



COZY AIRCRAFT FORUM

Soup to Nuts*?

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July 31st, 2010

1:00 PM – 2:15 PM

Forum Tent 02 – GAMA Pavilion

* With apologies to Bernard Kliban

What Will I Talk About?



- ***Standard Introduction for the Newbies – 15 min.***
 - *Who Am I?*
 - *What's a COZY MKIV?*
 - *Why a COZY MKIV*
 - *COZY MKIV Plans*
 - *COZY MKIV Cost*
 - *COZY MKIV Support*
 - *COZY MKIV Parts Vendors*
 - *How Many COZY's Under Construction / Flying?*

- ***Further Topics – 30 min:***
 - *COZY Aircraft Structures*
 - *Flight Testing Methods*
 - *COZY Engine choices*
 - *Fuel Compatibility*
 - *Strake Mod. Aerodynamics*
 - *Common Modifications*
 - *Performance Mods*
 - *My Recent Modifications*
 - *Propeller Belleville Washer Summary*
 - *COZY Safety Record*
 - *Safety Mods/Issues – Aging of Fleet*
- ***Futures / State of Design***
- ***Questions and Answer (ANY topic)***

Who The Heck Am I?



- Biography / Resume'
 - <http://www.mdzeitlin.com/Marc/bio.html>
- Built Quickie Q2
- Built COZY MKIV #386, N83MZ – ~670 flying hours
- Started / Administer Unofficial COZY Builders Web Page and COZY Mailing List (~620 members)
- Work for Scaled Composites as Mechanical Engineer/Manager – Currently Lead Project Engineer for SS2 Rocket Motor (RM2) Design/Development/Testing

What's a COZY MKIV?



- History
 - Designed by Nat Puffer
 - Derivative of Burt Rutan's Long-EZ
 - Evolved from 3-place to current 4-place in early 1990's
- Type
 - Canard – big wing in back, small wing in front
 - 4 place, or 2+2, or 2 + LOTS of baggage
 - Efficient, fast, long distance cruiser
- Aerodynamics – Nat's 2005 Oshkosh Forum
 - http://www.cozybuilders.org/Oshkosh_Presentations/Nats_OSH2005_Presentation.pdf

Why a COZY MKIV?



- Want to **BUILD**
- Use-Model comparison
- Economics
- Carrying Capacity
- Safety Features
- Composites



COZY Plans Availability



- Cozyaircraft Corp.
now owned by ACS



- Plans available
through ACS

<http://www.aircraftspruce.com>

Vendor Display Building at OSH

COZY MKIV Cost



- Low End - \$35K to \$50K
 - High Time Engine (maybe Auto Conversion)
 - Good Scrounging
 - Minimum Instruments - VFR Only
- Mid-Range - \$50K to \$75K
 - Some Prefab (not much)
 - Rebuilt Engine
 - High end VFR - Low End IFR Panel
- High End - \$75K to \$120K
 - Lots of Prefab components / paid help
 - New Lycoming
 - Complete Latest IFR Stack Panel
- Plans – NOT A KIT!!!

COZY Support Methods



No Official Support from ACS, But:

- COZY Newsletter archives
 - <http://www.cozybuilders.org/newsletters/>
- COZY Mailing List
 - http://www.cozybuilders.org/mail_list/
- Unofficial COZY Builders Web Page
 - <http://www.cozybuilders.org/>
- Builder's Web Pages (links from **UCBWP**)
- Canard Aviator's Mailing List
 - <http://groups.yahoo.com/group/canard-aviators/>
- CSA Newsletter
 - http://www.cozybuilders.org/ref_info/other_news.html
- Freeflight Composites (Burrall Sanders)
 - <http://www.freeflightcomposites.com/services.htm>

If you're a current or prospective COZY builder or flyer and believe that official support from a sanctioned ACS/Nat Puffer avenue would help convince you to build this plane:

**Let Jim Irwin
at ACS know!**

COZY Parts Availability



- ACS, Wicks, etc. for most composite & standard aircraft materials
- Two main vendors provide metal parts:
 - CG Products
 - <http://www.cozygirrrl.com/aircraftparts.htm>
 - EZ Nodelift
 - <http://www.eznodelift.com/>
- Other part vendors for miscellaneous items – see:
 - <http://www.cozybuilders.org/newsletters/suppliers.html>
 - http://www.cozybuilders.org/newsletters/na_suppliers.html

How Many COZY's?



