COZY AIRCRAFT FORUM

Soup to Nuts*?

Marc J. Zeitlin

July 29th, 2011

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***
  - ***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 – ~780 flying hours
- Started / Administer Unofficial COZY Builders Web Page and COZY Mailing List (~642 members)
- Work for Scaled Composites as Mechanical Engineer/Manager – Currently Lead Project Engineer for SS2 Rocket Motor (RM2) Design/Development/Testing

- As of May 1st, 2011, I provide **OFFICIAL** technical support for COZY aircraft to all builders, flyers and prospective builders

What's a COZY MKIV?

- Aircraft Type
  - Canard pusher – big wing in rear, small wing in front, engine in rear
  - 4 place, or 2+2, or 2 + LOTS of baggage
  - Efficient, fast, long distance cruiser

- History of the COZY MKIV
  - Designed by Nat Puffer as a derivative of Burt Rutan/RAF's Long-EZ
  - First as a side-by-side two seater in mid-80's
  - Next, added single rear seat (kept Long-EZ rear end, spar and wings)
  - Evolved from 3-place to current 4-place MKIV in early 1990's – rear end modified to be similar to Defiant landing gear/firewall structure; canard airfoil updated

- COZY/canard aerodynamics – Nat's 2005 Oshkosh Forum
  - http://www.cozybuilders.org/Oshkosh_Presentations/Nats_OSH2005_Presentation.pdf

Why a COZY MKIV?

- You want to **BUILD** an airplane
- Use-Model – your comparison indicates a COZY is the type of aircraft you want to fly – shouldn't be because "ooohhh, that's a cool looking plane"
- Economics – a COZY MKIV can be flown for less than renting a C-172 with fewer fuel stops in less time
- Carrying Capacity – you need more than 2 seats, or 2 seats and LOTS of baggage space
- Safety Features – you want a canard's stall/spin resistance
- Composites – you like the build materials

COZY Plans Availability

- Cozyaircraft Corp. owned by ACS since 2004
- Plans available through ACS

http://www.aircraftspruce.com

Vendor Display Building “A” 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!!! This means you can customize your spend rate, as well as what you spend money on. Cost control is completely up to you, your desires, needs, and ability to pay

COZY Support Methods

- **Official support from me (my contact info on last slide), afforded by ACS (thanks, Jim Irwin!)**

- COZY Newsletter archives
  - http://www.cozybuilders.org/newsletters/
- COZY Mailing List
  - http://www.cozybuilders.org/mail_list/
- **U**nofficial **C**OZY **B**uilders **W**eb **P**age (UCBWP)
  - http://www.cozybuilders.org/
- Canard Aviator's Mailing List
  - http://groups.yahoo.com/group/canard-aviators/
- CSA Newsletter (mandatory for all canardians)
  - http://www.cozybuilders.org/ref_info/other_news.html
- Freeflight Composites (Burrall Sanders)
  - http://www.freeflightcomposites.com/services.htm
- Other builder's web pages (links from **UCBWP**)

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 Noselift
    - http://www.eznoselift.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
- ~1650 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 – Neither did RAF for Long-EZ
  - 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

Bulkhead(s)

- 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

COZY Aircraft Structures (continued)

- August, 2011 **Sport Aviation** article by **Dick VanGrunsven** (designer of all RV aircraft) addresses overweight/overpowered aircraft – specifically an award winner RV-10 written up in Sport Aviation!

- A couple of quotes from Dick:

  – …Any "penciled in" gross weight increase is just wishful thinking. **The laws of physics are not repealed by wishful thinking.**

  – **WHO OWNS THE MARGIN?**
  It seems common practice among homebuilders to second-guess the factory engineers, particularly regarding gross weight increases. Because of all of the added features, empty weight creep erodes the aircraft's useful load. The simple solution for the homebuilder is to "pencil in" a new gross weight limit. "It's only 100 pounds (3.7 percent) more; how much eff ect can that possibly have?" Imagine this example: You are on a mid-size airliner with a gross weight of 270,000 pounds. Just before leaving the gate, the captain comes on the PA system and says: "We've overbooked more than usual today, so we're going to assume that the factory engineers over-designed this airplane and allowed an abundant safety margin. We're going to take off at 280,000 pounds instead. So move over, there are 50 more passengers coming on board." Run the numbers; it's the same over-weight ratio as simply pencilling in an additional 100 pounds to the gross weight of an RV-10.

