

Flight Testing & Checklists

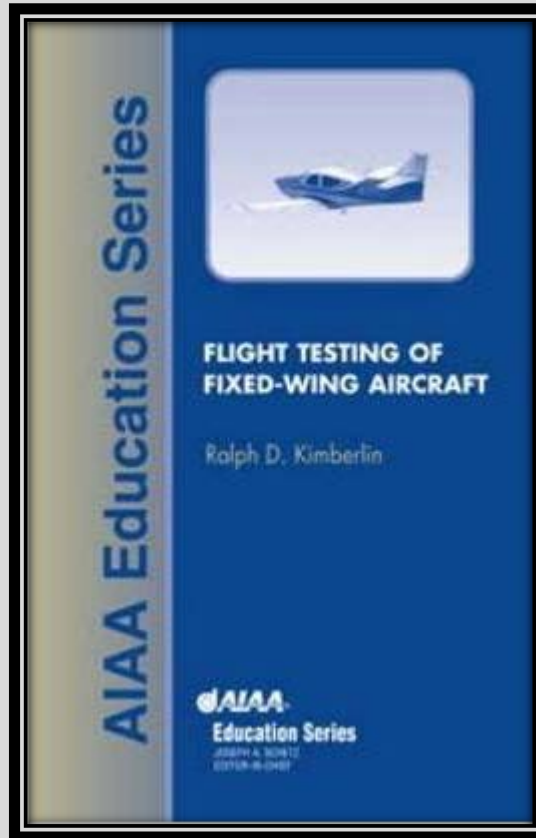
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2/16/2018

To Do List

- 1) Make to do list ✓
- 2) Check off first thing on to do list ✓
- 3) Realize you've already accomplished ~~2~~ things ✓
- 4) Reward yourself with nap (in progress)

