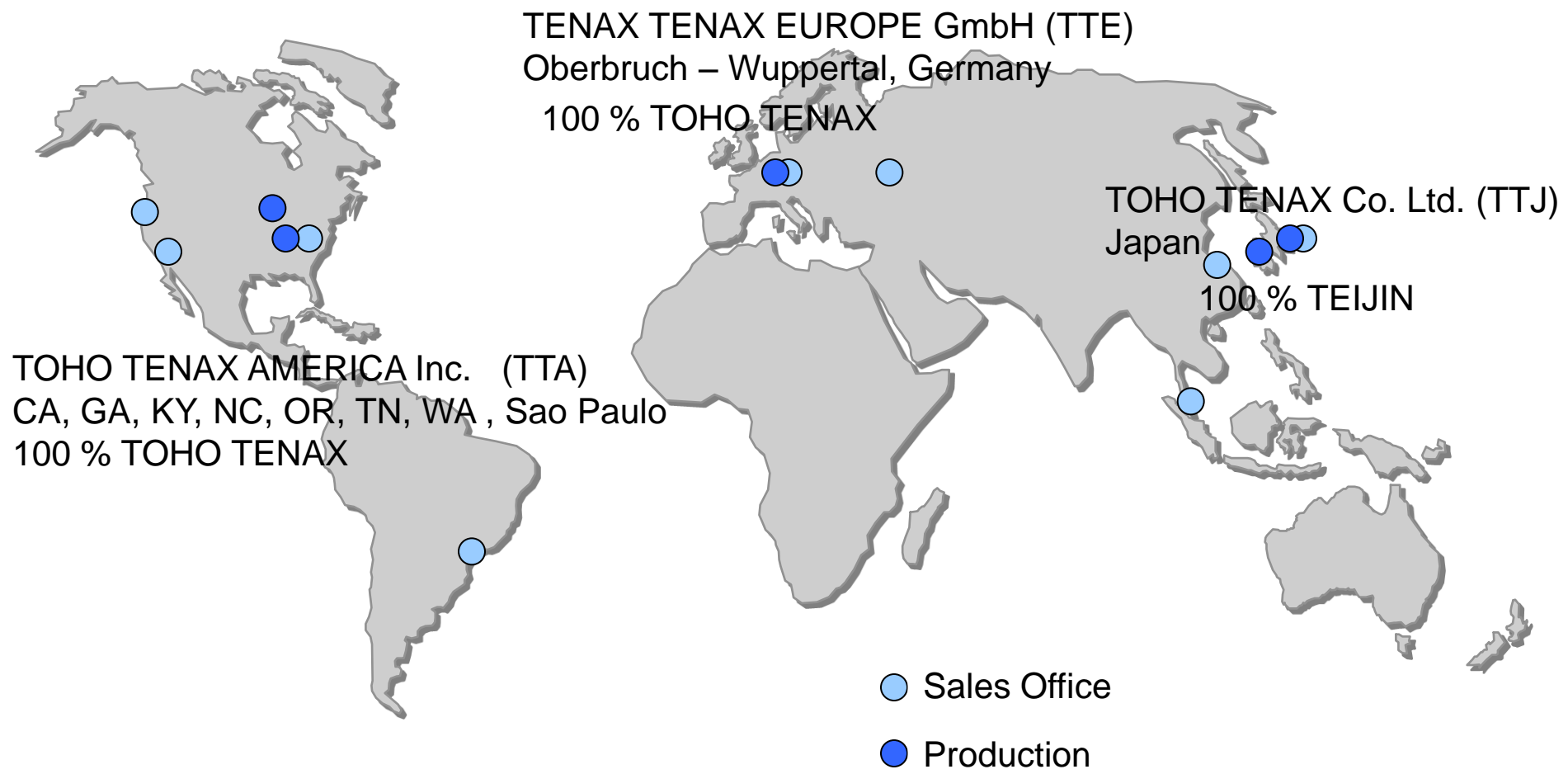
***“Metallic to Carbon Fiber”***

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# Aerospace Market

Teijin Group



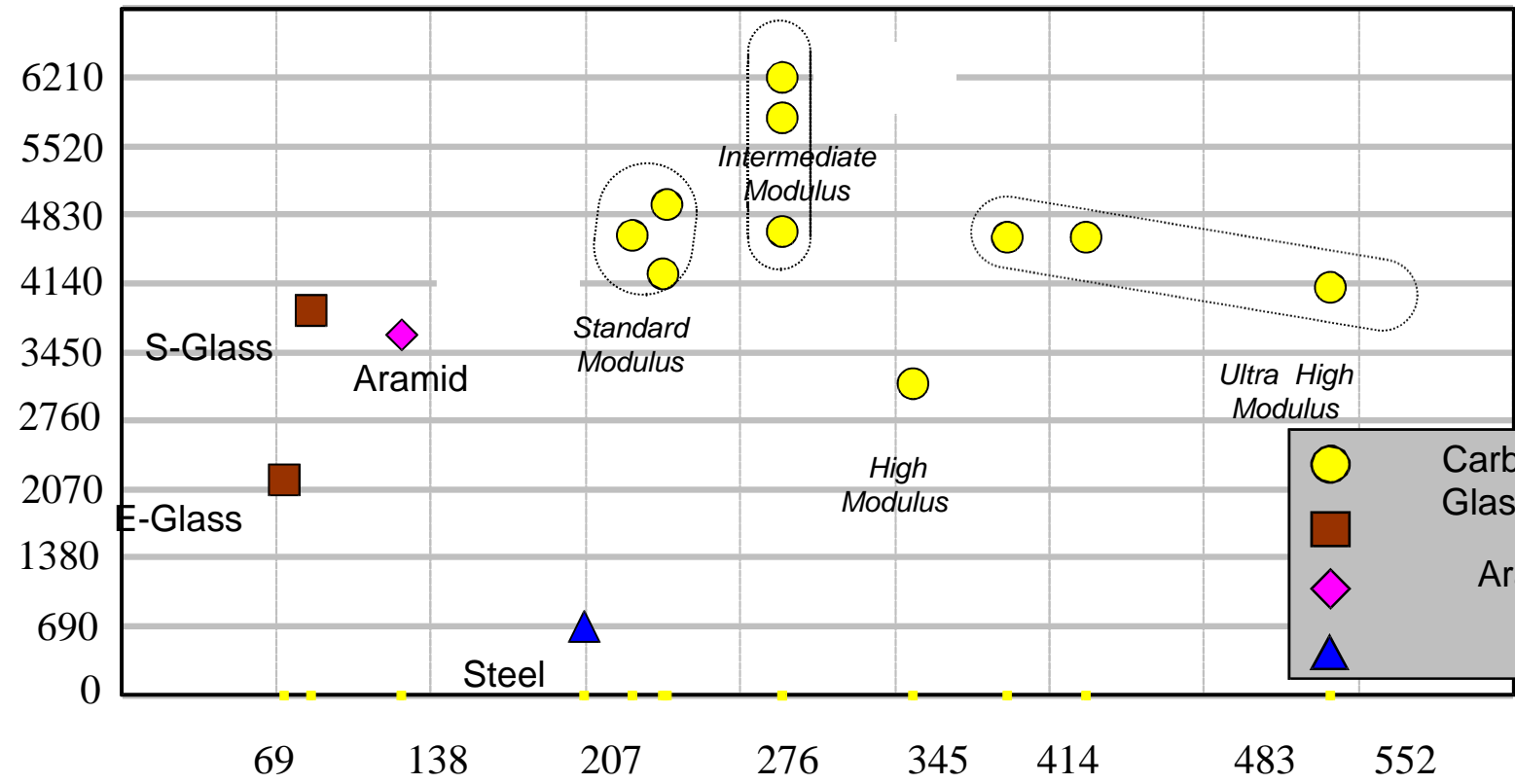
# *Aerospace Market*

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- Metallic to Carbon fiber
  - Aluminum
  - Stainless Steel
  - Titanium
- Structures
  - Powerplant (primary & secondary)
  - Airframe (primary & secondary)
- Future Market
- Conclusion

