Re: Buying a BBJ and converting it to hydrogen

Source: http://sci.tech−archive.net/Archive/sci.energy.hydrogen/2007−12/msg00596.html

- *From*: BradGuth <bradguth@xxxxxxxxx>
- *Date*: Sun, 30 Dec 2007 12:42:19 −0800 (PST)

I agree that a fat BBJ that's getting your supposedly cheap LH2 and consuming atmosphere of mostly N2 as it's fuel is technically doable, although not nearly as fast due to the aerodynamic friction, and not without creating NOx unless that useless N2 portion of our atmosphere is getting eliminated while on the fly.

− Brad Guth

Willie.Moo...@xxxxxxxxx wrote:

> On Dec 24, 4:07ýpm, BradGuth <bradg...@xxxxxxxxx> wrote:
>
> > On Dec 23, 2:50 pm, Willie.Moo...@xxxxxxxxx wrote:
> >
> > > On Dec 24, 2:15 am, BradGuth <bradg...@xxxxxxxxx>
> > > wrote:
> > >
> > > > Good grief! ý For the same cruising range,
> > > > perhaps using an A380 with
> > > > roughly 10% the passenger and freight
> > > > capacity is a more than likely
> > > > alternative. ýRemember the amount of
> > > > volume necessary for the LH2 is
> > > > not going to be all that unlike the shuttle ET,
> > > > except you'll need
> > > > much more fuel storage capacity your unless
> > > > cruising range isn't a
> > > > factor.
> > > > − Brad Guth

Willie.Moo...@xxxxxxxxx wrote:

I was going to call this what I did during my summer vacation! ýlol

All this discussion about hydrogen fueled airlines and such caused me to spend a lot of time, a few minutes a least, thinking in detail about what it would take to convert a conventional airliner to burn hydrogen.

That and the stink some reporters on FOX made about Al Gore's carbon foot print because he flew a private jet around − haha − caused me to think about private jets conversions. ýI'm thinking about buying a used BBJ − and a new one − which will be delivered in 7 years − and when the old one is retired − having all the pieces and parts in place to upgrade it.

The jet engine isn't difficult at all. The first jet engines used hydrogen. ýIn today's world NOx production can be a problem, but this can be reduced dramatically by staged combustion of the hydrogen − which entails burner changes. ýWith these changes engineers who have tested jet engines with hydrogen at the Dornier aircraft company, in 1998 and 1999 − were able to get hydrogen fueled jets to produce 2% to the NOx of regular jet fuel powered varieties. ýThat with a total reduction to zero of carbon was great!

Alright, so take a look at slides 30 and 31 at the following URL

http://www.theoildrum.com/uploads/3246/csmith.pdf

On slide 30 is shown a hydrogen version of the Dornier 328. ýThis Dornier 328 shown here uses under wing nacelle tanks and a stretch in cabin volume to increase it to 50 passengers − to take advantage of the increased lifting capacity.

On slide 30 is shown a hydrogen version of the Airbus A300 − a hydrogen version of the Beluga − which is basically a Beluga with hydrogen tank up top, and a standard A300 interior below. ýHydrogen's high efficiency at longer range means they opted for longer range aircraft here.

But we're looking at a Boeing BBJ variant. ý Here are the typical 737 specs − this is a starter for a preliminary analysis of what I have in mind. ý This is a 737 800 a little bigger than the BBJ − but will do for our purposes of a preliminary analysis.

737−800 Technical CharacteristicsPassengers

ýTypical 2−class configuration ý162
ýTypical 1−class configuration ý189

Cargo 1,555 cu ft (44 cu m)
Engines (maximum thrust) ýCFMI CFM56−7 27,300 lb
Maximum Fuel Capacity 6,875 U.S. gal (26,020 L)
Maximum Takeoff Weight 174,200 lb (79,010 kg)
Maximum Range 3,060 nautical miles (5,665 km)
Typical Cruise Speed (at 35,000 feet) ý0.785 Mach

Basic Dimensions
ý Wing Span ý ý ý ý ý ý112 ft 7 in (34.3 m)
ý With Winglets ý ý ý ý117 ft 5 in (35.8 m)
ý Overall Length ý ý ý ý129 ft 6 in (39.5 m)

ý Tail Height ý ý ý ý ý ý ý
41 ft 2 in (12.5 m)
ý Interior Cabin Width ý11
ft 7 in (3.53 m)

So, has anyone ever seen a 747 carry the Space Shuttle Orbiter around?

http://www.murdoconline.net/2007/enterprise_atop_747−thumb.jpg

Compare that to the Airbus A300 hydrogen variant.

