STRATOSPHERIC REMOTE SENSING FROM THE M55 "*GEOPHYSICA*"

CEOI-ST Airborne Workshop
ATC (Royal Observatory), Edinburgh
2015-10-07

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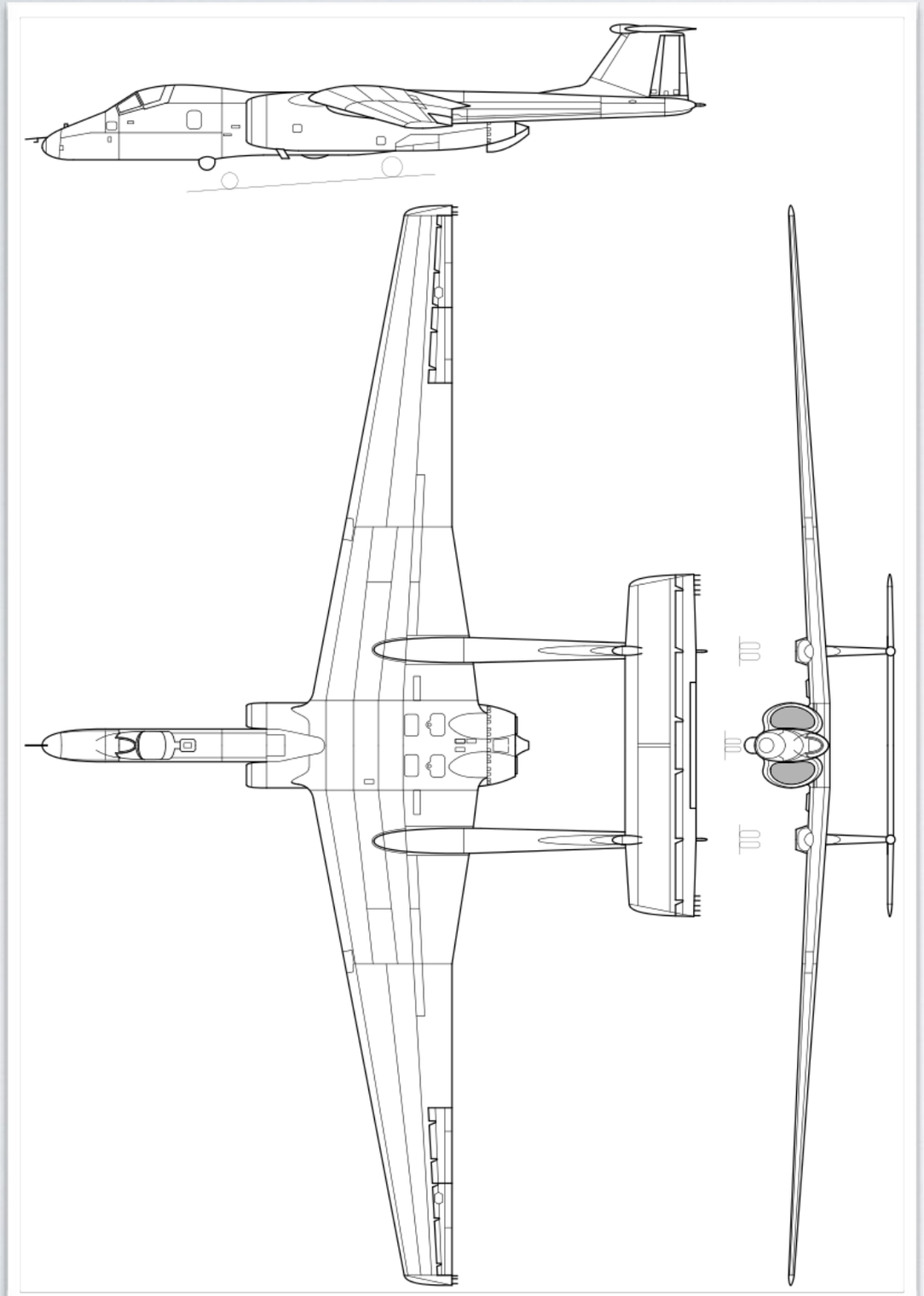
HISTORY OF THE M55 GEOPHYSICA

- 1950-60: USA use stratospheric reconnaissance balloons over Russia (jet stream)
- 1978: *Subject 34:* stratospheric fighter to shoot down balloons, but prototype crashed in snow storm
- Spy satellites and Lockheed SR 71 make stratospheric fighter concept obsolete
- 1982: M-17 *Stratosphera* reconnaissance aircraft. Repurposed for science (Antarctic ozone hole 1992). Set 12 FAI world records and still holds 5.
- 1988: M-55 *Geophysica* twin turbojet engines. Increased takeoff weight. Set and holds 15 FAI records.
- Plans to use M-55 as a platform for digital communication over South Asia