Additional Reference – *Flight Testing of Fixed-Wing Aircraft*, Ralph Kimberlin



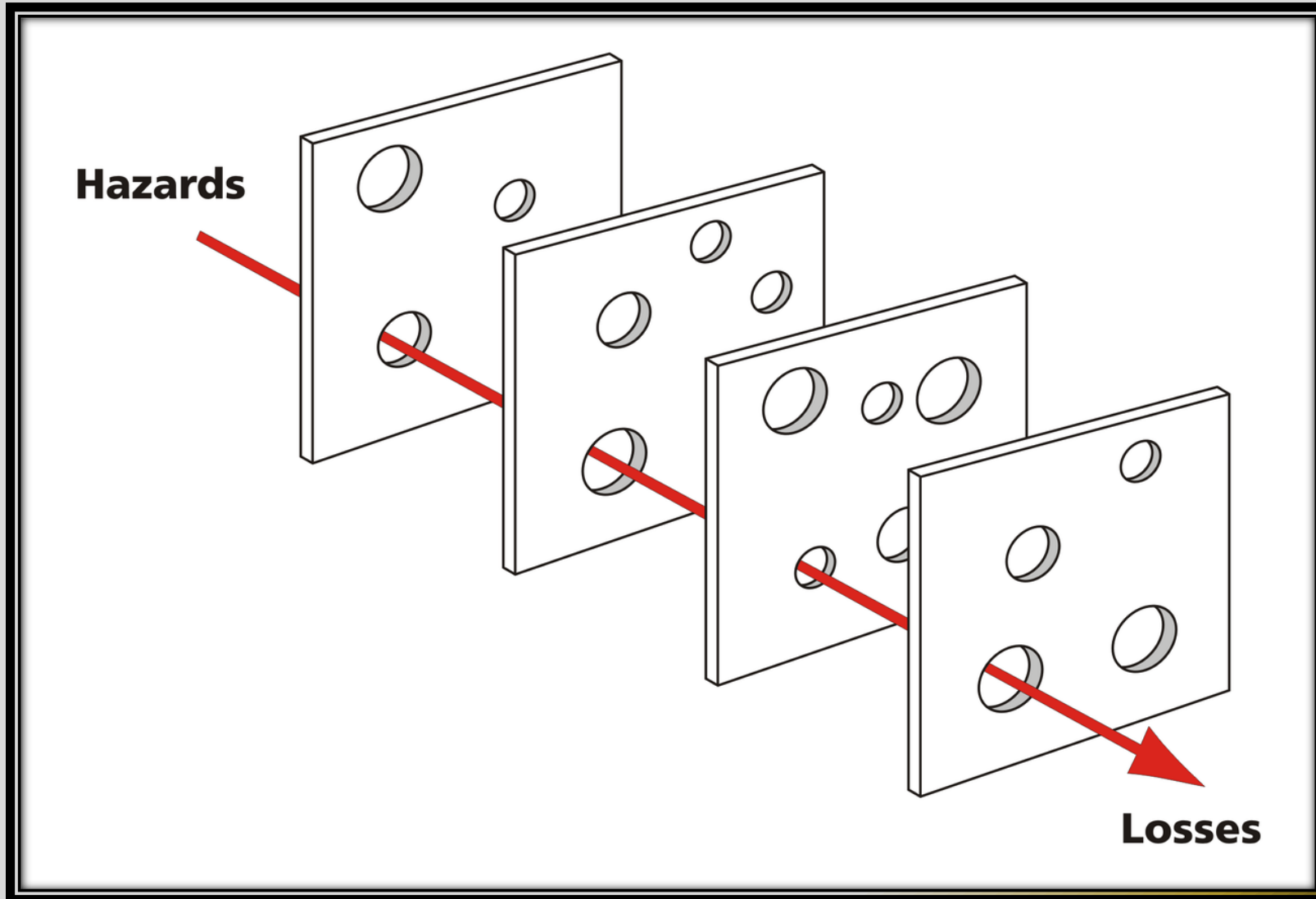
Topics

- Safety
- Operating Limitations
- Regulations
- Briefing
- Pre-Flight Checklist
- In-Flight Checklist
- Post-Flight Checklist
- Debriefing

Safety

- Maintain safety for EVERYONE involved
 - Pilot
 - Ground crew
 - Spectators
 - Bystanders
- Set up safety procedures *and follow them*
- No one person is in charge of safety during testing: everyone must be aware of what is happening
- “Swiss cheese” model
 - Several seemingly small events lead to major loss