Does that suggest anything?

Sure does − what about an ADD ON TANK right on top of the 737? ýThat way you could store your tanks on the tarmac, refill them and lift
them in place, like changing batteries on a big energizer bunny.
Sweet.

So, fuel volume is 26 cubic meters. ýThat means you carry around 20.8
metric tons of the stuff on a typical day. ýThis translates to 890 GJ
of thermal energy.

Converting to hydrogen therefore which has 143 GJ

per metric ton,
means that you need to carry
6.3 metric tons of hydrogen
around with
you. ýAdd in a fuel tank
weight of 10% fuel weight,
and that's 0.6
metric tons. ýAdd
interconnects and so forth,
that's 0.1 metric tons.
A total of 7 metric tons of
weight replacing 20.8 metric
tons. ýThis
adds 13.8 metric tons to the
payload capacity of the
aircraft.

Now,at 70 kg per cubic
meter that translates to 90
cubic meters. 3..5x
as large as the jet fuel tank.
Let's say we can occupy
60% of the
fuselage length above the
CG with a tank − judging
from the Space
Shuttle length atop the 747
transport ship. ýWe might
be able to do
more, but won't know for
sure without detailed wind
tunnel tests and
flow analysis.

60% of the 39.5 m length is
23.7 m. ýDividing this
dimension into the
total volume of 90 cubic
meters comes up with 3.8 sq
meters. ýAssuming
a constant circular cross
section (as a first pass)
produces a
cylinder 2.2 m in diameter
and 23.7 meters long. ýNow
a cylinder is
not ideal, an ideal shape

would be some sort of tear drop shape that has a much lower drage − up to 1/10th that of a cylnider, but the volume and diameter relations would be within a factor of 50% of the diameter calculated here − that is 3.3 m maximum diameter would be near the right size of a optimally shaped tear drop holding the requisite hydrogen.

A 26% increase in dimension allows a doubling of the fuel capacity (with a reduction of payload gain to 6.8 metric tons) and an increase in range to 8,000 km while increasing speed by 5% and other improvements besides, like increase angle at take off, shorter take off and landing runs etc, despite the increase in form drag (and reduction in induced drag)

The 14 ton fuel tanks (and 1.2 ton empties) would be easily lifted off the top of an aircraft that taxied under a loading crane − or had a loading crane on a truck drive up to the aircraft − removing the empty and loading up the full one. ýSeveral could be kept at airports that served hydrogen fueld 737s.

So, the used BBJ costs $32
million − what do you think
the upgrades
and infrastructure would
cost? ý(and you'd keep the
jet fuel tanks and
be able to switch back and
forth if needed)− Hide
quoted text −

− Show quoted text −

Brad,

And you claim not to be a master of Black Propaganda. ýBut
here you
are, practicing it like a pro.

You'e gotta know that the Space Shuttle ET carries 106
metric tons of
liquid hydrogen in 1,497 cubic meters while I just said that I
would
carry 6.3 metric tons of liquid hydrogen in 90 cubic meters −
to
maintain the same range − and perhaps double that to 12.6
metric tons
in 180 cubic meters to nearly DOUBLE the range.

Sheez

http://en.wikipedia.org/wiki/Space_Shuttle_external_tank

But here you are, forever stuck within this anti−think−tank of Usenet naysayland, still poor as hell and going nowhere fast, much less via hydrogen. ýWhat's wrong with this picture.
− Brad Guth− Hide quoted text −

− Show quoted text −

Your statement is nearly free of any meaning in the context of our discussion. You compared the add−on tank which is to carry from 6.2 to 12.4 metric tons of hydrogen to the Space Shuttle External Tank that masses over 700 tons!!! I replied that such a comparison is not only inaccurate, but it marginalizes the very concept. You replied with gibberish.