Source: Wikipedia

TECHNICAL SPECIFICATIONS M55



Crew: 1 (M-55UTS: 2)
Length: 22.867 m (75 ft 0 in)
Wingspan: 37.46 m (122 ft 11 in)
Height: 4.8 m (15 ft 9 in)
Wing area: 131.6 m^2 (1,417 sq ft)
Aspect ratio: M-55:10.6
Empty weight: 13,995 kg (30,854 lb)
Gross weight: 23,400 kg (51,588 lb)
Max takeoff weight: 23,800 kg (52,470 lb)
Fuel capacity: T-8V aviation jet fuel 7,900 kg (17,400 lb) initially, 8,300 kg (18,300 lb) later
Powerplant: 2 × Soloviev D-30-V12 low bypass turbofan, 93.192 kN (20,950 lbf) thrust each

Maximum speed:
332 km/h (206 mph; 179 kn) at 5,000 m (16,000 ft)
750 km/h (470 mph; 400 kn) at 20,000 m (66,000 ft)
Range: **4,965 km** (3,085 mi; 2,681 nmi)
Endurance: **6.5 hours** at 17,000 m (56,000 ft)
Service ceiling: **21,500 m** (70,538 ft)
Maximum glide ratio: ca 30:1 engine off
Time to altitude: 21,000 m (69,000 ft) in 35 minutes
Take-off distance: 900 m (3,000 ft)
Landing distance: 780 m (2,560 ft)

Data from The Osprey Encyclopedia of Russian Aircraft 1875 - 1995

MANAGEMENT AND ACCESS

- Aircraft owned and operated by Myasishchev Design Bureau (MDB), based in Zukovsky (Russia)
- EEIG formed in 2002 to coordinate flight activities between the scientific community and MDB
- Under EEIG, part of EUFAR fleet for a short while
- EEIG dissolved in 2006, MDB get a new “director”
- Forschungszentrum Jülich and Karlsruhe Institute Technology (KIT) now liaise directly with MDB on a case by case basis

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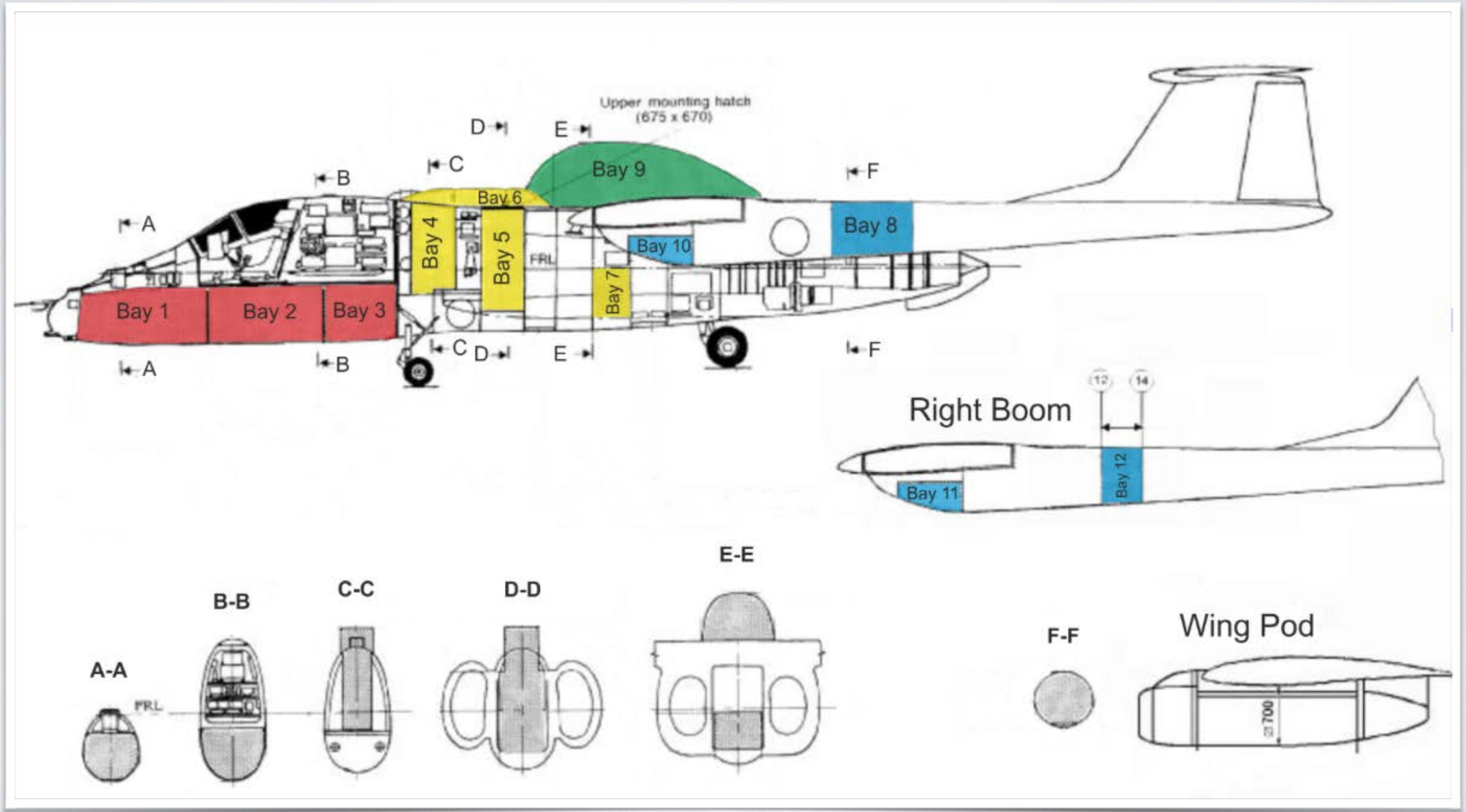
SCIENTIFIC ACTIVITY