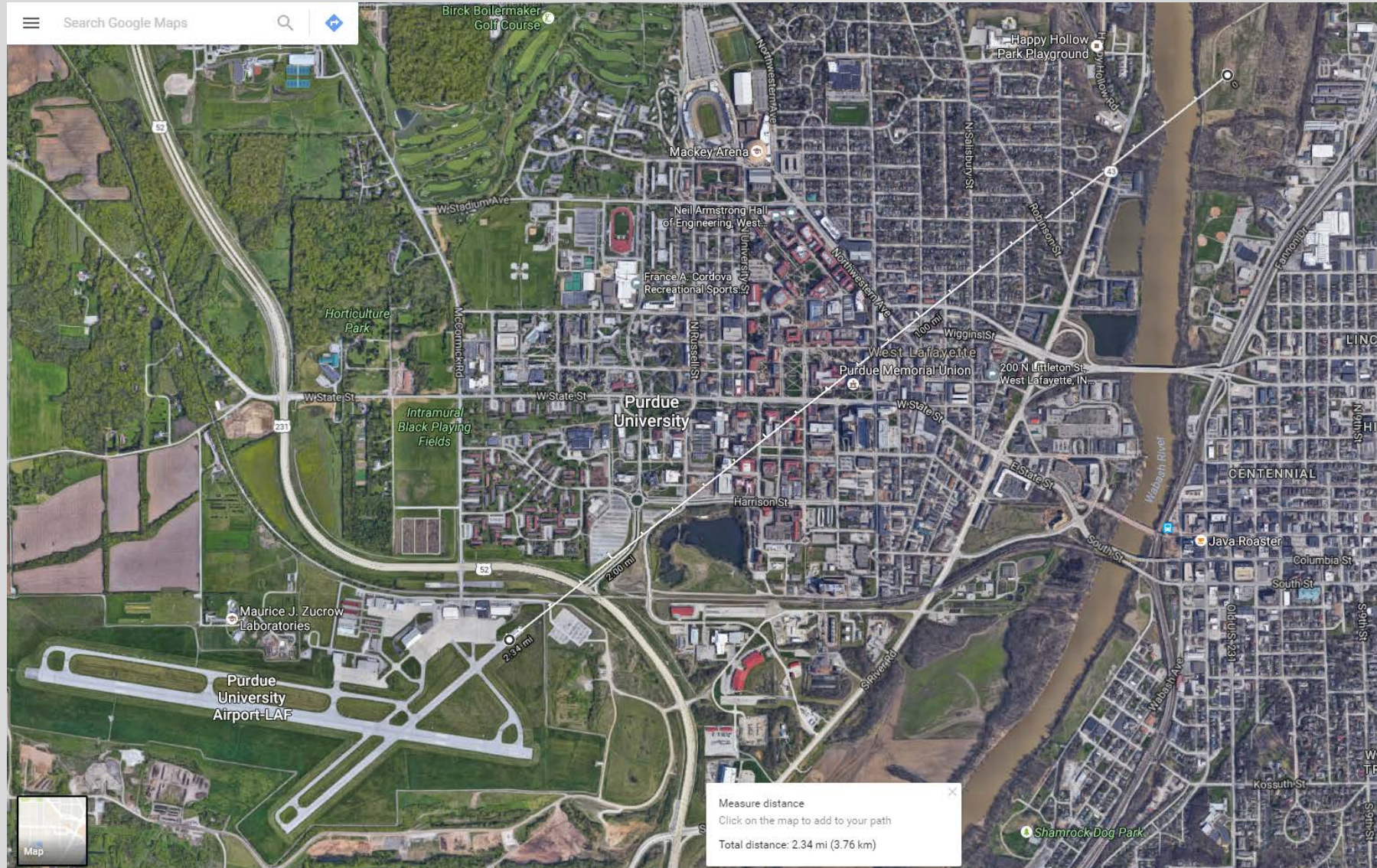
Safety



Safety

- Maintain situational awareness
 - Other people may be flying with you
 - An extra set of eyes is always helpful
- [AMA Safety Code](#)
- [Flight Test Safety's Best Practices](#)
- Absolutely must maintain sufficient clearance from manned aircraft
 - For UAS: FAA-mandated maximum of 400 ft AGL
 - Example: at the local AMA field, 400' AGL puts only 300 feet in between our aircraft and aircraft on glideslope for RW 23 at KLAF
 - If the manned aircraft is 1° below glideslope, that clearance is down to about 100 feet

Safety



Operating Limitations

- Intrinsically related to the safety of the operation
- Often driven by weather or other physical factors
 - Cloud ceiling
 - Temperature limits
 - Can be an aircraft or a pilot limitation
 - Wind speed/direction
 - Visibility
 - Battery voltage
 - Did you bring a tool kit?
- Develop a GO/NO-GO decision tree for testing based on your operating limitations

Regulations

- Federal
 - [FAR Part 107](#)
- State or local legislation
- Community-Based Organization
 - [Academy of Model Aeronautics](#)
 - Provides insurance and other services
- Local club
 - Often have their own safety rules for specific sites
- Land owner



Procedures

- Step-by-step of each segment of testing, from beginning to end
 - One action per step, e.g.
 1. Ensure prop arc clear
 2. Insert safety plug
 3. Verify correct ESC tone output (verify # battery cells)INSTEAD OF
 1. Power up propulsion system
 - Checklist format is nice
- If you have one person create procedures, have another verify and offer corrections/improvements
- Likewise, have a second person verify all checklist items during test execution

Procedures

- Pre-flight procedures ensure you will be ready to fly at the field
 - There will be snow on the ground (in Indiana anyway...) at some point
- Procedures for flight are broken down by maneuver
 - Traditionally called “cards” as the pilot would have them on a kneeboard in the aircraft
 - For UAS flight testing:
 - All or most data acquired on-board
 - Have a teammate tell the pilot what maneuvers are to be flown and with what parameters
 - Airspeed tolerances, altitude tolerances, power settings, etc.
 - Live data on the ground makes this easy
 - Once autopilot control gains are known, may be able to automate some tests
 - Pilot input is valuable to assessing the performance

Briefing



Briefing

- Discuss with team what will happen during flight
- Build list of extra items to take that are not already on a “Things to take flying” checklist
- Assign jobs
 - Video
 - Hand-written notes
 - Spotter
 - Etc.
- Walk through checklists

Example Checklist

- Small GA aircraft
- IC engine – not all steps applicable
- Notice breakdown of steps
 - Line-by-line
 - Single item per line
- Generally verbalize “Preflight checklist complete” after completing that section
 - “Before start checklist complete” ... etc.