- ~ 2000 Rutan Derivative Canard Aircraft flying (VariViggen , V.E., L.E., Defiant, Berkut, E-Racer, SQ2000, Velocity, COZY III, COZY MKIV)
- ~ 220 - 300 flying COZY's all over the globe
- ~1600 COZY MKIV plans sold
- ~ 600-800 actually under construction
- 5-10 new COZY MKIV first flights per year

- These numbers are **ALL ESTIMATES** – real stats are hard to come by

COZY Aircraft Structures



- Lack of structural failures in type is **NOT** a license to make structural mods, **HOPING** that the (**UNKNOWN**) safety factor will save your butt!
 - Only known testing **to failure** are on L.E./V.E. canard – one failed at 14G, another at 6 – 7G's – shows variability in MFG and structural capabilities
 - At least one L.E. wing test done – no details known
 - **NO COZY** structural testing has **ever** been done! Do you know the safety margins? I don't! Nat never published any structural design info or analysis
 - Modifications to composite structures are far more complex and difficult to analyze than with metal structures
- Wing/Canard:
 - Spars: Carry bending loads in wings
 - Shear Webs: Carry shear loads in wings – transfer loads from top to bottom
 - Skins: Carry twisting loads in wings
- Fuselage:
 - Bulkheads: Stiffen fuselage in bending (sideways) and twisting
 - Sides: Stiffen fuselage in bending and twisting
 - Longerons: Help stiffen – mostly act as mounting “hardpoints”
 - Reinforcements: On LG Bulkheads/Firewall/Seatbelt Attach/Canard Attach
 - Thicken, hardpoints, transfer loads between major structures

Flight Testing Methods



- **Purpose of Phase I Flight Testing:**
 - Determine **ALL** performance characteristics of airplane at **ALL** corners of the attainable performance envelope
 - Calibrate Pitot Static System – CAS vs. IAS (MUST understand difference between IAS/CAS/TAS/GS)
 - Rotation speeds
 - Climb performance
 - Cruise performance
 - Descent performance
 - gear retracted, extended
 - LB retracted, extended
 - Landing speeds
 - Stalls
 - accelerated stall (more than 1G – performed in 15, 30, 45, 60 degree banked turns)
 - Deep stall susceptibility
 - Pitch stability (stick fixed and stick free)
 - Lateral Stability (spiral, Dutch Roll, Roll/yaw coupling)
 - Flutter (stick raps)
- **Performance Envelope Includes:**
 - Forward, Mid, Aft CG
 - MGW, Middle Weights, Light Weights
 - Full, Mid, Low Fuel
 - Speeds from Vs to Vne+10%
 - Altitudes from SL to Service Ceiling (or max desired altitude)
 - **ANY AND ALL** maneuvers that may be attempted in Phase II
- **Flight Test Guidelines:**
 - See **AC90-89A** – **EXCELLENT** FAA guide
 - See **COZY POH** recommendations
 - See **Aerocanard Flight Test Guidelines**
 - Use a Test Pilot if not completely capable and current
 - Should take 30-35 hours **AT LEAST** to perform all required tests – if you're done after 15 hours, you haven't done enough
 - Flying around in circles for 40 hours at one CG is **NOT** flight testing, especially in a custom, plans built aircraft, no matter how many people **SEEM** to get away with it
- **CG Determination:**
 - Need **ACCURATE** empty CG – implies accurate weighing
 - Bathroom scales are **NOT** accurate enough – need calibrated aircraft scales
 - Can weight with ballast / passengers / pilot for more accurate station information
 - Use accurate spreadsheet / calculations to determine flight CG – see sample on **COZYBUILDERS** web page
 - Use weights (lead, steel, sandbag, water container) at appropriate station to set CG during testing
- **Procedures:**
 - Start testing in **CENTER** of CG range
 - Slowly add weight and move forward and aft within CG range
 - Start with mild maneuvers
 - Start with short flights
 - Runway flights OK if have **LONG** runway
 - Gear stays down on first few flights

COZY Engine Choices



FLYING:

- Lycoming O-360 / O-320 – many variants
 - Hundreds flying successfully
- Lycoming O-540 (only marginally “alternative”)
 - Three flying successfully (Jannie Versfeld / Chris Esseltstyn / Scott Carter)
- Jabiru 5100
 - One flying successfully (Larry Hill)
- Subaru -
 - Two flying (different variants) semi-successfully (Al Wick / Keith Spreuer)
- Twin Suzuki -
 - One flying successfully in Venezuela (Leon brothers)
- Rotary (Mazda 13B variants) -
 - Two “flying” – low flight time, numerous engine related incidents (John Slade / Steve Brooks)
 - Two others removed for Lycomings after minimal flight time (Joe Hull / Bulent Aliev)
- V8 variants -
 - One flying in South Africa (Rego Burger) (few hours due to accident – not engine related)
 - One removed long ago and replaced with Lycoming
- Turbo-prop (Allison) -
 - One flew – crashed during Phase I in 2008 (cause unknown)
- Jet Turbine -
 - One flying successfully (Greg Richter)