- APE-POLECAT 1996/97 (Rovaniemi, Finland)
- APE-THESEO 1999 (Seychelles)
- APE-GAIA 1999 (Ushuaia, Antarctica)
- APE-INFRA 2002/03 : TROCCINOX, ENVISAT, EUPLEX
- ENVISAT validation 2002/03 (Arctic, including one NERC flight)
- EUPLEX 2003 (Arctic)
- TROCCINOX 2004, 2005 (Bauru, Brasil)
- EUFAR transnational access flights 2005 (Burkina Faso)
- SCOUT-O3 2005/06 (Darwin, Australia)
- AMMA 2006(Ouagadougou)
- RECONCILE/Premier-Ex 2010 (Kiruna, Sweden)
- ESSENCE 2011 (Kiruna, Sweden)
- StratoClim 2016 (India?)

Science campaign currently every 3-4 years (2-8 flights
Test campaign 6 months ahead of science campaign (1-2 flight

LOCATION OF INSTRUMENT BAYS

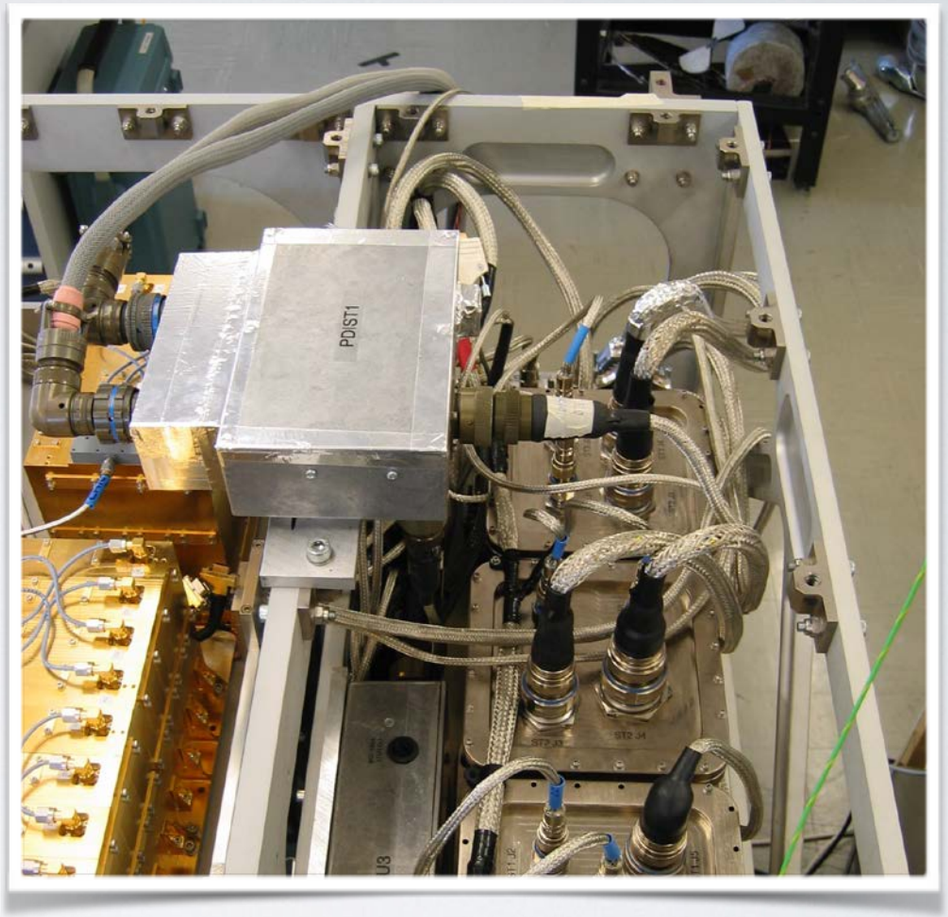


BAY CAPACITIES AND PAYLOAD

				Payload Configuration			
				In Situ		Remote Sensing 1	
	Bay	Volume m³	max. Weight (kg)	Name	Weight (kg)	Name	Weight (kg)
Under Cabin Bay	#I	2,052	360	CHIWIS/ STRATOMAS		GLORIA	276