Piper PA28-161 Warrior

PREFLIGHT		WHILE TAXIING		CRUISE	
CERT/DOC	ON BOARD	BRAKES	CHECK	POWER	2300 RPM
Mx LOG	CHECK	D.G.	CHECK	AT	AS REQUIRED
TACH/HOBBS	RECORD	T.C.	CHECK	MIXTURE	LEAN AS REQ'D
PARKING BRAKE	AS REQUIRED	VOR	CHECK	D. SEL	CYCLE 6-12
CONTROL LOCK	AS REQUIRED			DESCENT	
MAGS	OFF			MIXTURE	AS REQ'D
MIXTURE	LEAN	GROUND CHECK		CARB HEAT	AS REQUIRED
CB's	IN	BRAKES	SET	AF'S	RECORDED
ALT STATIC AIR	NORMAL	THROTTLE	2000	EXT LIGHTS	ALL ON
BATT MASTER	ON	ENGINE INST	CHECK	FUEL SEL	PROPER TANK
FUEL QUANTITY	CHECK	VACUUM	CHECK		
ANNUNCIATORS	ON	ALTERNATOR	TEST	BEFORE LANDING	
LIGHTS	CHECK	MAG CHECK	MAX DROP 175	APP BRIEF	COMPLETE
PITOT HEAT	CHECK		MAX DIFF 50	MIXTURE	FULL RICH
BATT MASTER	OFF	CARB HEAT	ON	CARB HEAT	AS REQUIRED
FLAPS	DOWN	THROTTLE	IDLE	FUEL PUMP	ON
EXTERIOR	USE POH	CARB HEAT	OFF	AUTO PILOT	OFF
		THROTTLE	800-1000	AIR SPEED	65 - 75 KIAS
BEFORE STARTING ENGINES		BEFORE TAKEOFF		AFTER LANDING	
BRAKES	SET	RADIOS	SET	FLAPS	UP
FLAPS	UP	D.G.	CHECK	TRANSPONDER	STBY
CHOCKS	REMOVED	ANNUNCIATORS	TEST	CARB HEAT	OFF
AVIONICS MSTR	OFF	MIXTURE	FULL RICH	FUEL PUMP	OFF
AUTO PILOT	OFF	ELEC. FUEL PUMP	ON	BEACON	REMAINS ON
PAX BRIEF	COMPLETED	ENGINE INST	CHECK	EXT LIGHTS	AS REQUIRED
SEATS/SEAT BELT	ADJUSTED	CARB HEAT	OFF	PITOT HEAT	OFF
ALL ELECTRICAL	OFF	CB's	IN	MIXTURE	LEAN AS REQ'D
CARB HEAT	OFF	SEAT BELTS	FASTENED	SHUTDOWN	
FUEL SELECTOR	FULLEST TANK	DOOR/WINDOWS	LATCHED	PARKING BRAKE	AS REQUIRED
		FLAPS	SET	AVIONICS MSTR	OFF
		TRIM	SET FOR T.O.	ELECTRICAL	OFF
		CONTROLS	FREE/CORRECT	THROTTLE	800-1000
		DEP BRIEF	COMPLETE	MAGNETOS	GROUND CHK
		PARKING BRAKE	OFF	THROTTLE	1200 / 10 sec
		TRANSPONDER	ALT	MIXTURE	CUTOFF
		EXT LIGHTS	ALL ON	THROTTLE	IDLE
		D.G.	CHK ON RWY	MAGNETOS	OFF
				BEACON	OFF
		TAKEOFF		FLIGHT PLAN	CLOSE
		THROTTLE	FULL OPEN	BATT MASTER/A	OFF
		ENGINE INST	CHECK	TACH/HOBBS	RECORD
		ROTATE	52 KIAS	LDG GEAR	CHECK
		INITIAL CLIMB	63 KIAS	PARKING BRAKE	RELEASE
		TRANSITION Vy	79 KIAS		
				KLAF FREQUENCIES	
PRE-TAXI		ENROUTE CLIMB		ATIS	127.75
RADIOS	SET	AIR SPEED	76 - 87 KIAS	TOWER	119.60
TRANSPONDER	STBY	MIXTURE	AS REQUIRED	GROUND	121.90
CLOCK	SET	FUEL PUMP	OFF	FSS	122.35
AIR SPEED	ZERO	EXT LIGHTS	AS REQUIRED	CHICAGO CTR	123.85
ATTITUDE INDICATOR	ERECT			UNICOM	122.95
ALTIMETER	SET				
D.G.	SET				
VSI	NOTE				
MIXTURE	LEAN AS REQ'D				

Example Checklist #2



SEABOARD WORLD AIRLINES 747F

NORMAL OPERATING CHECKLIST

BEFORE STARTING

- INS 3 CKD/ALIGN
- O₂ & INTERPHONE ON 100% CKD/BOOM
- STATIC SOURCE SEL NORMAL
- ANTI-SKID ON
- BODY GEAR STEERING ARM
- AUTO BRAKE LDG-OFF
- COMPASS CONTROLLERS SLAVED
- EMERGENCY LIGHTS ARMED
- SEAT BELT, NO SMOKE ON
- ALT FLAPS OFF
- STALL WARNING TEST/NORMAL
- MACH A/S TEST
- NACELLE & WING ANTI-ICE OFF
- PROBE HEAT PITOTS ONLY
- WINDOW HEAT ON
- EXTERIOR LIGHTS SET
- RADIO INS SWITCH RADIO
- NAV RADIOS/AUTO FLT PANEL CKD/SET
- GROUND PROX TEST
- FLT MODE ANNUNCIATORS TEST
- FLT INSTR/FLT DIR/ALTS CKD/TEST/SET
- RADIO ALT TEST
- RESERVE BRAKE CKD/CLOSED
- LDG GEAR DOWN/GREEN
- SPEED BRAKE FWD DETENT
- THROTTLES/START LEVERS CLOSED/CUTOFF
- PARK BRAKE SET/PRESS CKD
- SELCAL/RADAR & TRANSPONDER SET/STBY
- ELECTRICAL PANEL SET
- OIL QUANTITY NORMAL
- FUEL QTY/GROSS WT LBS/SET
- FIRE WARNING TEST
- WT & BALANCE LBS/%
- ANTI SKID GROUND MODE TEST
- FLT RECORDER TEST/SET

PRIOR TO PUSH BACK/START

- INS 3 NAV
- BEACON ON
- HYDRAULICS #1 ADP/#4 ELEC PUMP ON
- DOORS CKD/LTS OUT
- EVAC SLIDES LATCHED & AUTO
- FUEL BOOST PUMPS ON