IN DEVELOPMENT:

- One Continental IO-360
- Numerous Mazda 13B and 20B variants
- Different Subaru (H3.0 turbo)

POSSIBILITIES:

- New Lycoming Variants (not major stretch)
- Deltahawk Diesel (expensive & not available)
- Mistral Rotary (**VERY EXPENSIVE**)

AUTO CONVERSION ISSUES:

- Difficult development – every one different than all others
- Hard to compete with simplicity of air cooled Lycoming, for all its faults
- Potential? **YES**. Actuality? **NOT YET**. Needs a **LOT** more development work

Fuel Compatibility

Aircraft Gasolines:

- 100 LL
 - Thousands of examples flying
- 100LL Successor – probably 94 octane no-lead
 - In development – same as 100LL but no lead
 - 80% of aircraft engines can use – only very high compression engines cannot

Mogas:

- Alcohol Free
- Alcohol
- All have unknown additives

Diesel:

- One EZ flying
- Bio-Diesel
- Jet-A

Synthetic Fuels – in development

- Swift Fuel
- GAMI G100UL

Epoxy Tank Sealants:

- EZPoxy with slow hardener (EZ87) is best
- Other EZPoxy's next
- MGS, etc. – seem to work with 100LL – no degradation seen

Other Tank Sealants:

- Pro-Seal polysulfide – best (890 Type A or equivalent)
 - Used in industry
 - Meets MIL Spec requirements
- Jeffco (epoxy – not polysulfide)
 - One Velocity had major peeling problems – unknown cause
- Vinylester Resins
 - Used for underground fuel tanks, some prefab aircraft



Strake & Strake Modification Aerodynamics



- **Basic Strake Aerodynamics:**
 - Common misconception that strakes do not produce lift – **NOT** just a fuel/storage tank
 - Flat top/bottom or not, strakes **DO** produce lift
 - **EVERYTHING** produces lift if at AOA to relative airstream – hold your hand out a car window, or watch a mattress on top of a car
 - Not most efficient lifting surface, but it **IS** a wing
 - Different shape/incidence angle than rest of wings, so will not follow wing's lift curve slope – has it's own
 - strakes will produce substantial lift at low airspeeds/high AOA's
 - little at high speeds/low AOA's (due to lack of camber / different incidence angle)
- **What is the Modification?**
 - Kick out straight LE of COZY strake
 - Shape like Long-EZ strake
- **Why Do It?**
 - Elbow/storage room for front seaters
 - Not enough work in the standard build – need more mods to keep busy
- **What's the Effect (Aerodynamically)?**
 - Small (area-wise)
 - Close to Fuselage (not very efficient lifting area anyway)
 - Very swept – low lift curve slope
 - Basically, Nothing Measurable – if you want to do it, don't worry about screwing up the aerodynamics of the aircraft



Common Modifications



- **Major:**

- Remove Lower Winglets
- Raise Canopy (1” – 2”)
- Widened (Aerocanard “style”) Canopy
- Forward Opening Canopy, a-la Cosy Classic
- Long-Eze type (“Cozygirrrl”) strake L.E.
- Original Length Canard

- Retractable Main Gear

(mandatory to have LW’s on COZY!)
(NP approved)

(per previous slide)

(NP mandatory to cut 6” from original – possible safety issue with rear CG, & rotation, but numerous flying)

(not recommended, but there are a few flying)

- **Minor:**

- Electric Nose Gear
- Electric Landing Brake
- Move Landing Lights
- Hanging Rudder Pedals (Velocity Style)
- Eliminate Fuselage Access Door
- Main Gear Leg Fairings
- Nose Wheel Doors
- Electronic Ignition
- Etc.

(NP approved)

(NP approved)

Performance Modifications



- Wheel Pants (size / design) - 8 to 12 kts
- Main Gear Leg Fairings - 3 to 5 kts
- Retractable Landing Gear - 0 to 20 kts
- Cowling/Cooling (airflow / boat-tail / exhaust) - 0 to 15 kts **potential**
- Nose Wheel Door - ?? (small)
- Winglet Intersection Fairings - ~1 to ~4 kts
- Spinner - 0 to 1 kts
- Electronic Ignition - 5% - 10% fuel efficiency

- Appropriate VG's (per **Mark Beduhn's** installation):
 - Decrease landing speed - 7 to 10 kts
 - Decrease top end speed - 1 to 3 kts