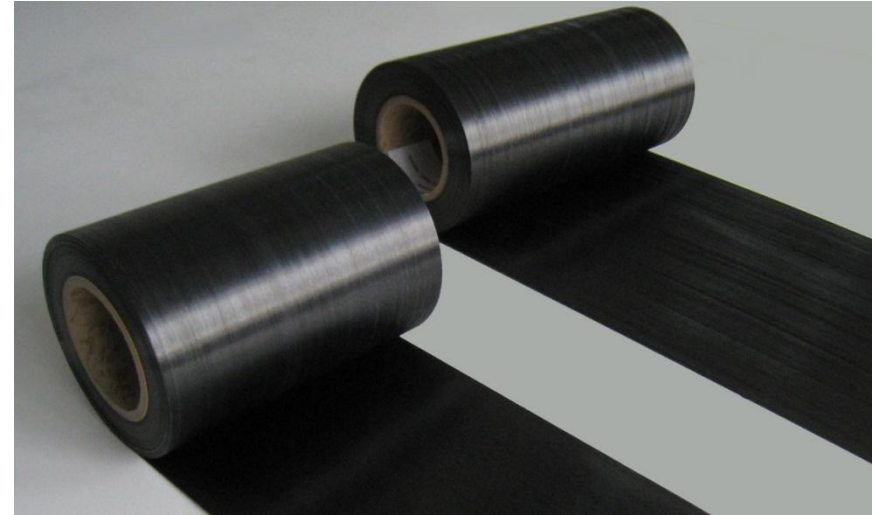
# Toho Tenax Materials

Tensile Strength (MPa)



Tensile Modulus (GPa)

# Toho Tenax Materials



## Fiber(s) / Tape(s)

- Tenax-E IMS 65 E23 24K
- Tenax-E IMS 65 F13 24K
- Tenax-E IMS 60 E13 24K
- Tenax-E HTS 40 F13 12K
- Tenax-E HTS 45 E13 12K
- Tenax-E HTS 45 E13 24K
- Tenax-E HTA 40 E13 3K
- Tenax-J HTS 40 E13 3K
- Tenax-J HTS 40 E13 6K
- Tenax-J HTA 40 E13 1K
- Tenax-J HTA 40 E13 3K

# *Metallic Fan Blade / Platform*



- Airbus 320



- CFM56-7B

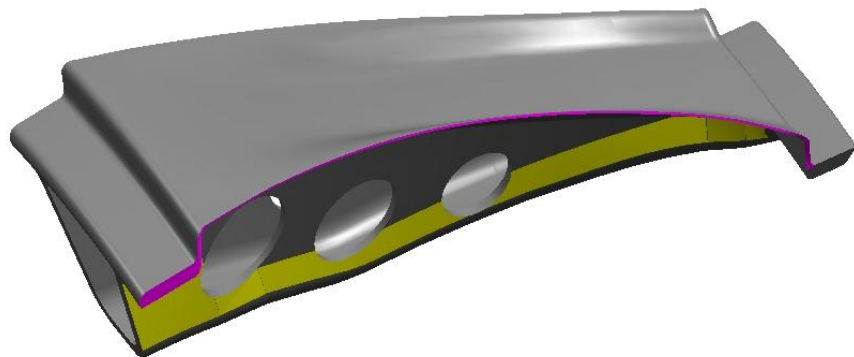




# Composite Fan Blade / Platform



- Boeing 777



GE90-115B



# Fan Blade Weight Examples

## CFM56 Engine Series Metallic



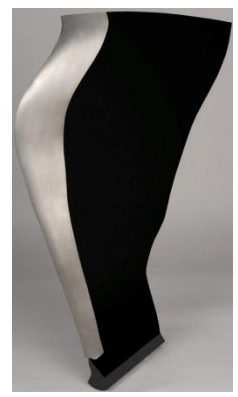
**CFM56-7B**  
Diameter – 61”  
24 blades  
**118 Kg. (260 lbs.)**  
**per Engine Set**  
- hollow titanium

## GE90



**GE90-115B**  
Diameter – 128”  
22 blades  
**462 Kg. (1,019 lbs.) per**  
**Engine Set**  
- 400+ plies of UDT & fabric