• REQUIRED AT TRANSIT STATIONS

BEFORE TAXI

- START ARM SWITCH OFF
- ELECTRICAL POWER SET
- APU BLEED CLOSE
- HYDRAULICS AUTO/NORMAL/QTY CKD
- SEAT BELTS & SHLDR HARNESS ON
- GEAR & NOSE STEER PINS REMOVED/CKD
- GROUND EQUIPMENT DISCONNECT/CLEAR

TAXI CHECK

- NACELLE ANTI-ICE SET
- FLAPS GREEN LIGHTS/DETENT
- CONTROLS CKD
- STAB & TRIM THREE SET
- TAKE OFF DATA CKD/SET
- FLT & NAV INSTRUMENTS X-CKD/SET
- ALTITUDE SELECT SET
- APU SHUT DOWN
- CARGO HEAT NORMAL
- FUEL HEAT OFF

- FUEL SYS SET/MAIN BOOST PUMPS ON
- IGNITION FLT START
- ANNUNCIATOR LIGHTS CKD
- AIR COND SET

BEFORE TAKE OFF

- LANDING & STROBE LIGHTS ON
- TRANSPONDER ON
- AUTO BRAKE ARM
- BODY GEAR DISARM

CLIMB

- LANDING GEAR UP & OFF
- FLAPS UP-LIGHTS OUT
- PROBE HEAT ON
- NO SMOKE OFF
- IGNITION SET
- FUEL SCHED SET
- AIR COND SET

TRANSITION LEVEL CHECK/OR/18,000 FT

- LOGO & LANDING LTS OFF/10,000'
- ALTIMETERS RESET

DESCENT

- IGNITION FLT START
- SEATBELTS/SHLDR HARNESS & SIGN ON
- FLT MODE ANNUNCIATORS TEST
- GROUND PROX TEST
- RADIO ALT TEST/2000
- RADIO INS SWITCH RADIO
- PRESSURIZATION SET
- HYDRAULIC SYSTEMS CKD/NORMAL
- FUEL MANAGEMENT SET FOR LANDING

FAA APPROVED
9/1/77

18,000 FT/OR/TRANSITION LEVEL CHECK

- ALTIMETERS SET/X-CKD
- LANDING DATA SET
- LANDING & LOGO LIGHTS ON/10,000'

APPROACH

- FLAPS GREEN LIGHT/DETENT
- ADF/VOR SWITCHES SET
- RADIO ALT MDA/DH SET
- NACELLE ANTI-ICE SET
- FUEL SYS MAIN BOOST ON/HEAT OFF
- NO SMOKE ON

BEFORE LANDING

- LANDING GEAR DOWN-GREEN LIGHT
- AUTO BRAKE SET/LT OUT
- SPEED BRAKE ARM
- FLAPS SET
- FLAG SCAN OM-500' CALL OUT

AFTER LANDING

- BODY GEAR STEERING ARMED
- SPEED BRAKE DOWN/DETENT
- FLAPS UP/LTS OUT
- LDG LTS & STROBE LIGHTS SET
- IGNITION OFF
- RADAR & TRANSPONDER OFF
- STABILIZER TRIM 5 SET
- BRAKE TEMP & HYDRAULICS CKD
- ANTI-SKID GROUND MODE TEST
- UPPER DECK & CARGO HEAT OFF
- FIRE WARNING TEST
- APU START

PARKING

- PARKING BRAKE SET
- APU OR EXTERNAL POWER CONNECTED
- START LEVERS OFF
- SEAT BELT OFF
- PROBE HEAT/WINDOW HEAT OFF
- EXTERIOR LIGHTS SET
- EMERGENCY EXIT LIGHTS OFF
- INS RECORD 3/OFF
- HYDRAULIC AIR PUMPS OFF
- WT & BAL POWER SW ON
- FUEL BOOST PUMPS OFF
- FUEL RESERVE VALVES CLOSED
- STANDBY POWER SWITCH OFF
- RADIO MASTERS SET
- FOR TERMINATING FLIGHTS-----
- OXYGEN VALVE CLOSED
- APU SET
- BATTERY SET

Pre-Flight Checklists

Why do they exist?