  Along with gross weight increases, some builders take the same liberties with horsepower increases and speed increases, betting their lives on the assumption that the airplane is designed with a huge margin of safety—it is really far stronger than it needs to be. This is not really true. **Certificated aircraft, and well-designed kit aircraft, are designed to withstand limit loads at specified maximum weights. During testing, they are subjected to ultimate loads, which are higher than design limit loads by a specified margin. Yes, there is a margin between the design and ultimate strengths. But that margin belongs to the engineer. He owns the margin. It is his insurance against the things he doesn't know or can't plan for, and the pilot's insurance against human error, material variations, and the ravages of time.** Wise pilots respect this design safety philosophy and leave this insurance policy in effect by operating strictly within established limits.

- Emphasis in **red** MINE…

Flight Test Review

- **NOTE:**
  - 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
  - Your airplane is NOT identical to any other airplane on the planet, and even if it has the same name as 200 other aircraft, it needs to be flight tested as if it was the only one on earth

- **Purpose of Phase I Flight Testing period:**

  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)
  - Takeoff / Rotation performance / airspeeds
  - Climb/Cruise performance
  - Descent performance – gear/landing brake retracted, extended
  - Landing performance / airspeeds
  - Stalls / Accelerated stall (more than 1G – performed in 15, 30 45, 60 degree banked turns)
  - Deep stall susceptibility / resistance (at rear CG limit)
  - Pitch stability (stick fixed / stick free)
  - Lateral Stability (spiral, Dutch Roll, Roll/yaw coupling)
  - Flutter susceptibility (stick / pedal raps)

- **Performance Envelope Includes:**
  - Forward, Mid, Aft CG
  - Max Gross Weight (per placard), Middle Weights, Light Weights
  - Full, Mid, Low Fuel
  - Speeds from Vs (aft CG, min weight) to Vne+10%
  - Altitudes from SL to Service Ceiling (or max desired altitude)
  - **ANY AND ALL** maneuvers that may be attempted in Phase II
  - Phase II flight is restricted to flight envelope expanded in Phase I

Flight Test Review (cont.)

- **Flight Test Guidelines:**
  - **AC90-89A** – **EXCELLENT** FAA guide
  - **COZY POH** recommendations
  - **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 think you're done after 10-25 hours, you **haven't done enough testing!!**

- **CG Determination:**
  - CG is even more critical for canard aircraft, with relatively small CG ranges and deep stall susceptibility
  - Need **ACCURATE** empty CG – implies accurate weighing
  - Bathroom scales are **NOT** accurate enough – need/use 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

- **Flight Test Procedures:**
  - No friends, observers, family – only required test crew – don't need pressure to perform
  - Be ready to cancel **ANY** test and **ANY** flight for **ANY** reason if everything is not "just right" (weather, physical condition, aircraft readiness, airport issues, etc.)
  - Have a planned and practiced "test card" for each flight – plan **EVERY** flight completely – all actions and all coms – do not deviate except in an emergency
  - Start testing in **CENTER** of CG range
  - Start testing at light weights
  - Slowly add weight and move forward and aft within CG range
  - Start with mild maneuvers
  - Start with short flights – 20 - 30 minutes
  - Runway flights OK if have **LONG** runway
  - Gear stays down on first few flights – verify
  - Need to be able to hold airspeeds to within 1-2 kts.
  - Need to be able to hold altitude to within ~20 - 50 ft.
  - Need to document everything – take notes, record audio, run video camera – whatever works for you – you won't remember everything

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 – works in low compression Lycomings
- Alcohol – **MAY** be incompatible with epoxy lined tanks
- All have other unknown additives
- Check with fuel system MFG's before using

Diesel:

- One EZ flying (Bill Allen)
- Bio-Diesel
- Jet-A

Synthetic Fuels – in development

- Swift Fuel
- GAMI G100UL
- None available yet…

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
  - Used successfully many times
- Vinylester Resins
  - Used for underground fuel tanks, some prefab aircraft
  - Be careful with respect to epoxy compatibility and adhesion

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)
    - Also operate in canard's downwash – changes lift distribution and lowers effective AOA