## LEAP-X



**LEAP-X**  
Diameter – 71”  
18 blades  
**76 Kg. (168 lbs.)**  
**per Engine Set**  
3D woven RTM



# Powerplant - Metallic Reverser



- Boeing 747

## 747/767/DC10/777 Legacy Propulsion System(s):

- CF6-80C2 Engine
  - Aluminum Engine Case
  - Metallic Fan Blades
  - Composite OGV's
  - Composite OGV Panels
- Thrust Reverser
  - Aluminum Core Cowl
  - Composite Translating Cowl
  - Composite Blocker Doors



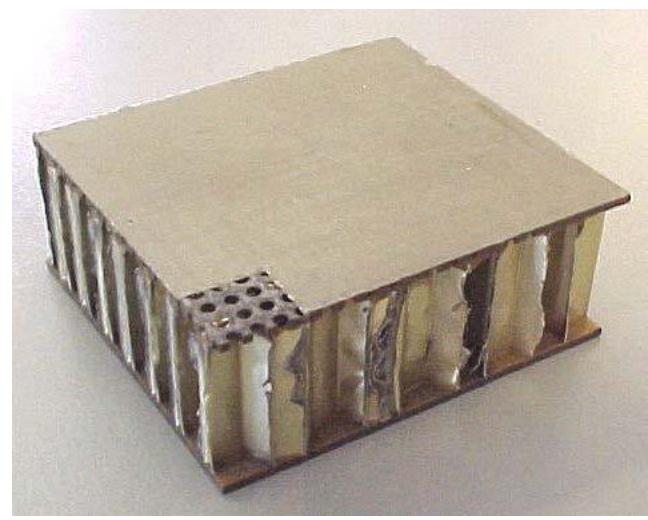
# Powerplant - Composite Reverser



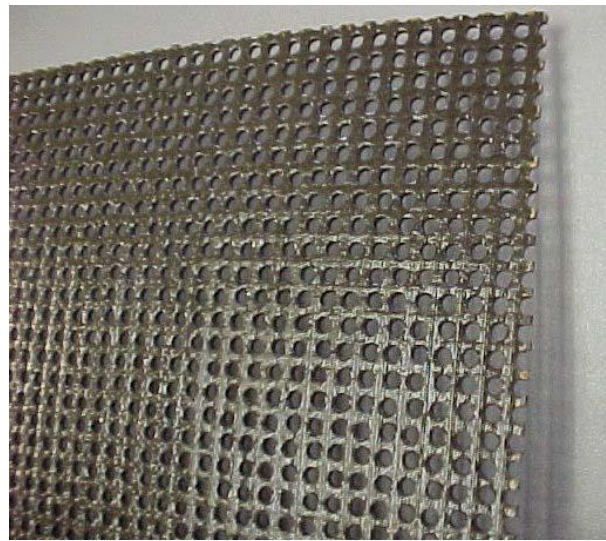
- PW 4168 Composite Reverser



- Airbus A330



- CF/BMI Bondment



- CF/BMI Acoustic Skin

# Thrust Reverser Weight Examples



**CF6-80C2 Core Cowl / Side Walls**  
**542 Kg. (1195 lbs.)**  
- 85% Metallic



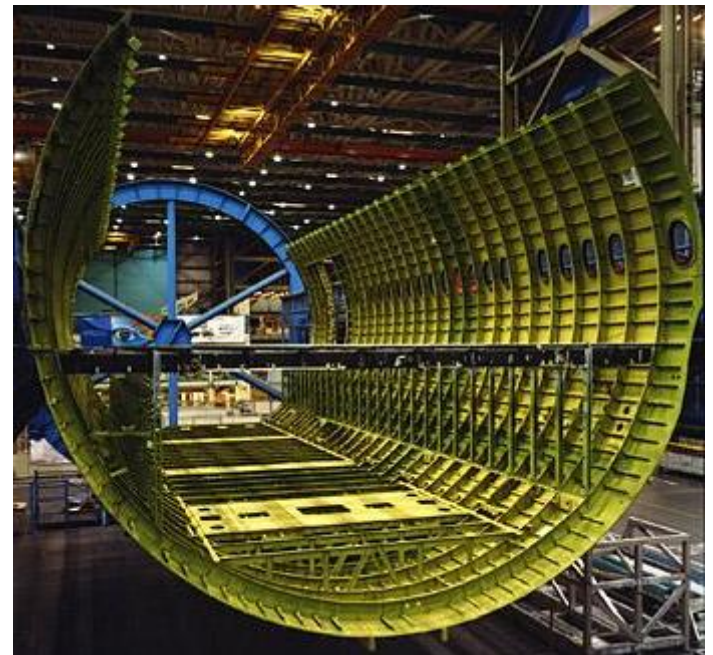
**PW4168 Core Cowl**  
**347 Kg. (765 lbs.)**  
- 85% Composite