- Get team and aircraft ready to fly
- Make sure nothing is missing...
- Ensure systems functioning nominally



Pre-Flight Checklists

- Before leaving base (Armstrong Hall, etc.)
 - Take flight box
 - Take plane
- Upon arrival at flight field
 - Unload components
- Before powering up
 - Visual inspection
 - Control surfaces
- Powering up
 - Plug in battery

Pre-Flight Checklists

Exercise:

- As teams, create a first draft for your team's pre-flight checklist (only pre-flight right now)
 - Google docs is fine
 - Be specific!
- 5 minutes to work, then quick 1-minute presentation from each team
- Discussion and thoughts from other teams/coaches

[Timer](#)

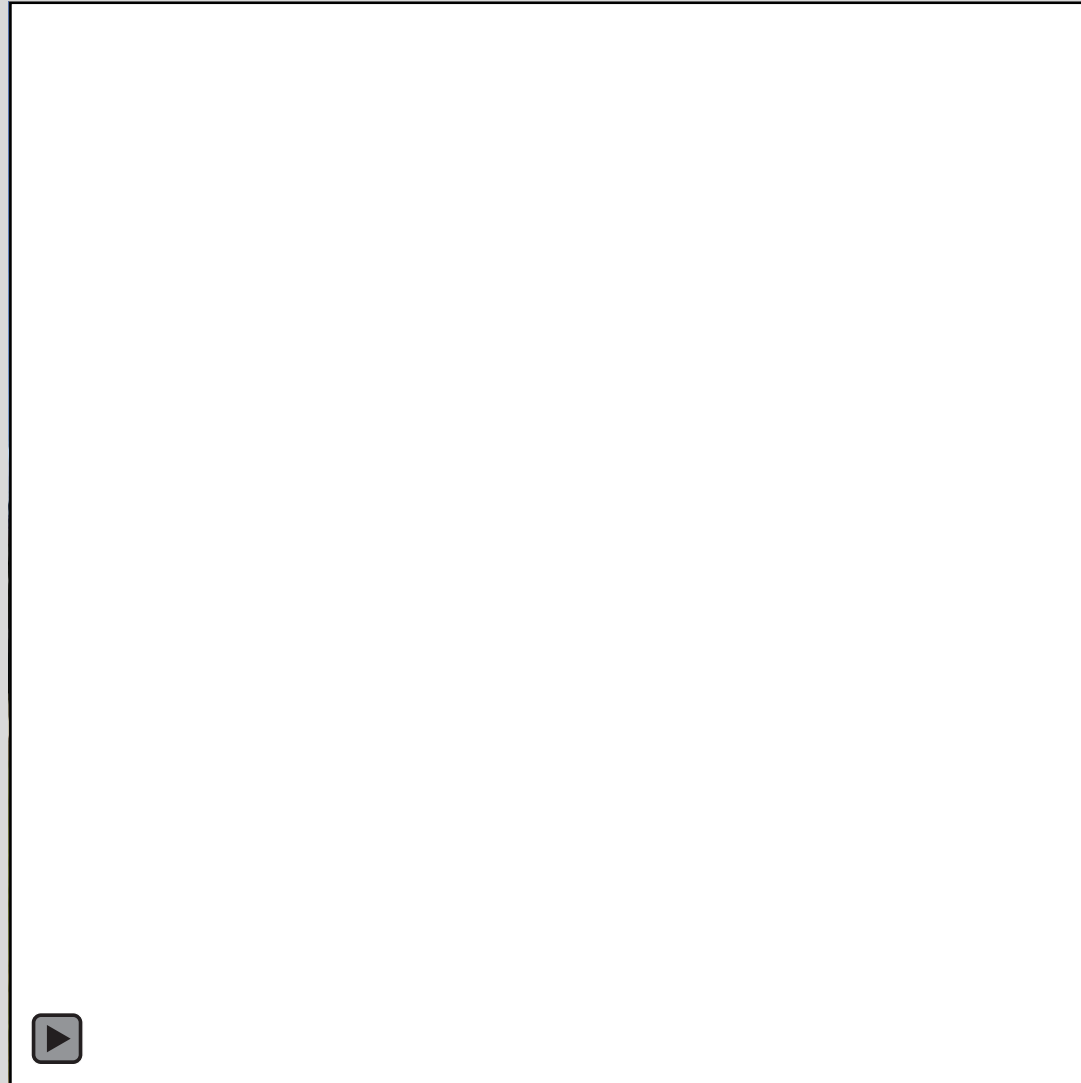
In-Flight Checklists

Why do they exist?

- Perform the tasks you want to perform in the way you want them performed
- Remove guess work in a fast-paced phases of flight
 - “Do I flip the switch now? I thought I was supposed to do X first”
- Ensure some performance value is being met
 - E.g. every 5 minutes, check battery voltage/% capacity remaining
- Make sure aircraft is in the correct configuration...

In-Flight Checklists

Example of a missed checklist item...



In-Flight Checklists

- Climb out – Manual Mode
- Climb out – Auto Mode
- Cruise – Manual Mode
- Cruise – Auto Mode
- Before Landing – Manual Mode
- Before Landing – Auto Mode

In-Flight Checklists

Exercise:

- As teams, create a first draft for your team's in-flight checklist (only in-flight right now)
 - Google docs is fine (new tab from earlier one works well)
 - Be specific!
- 5 minutes to work, then quick 1-minute presentation from each team
- Discussion and thoughts from other teams/coaches

[Timer](#)

Post-Flight Checklists

Why do they exist?