I do admit on re−thinking that metaphorically an add−on tank atop a 737 airframe can be thought of as a sort of external tank similar to the shuttle, and perhaps I shouldn't have responded so negatively to your concept.

I've done a little more thinking on this subject...

Measurement BBJ
Crew 2

Length 39.47 m (126 ft 6 in)
Fuselage Width 3.76 m (12 ft 4 in)
Fuselage Height 4.11 m (13 ft 6 in)

Wingspan 35.79 m (117 ft 5 in)
Height 12.05 m (41 ft 2 in)

Weight Empty 45,730 kg (100,815 lb)
Maximum take−off weight 79,015 kg (174,200 lb)
Maximum landing weight
Maximum speed 890 km/h (481kt, Mach 0.82)
Range 10,620 km (5,735 nm)
Service Ceiling 12,496 m (41,000 ft)
Thrust−to−weight 0.52:1
Powerplants CFM International CFM56−7 turbofans
Thrust 117.4kN (26,400 lbf)

Now draw an arc that represents the top of a BBJ fuselage. Make a copy of that arc. Move it up 1 meter. Draw vertical lines connecting the ends of the top arc to the ends of the buttom arc. What is the area of the space between? The answer is 3.76 m! The same as a rectangle 1 meter tall by 3.76 m width. That's because the arc above adds what the arc below subtracts from a box made by the box when connecting the ends horizontally.

39.47 meter length x 3.76 m2 = 148.4 cubic meters

for every meter of height added. At 0.07 tonnes per cubic meter that's 10.388 tonnes per meter of height added to the 4.11m height of the existing BBJ cabin. 1.5m height addition, slightly shorter length than that given here, due to rounding of the front before reaching the nose, and before reaching the tail, provides for 12.5 metric−ton hydrogen capacity − giving the modified aircraft 20,000 km range, while INCREASING payload and take off performance. Modifying the wings and flaps to lower landing speed, modifying the engines to take advantage of hydrogen to increase thrust 22% − allows STOL performance.

This tank is likely to have 0.05% boil off per day. Thus 14% remains after 30 days. Most aviation and jet fuels have a more limited life than this;

http://www.intertek−cb.com/petrotesting/jetfueldegradation.shtml

The Glenn Research Center in Cleveland Ohio has looked into the potential of MEMs based cryogenic refrigerators that are powered by the boil off to reduce boil off rates below these levels. Boil off itself can be used by fuel cell systems to provide auxiliary power for the tank.

http://www.cstl.nist.gov/projects/fy05/msci05radebaugh.pdf

A fully fueled tank holding 12.5 tonnes of hydrogen with a 0.05% boil off yields 6.25 kg per day. That's 260 grams per hour. 72 milligrams per second. Enough to generate 6.1 kW of electrical power in a fuel cell that's 60% efficient. A cryogenic refrigerator that reduces boil off by a factor of five, would consume 1.22 kW. Modulating this output would allow power levels of the tank systems to be throttled up and down, and operate independently of the external tank.

http://www.flickr.com/photos/8362988@N06/810948952/

The tank would start just above the front wind screen and arc up 1.5 meters by the time is went behind the entry door. Then its sides would wrap around the back of the door, and run along the top edge of the windows. It would have a slot in the back to wrap around the base of the tail fin, as it tapered back to end at the tail section. The antennae located on the top would be surrounded by pickups, and the antennae patterns would be repeated precisely atop the tank. Structural connections would be located at appropriate points around the roof of the aircraft. Fuel connections would be placed in the base of the tail section and connect to the tank there during set down. In the superstructure just described, there would be four tank sections running the length of the tank just behind the door and running to just past the the base of the tail. Each tank holding 3.125 metric tons of hydrogen. Mechanical, electrical, and other components are located in the tank housing fore and aft of these four dewars.

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