My Recent Modifications



Working from front to back:

- Replaced the nose skid
- Refabricated the nose strut cover
- Installed nose gear doors
- Refurbished the nose wheel (CG style)
- Rebuilt brake master cylinders
- Fabricated air seals around canard to work with removable canard cover
- Repositioned GPS antenna
- Removed vacuum instruments (AI and DG)
- Installed wiring harness for **Dynon** EFIS (no EFIS yet)
- Installed wiring for **Lightspeed** EI
- Installed fuselage side windows between strakes and IP
- Replaced all brake tubing with 5052 AL hard lines and braided SS/Teflon hoses (flex to Master Cylinders and down gear legs)
- Installed second rear seat vent
- Installed extra Emergency Fuse Bus on inside firewall
- Installed **Lightspeed** EI box on inside firewall
- Installed **Andair** High Pressure Fuel Pump on inside firewall (low)
- Fabricated gear leg fairings
- Fabricated gear leg/fuselage intersection fairings
- Refabricated gear leg/wheel pants fairings
- Had engine torn down and rebuilt bottom end
- Removed vacuum lines and pump
- Installed **Lightspeed** EI (crank sensor version)
- Installed **Airflow Performance** Fuel injection
- Refabricated engine baffling (1/2 or so - replaced many rivets with screws for maintainability, reinforced weak areas, etc.)
- Modified cowl to fit FI servo/fuel lines
- Peeled old paint and primer
- Recontoured whole plane
- Repaint whole plane (except cowling)
- Installed clickbond studs for all rudder/aileron attachments - no exposed screws

My Recent Mods - Pics



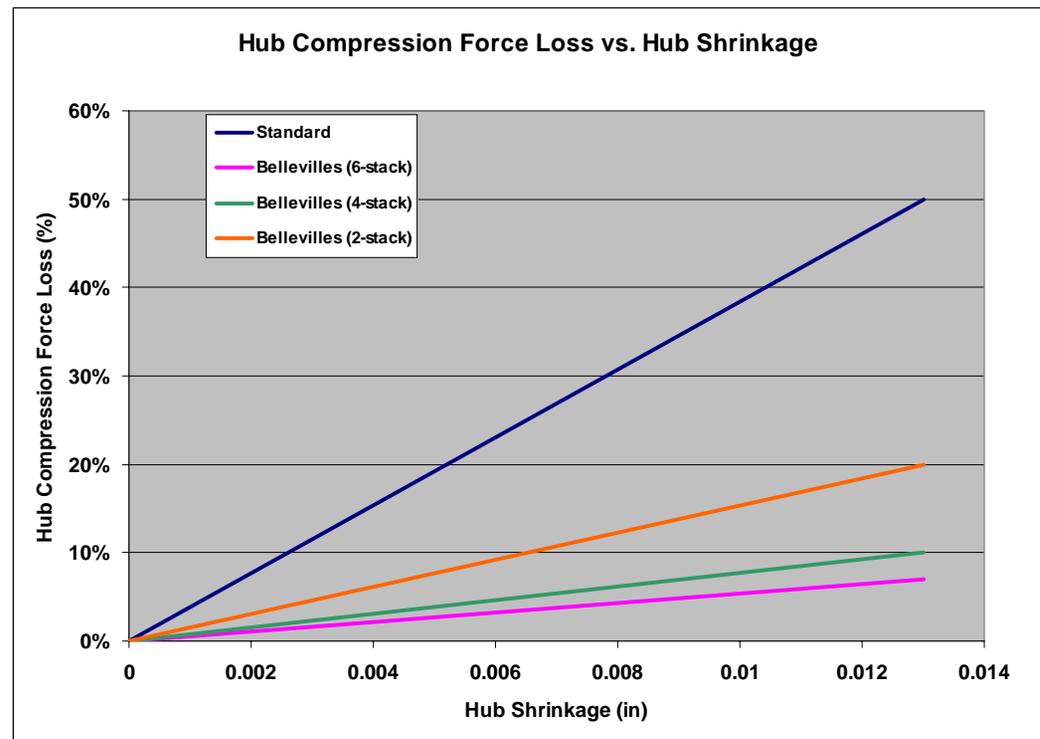
My Recent Mods - Pics



Belleville Washer Summary



- Prop Bolt issues
- Wood Props require lots of attention and maintenance
- Improper torquing / maintenance
- Need robust prop bolt solution for wood prop hubs
- Using Bellevilles eliminates need for retorquing