- Ensure safety of team
- Ensure safety of spectators
- Prepare aircraft for disassembly/transport/another flight



Post-Flight Checklists

- Disarm System
- Safe System
- Remove battery
- Download logs
- Secure components



Post-Flight Checklists

Exercise:

- As teams, create a first draft for your team's in-flight checklist (only post-flight right now)
 - Google docs is fine (new tab from earlier one works well)
 - Be specific!
- 5 minutes to work, then quick 1-minute presentation from each team
- Discussion and thoughts from other teams/coaches

[Timer](#)

Debriefing

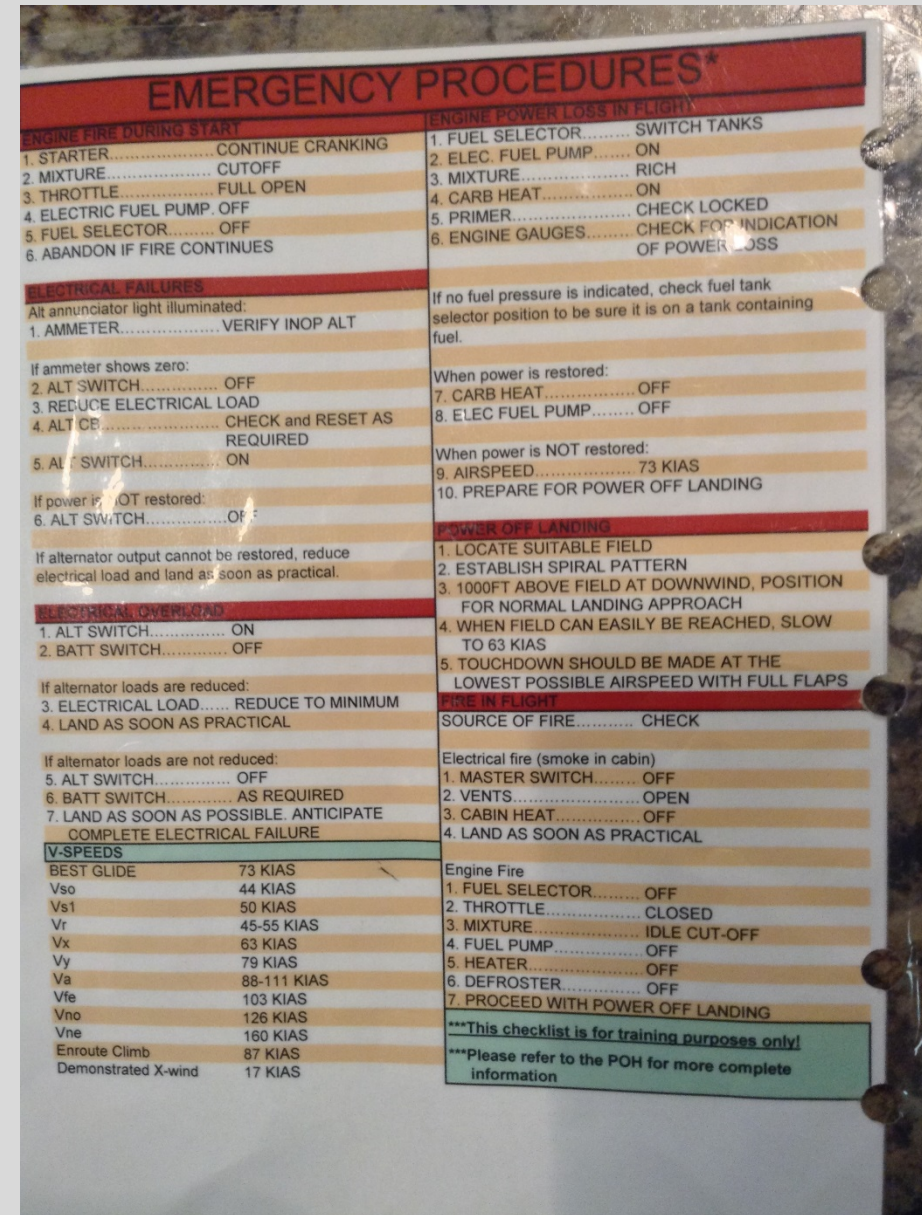
- Wrap-up of what went well
 - And what did not
- Assign next tasks (hopefully not repairs)



One more example checklist

Emergency Procedures

- Not much to be done for a lot of in-flight emergencies for R/C aircraft
 - But regaining control from an erroneous autopilot is possible!
- Crash debris recovery procedures should be put in place
 - LiPo batteries need monitored
 - Motors may still spin