# Airframe Metallic Fuselage



- Boeing 777-200



# Airframe Composite Fuselage



- Airbus A350



# Fuselage Weight Examples



**Boeing 777-200**  
**7,280 Kg. (16,050 lbs.)**  
**- 90% Metallic**



**Airbus A350-900**  
**4,105 Kg (9,050 lbs.)**  
**- 75% Composite**



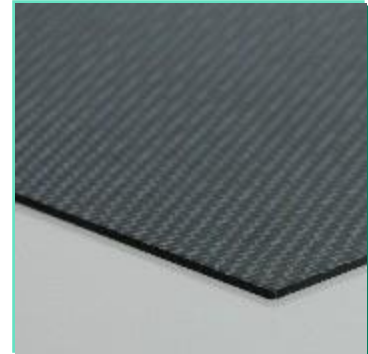
# TPCL Process / Part Making



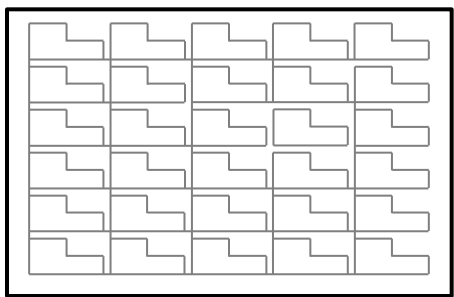
Fiber



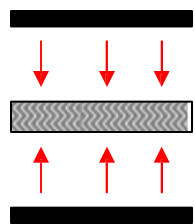
TP Prepreg



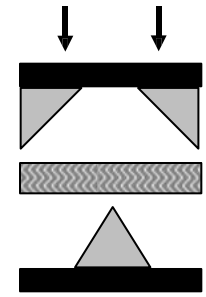
TPCL



Waterjet Blanks



IR Oven



Press



Part (Clip)

# Toho Tenax TPCL Materials

Tenax®-E	Reinforcement	FAW weight [g/m <sup>2</sup> ]	Fiber	Matrix content [%wt.]	Matrix	Nominal thickness [mm]
<b>TPCL PEEK</b> (HTA40 E13 3K)	5HS fabric	285	High TS 3K	40	<b>PEEK</b> (Evonik)	0.31

- Laminate size: 800 (warp) x 1200 mm (0.96 m<sup>2</sup>)
- Thickness: typically from 1.86 to 4.96 mm (6 to 16 plies)
- Aero grade

# Future Market – Regional Engine



GE 20 Passport (TECH-X)

Integrated Nacelle/Thrust Reverser

## **Bombardier Global 7000/8000 propulsion system:**

- GE Passport 20 Engine
  - Composite Fan Case
  - Composite OGV's
- Nacelle System
  - Composite Inlet Cowl
  - Composite Core Cowl
  - Composite Translating Sleeve



# Future Market – Fleet Engine

## A320neo / 737 MAX propulsion system:

- LEAP-X Engine
  - Composite Fan Blades
  - Composite Fan Case
  - Composite OGV's
- Nacelle System
  - Composite Inlet Cowl
  - Composite Reverser
  - Composite Fan Cowl Doors