- **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 (NP mandatory to have LW's on COZY!)
  - Raise Canopy (1" – 2") (NP approved)
  - Widened (Aerocanard "style") Canopy
  - Forward Opening Canopy, a-la Cosy Classic
  - Long-Eze type ("Cozygirrrl") strake L.E. (per previous slide)
  - Original Length Canard (**NP mandatory** to cut 6" from original – possible safety issue with rear CG, & rotation, but numerous flying)
  - Retractable Main Gear (not recommended, but there are a few flying)

- **Minor:**
  - Electric Nose Gear (NP approved)
  - Electric Landing Brake (NP approved)
  - Move Landing Light position
  - Hanging Rudder Pedals (Velocity Style) (might be a few flying)
  - Eliminate Fuselage Access Door (stop air/water leaks)
  - Main Gear Leg Fairings (drag decrease)
  - Nose Wheel Doors (stop air leaks; possible drag decrease)
  - Electronic Ignition (efficiency; fuel consumption; easier starts)
  - Etc.

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
- Replaced parking brake valve
- Fabricated air seals around canard to work with removable canard cover
- Installed fuselage side windows between strakes and IP – **HUGE VISIBILITY IMPROVEMENT!!!**
- Installed electric heated seats
- Installed second rear seat vent

- Repositioned GPS antenna
- Installed GPS connection bus
- Installed **Dynon** DSAB connection bus
- Removed vacuum instruments (AI and DG)
- Installed **Dynon** EFIS and wiring harness
- Installed **Dynon** Pitch autopilot servo
- Installed wiring for **Lightspeed** EI
- Replaced all brake tubing with 5052 AL hard lines and braided SS/Teflon hoses (flex to Master Cylinders and down gear legs)

- Installed extra Electrical emergency fuse bus on inside firewall
- Installed **Lightspeed Plasma III** EI box on inside firewall
- Installed **Andair** High Pressure Fuel Pump/Filter on inside firewall (low)
- Had engine torn down and rebuilt bottom end
- Removed vacuum lines and pump
- Installed **CG Products** air/oil separator
- Installed **Lightspeed Plasma III** EI (crank sensor version)
- Installed **Emagair** PMAG
- 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

- Fabricated gear leg fairings
- Fabricated gear leg/fuselage intersection fairings
- Refabricated gear leg/wheel pants fairings
- 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

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, 26 total known COZY accidents - 19 reported accidents in USA, 1 in Canada, 1 in Mexico, 3 in France, 2 in South Africa

- **8 Fatal Accidents**
  - **Phase I**
    - 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**
    - 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

- **18 Non-Fatal Accidents**
  - 5 engine / fuel system failure
    - (clogged fuel strainer) — 5/7/1996 - N86LM
    - (fuel contamination – hyd. Lines in tank) — 2/11/1997 - N34PC
    - (fuel filter clogged) — 5/30/2003 - N94WD
    - (LB extension - overheating) — 11/5/2008 - N637PS
    - (Gascolator install issue) — 5/20/2011 - N205TJ
  - 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** 120 flying (avg.), 60 hrs/yr (avg.), 20 years – 144K hrs total

- **5.6/100K** hrs **fatal** (**4.2/100K** w/o Phase I) – GA is ~**1.3/100K** hrs
- **18.1/100K** hrs total – GA is ~**6.3/100K** hrs

Safety Modifications/Issues

- **Flying/Landing Techniques / Judgment:**
  - Single largest factor – at least 1/3 of all COZY accidents
  - Under our control – must actively manage and learn
  - Gave presentation on "Judgment" at COZY dinner in 2009 – available on COZY builders web

- **Mechanical/Other 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** (**FHC** 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 June, 2010

- **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 ~20-40/year (per Jim Irwin)
  - New completions all the time
  - Slow evolution of derivatives
    - Chris Esselstyn's stretched retract
    - FHC popularity
    - Other O-540 variants
    - Wider fuselages, etc.

- **State of Design Questions:**
  - Extremely well developed design/plans – however…
  - Official Builder Support in "Test" phase
  - 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 – <u>VERY</u> worrisome to me**

Questions? (& Answers)

- My Email: marc_zeitlin@alum.mit.edu
- My Phone: (978) 502-5251

- Website: http://www.cozybuilders.org/

- Scaled is hiring engineers! Talk to me / send resume' if interested