COZY Safety Record



- **NO** accidents caused by structural/aerodynamic failure of properly built and flown COZY aircraft – in fact, of **ANY RUTAN/DERIVATIVE CANARD**
- Since 1989, 25 total known COZY accidents - 18 reported accidents in USA, 1 in Canada, 1 in Mexico, 3 in France, 2 in South Africa

| • 8 Fatal Accidents | • 17 Non-Fatal Accidents |
|---|---|
| <ul style="list-style-type: none"> – Phase I <ul style="list-style-type: none"> • COZY MKIV - poor approach and hard landing – flip and burn 9/21/1994 - N151JE • COZY MKIV (turbine) - 1 Unknown cause – crash into water 5/4/2008 - N14GG – Phase II <ul style="list-style-type: none"> • COZY MKIV - low approach snagging wires 1/1/1995 - N5037 • COZY III – suspected prop fouling / open canopy in France 2001 - builder: Soria • COZY III - severe wind shear - Mexico 1/18/2002 - N41CZ • COZY Classic <improper build / CG problems?> in France 2004 - F-PSCF • AeroCanard - takeoff problem / probable prop fouling from open canopy 12/12/2007 - N199JW • COZY MKIV – Pilot error/intention at low altitude 7/24/2008 - N500K | <ul style="list-style-type: none"> – 4 engine / fuel system failure (clogged fuel strainer) (fuel contamination – hyd. Lines in tank) (fuel filter clogged) (LB extension - overheating) 5/7/1996 - N86LM 2/11/1997 - N34PC 5/30/2003 - N94WD 11/5/2008 - N637PS – 3 poor approach / landing 1/22/2003 - N96PJ 1/26/2003 - N320FR 11/15/2008 - N149CZ – 2 fuel exhaustion 2/25/1989 - N611CZ 12/2/2003 - N238CZ – 1 GU canard contamination / CG related 6/23/1995 - N84CZ – 2 deep stalls 10/4/1996 - N96PJ 4/17/2010 - N68TF – 1 canopy open/prop damage/emerg. landing 5/9/2010 - N144TJ – 1 rudder flutter (improper build) in France 2004 – 1 overtightened bolts and/or wheel pant tangled in wheel in South Africa – 1 poor takeoff / no rotation in South Africa – 1 Winglet problem in Canada? |

Accident **RATE** – **Assume** 112 flying (avg.), 60 hrs/yr (avg.), 19 years – 125K hrs total

- **6.4/100K** hrs **fatal** (4.8/100K w/o Phase I)
- **20/100K** hrs total
- GA is **1.26/100K** hrs
- GA is **6.32/100K** hrs

Safety Modifications/Issues



- **Flying/Landing Techniques / Judgment:**
 - Single largest factor – at least 1/3 of all COZY accidents – could be as much as 1/2
 - Under our control – must actively manage and learn
 - Gave presentation on “Judgment” at COZY dinner last year – available on web
- **Actual Issues:**
 - Nose Strut safety bolt – broken struts
 - Safety wire/hose clamp exhausts – broken exhaust through prop
 - Composite props (Catto/Hertzler) – MUCH more resistant to FOD than 100% wood props
 - Forward Hinge Canopy – have lost canard aircraft due to canopy opening upon takeoff and prop fouling – **FLY THE PLANE** (does prevent bailing out, but who flies with a parachute?)
 - Brake sizing / system components – have been fires, lost brake effectivity
 - Nose gear rigging (shimmy reduction)
 - Fuel contamination – follow Al Wick’s tank cleaning methodology (and don’t route hydraulic lines through gas tank)
 - Non-aircraft rated fittings/lines – “Walrus” custom canard aircraft burned a few weeks ago
- **Potential Issues:**
 - Roll bar – have been rollovers, but no injuries
 - Control System play – torque tube mounts / bolted joints
 - Other?

Futures / State of Design



- **Future of COZY:**
 - Very active community: plans sales still ~10-20/year
 - New completions all the time
 - Slow evolution of derivatives beginning
 - Chris Esselstyn's stretched retract
 - Other O-540 variants
 - Wider fuselages, etc.

- **State of Design Questions:**
 - Extremely well developed design/plans – however...
 - Official Builder Support?
 - Nothing now
 - If you believe so, tell ACS a paid position is needed and should be supported from plans/parts sales
 - Official Designer (qualifications)?
 - Who Approves Vendors/Parts?
 - Who Approves Modifications/Design Changes/Fixes?
 - How is Design Advancing?
 - Fits and starts
 - Randomly
 - Little good testing of mods, per Nat's example

- **MANY non-engineered mods occurring – VERY worrisome to me**

Questions? (& Answers)



- My Email: marc_zeitlin@alum.mit.edu
- Website: <http://www.cozybuilders.org/>
- Scaled is hiring engineers! I have cards if interested.