CFMI LEAP-X



LEAP-X Nacelle System

## 3-D woven Resin Transfer Molding (3-DW RTM)

- Durability
- Weight
- Noise
- Maintenance

## Composite fan case

- Weight
- Fatigue resistance



*1,000 lb weight benefit per aircraft*



# Future Market – ER & Cargo Engine



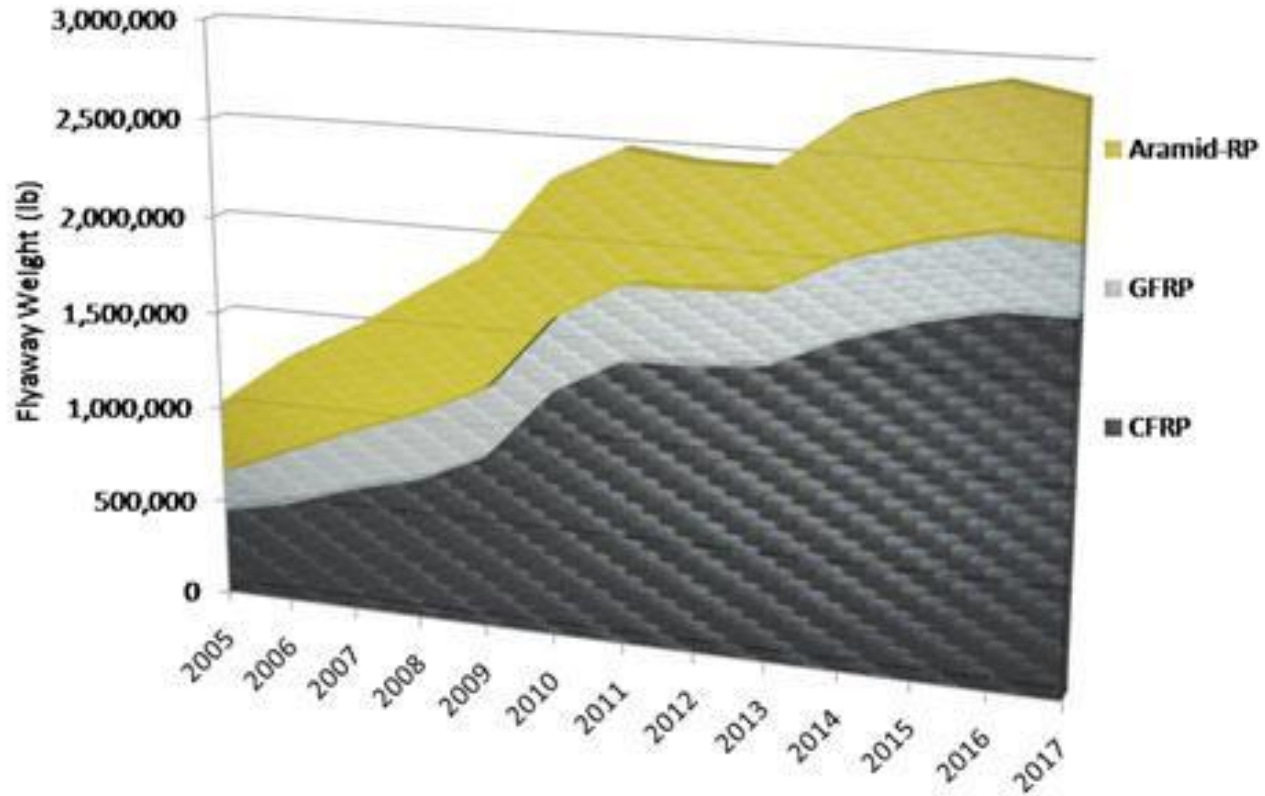
## 747-8F Propulsion System:

- GErx-2B Engine
  - Composite Fan Blades
  - Composite Fan Case
  - Composite OGV's
- Nacelle / Thrust Reverser
  - Composite Translating Cowl
  - Composite Core Cowl
  - Composite Blocker Doors



# Material Types

**Forecasted Engines Composites Structures Requirements  
by Material Type, 2005 - 2017**  
(2008-17 forecasted total: 24,760,000 lb)





## Conclusions

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- Engine market will continue to utilize CF for rotating parts. Additional uses in areas where high strength is necessary or weight savings displace traditional metallic components.
- Airframe market will continue to utilize CF for weight savings and reduce fuel consumption.
- Technology areas will continue to advance in areas of manufacture and assembly to increase CF usage.
  - Thermoplastics to reduce fasteners and part count.

# Questions ???

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