Mission Planner's Pre-Flight Feature



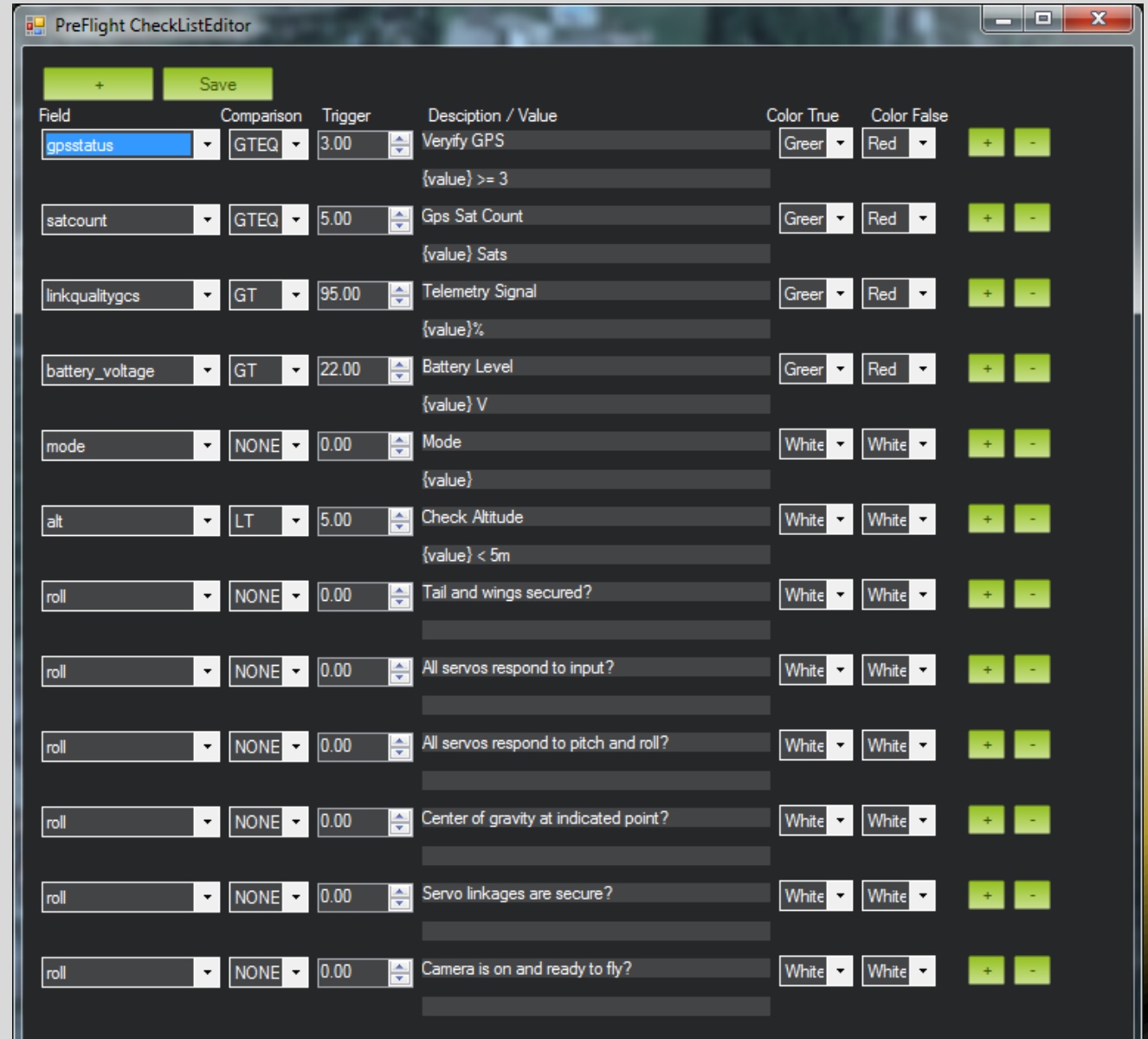
Quick Actions PreFlight Gauges Status Servo Telemetry Logs DataFlash Logs Scripts Messages

Edit

Verify GPS	0 >= 3	<input type="checkbox"/>
Gps Sat Count	0 Sats	<input type="checkbox"/>
Telemetry Signal	0%	<input type="checkbox"/>
Battery Level	0 V	<input type="checkbox"/>
Mode	Unknown	<input type="checkbox"/>
Check Altitude	0 < 5m	<input checked="" type="checkbox"/>
Tail and wings secured?		<input type="checkbox"/>
All servos respond to input?		<input type="checkbox"/>
All servos respond to pitch		<input type="checkbox"/>
Center of gravity at indicated		<input type="checkbox"/>
Servo linkages are secure?		<input type="checkbox"/>
Camera is on and ready to fly?		<input type="checkbox"/>

Mission Planner's Pre-Flight Feature

- Very customizable – add any parameter and trigger level
 - Battery voltage
 - % capacity remaining
 - Geofence
 - Etc.
- Add items that are not inherently part of the Pixhawk
- Add as many lines as you want



Questions?