	#II	1,963	430	ERICA		MARSCHALS	
	#III	1,135	100	MAS		MAS	
Fuselage Bay	#IV	0,315	60	FISH		FISH	
	#V	0,600	80	WAS		WAS	
	#VI	0,580	25	MAL-UP		MAL-UP	
	#VII	0,380	30	MAL-DOWN		MAL-DOWN	
Boom Bays	#VIII	0,558	80	HAGAR, COPAS 1/2		HAGAR, COPAS 1/2	
	#X	0,240	30				
	#XI	0,240	30				
	#XII	0,120	30				
Dorsal Bay	#IX	3,300	300	CHIWIS/ STRATOMAS, AMICA, COLD		MIPAS?	
Under Wing Pylon			30				
Under Wing Pod left		0,865	300	HALOX		HALOX	
Under Wing Pod right		0,865	300	SIOUX		SIOUX	
Total Weight (kg)			2185		0		0

INTERFACES

- Power through military spec plugs (procured through MDB, but expensive)
- Aircraft housekeeping data (UCSE): Time, pressure, temperature, airspeed, attitude (i.e. roll), etc.
- Pilot control interface (extremely basic, i.e. shutter on/off at agreed altitude)



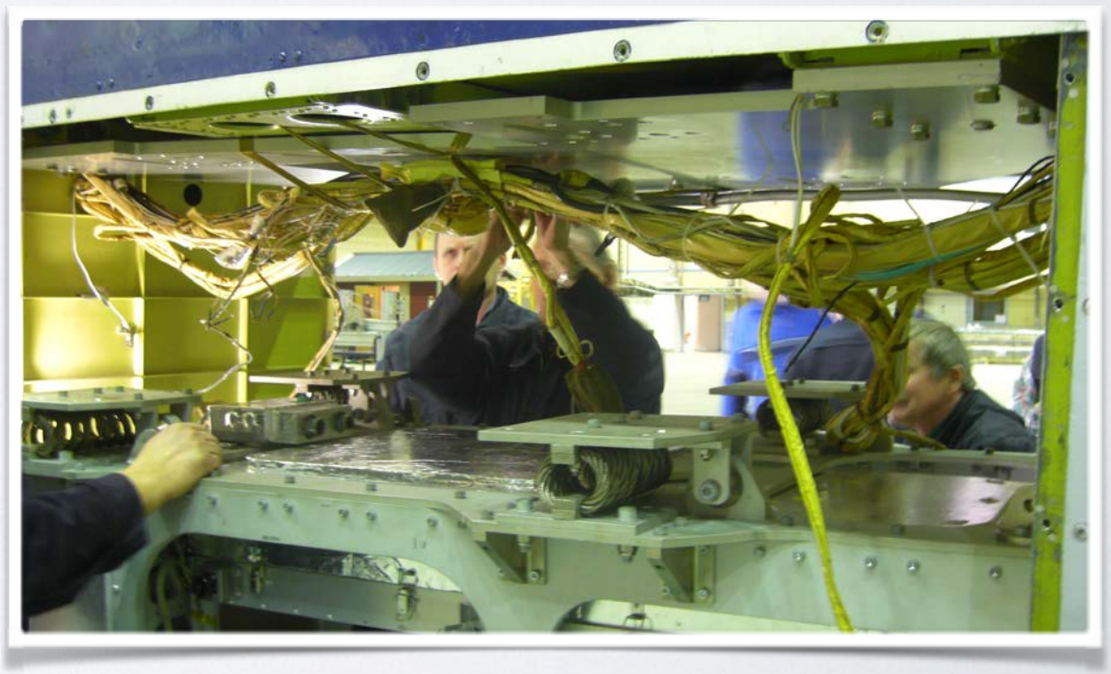


Photo: Peter Preusse (FZJ

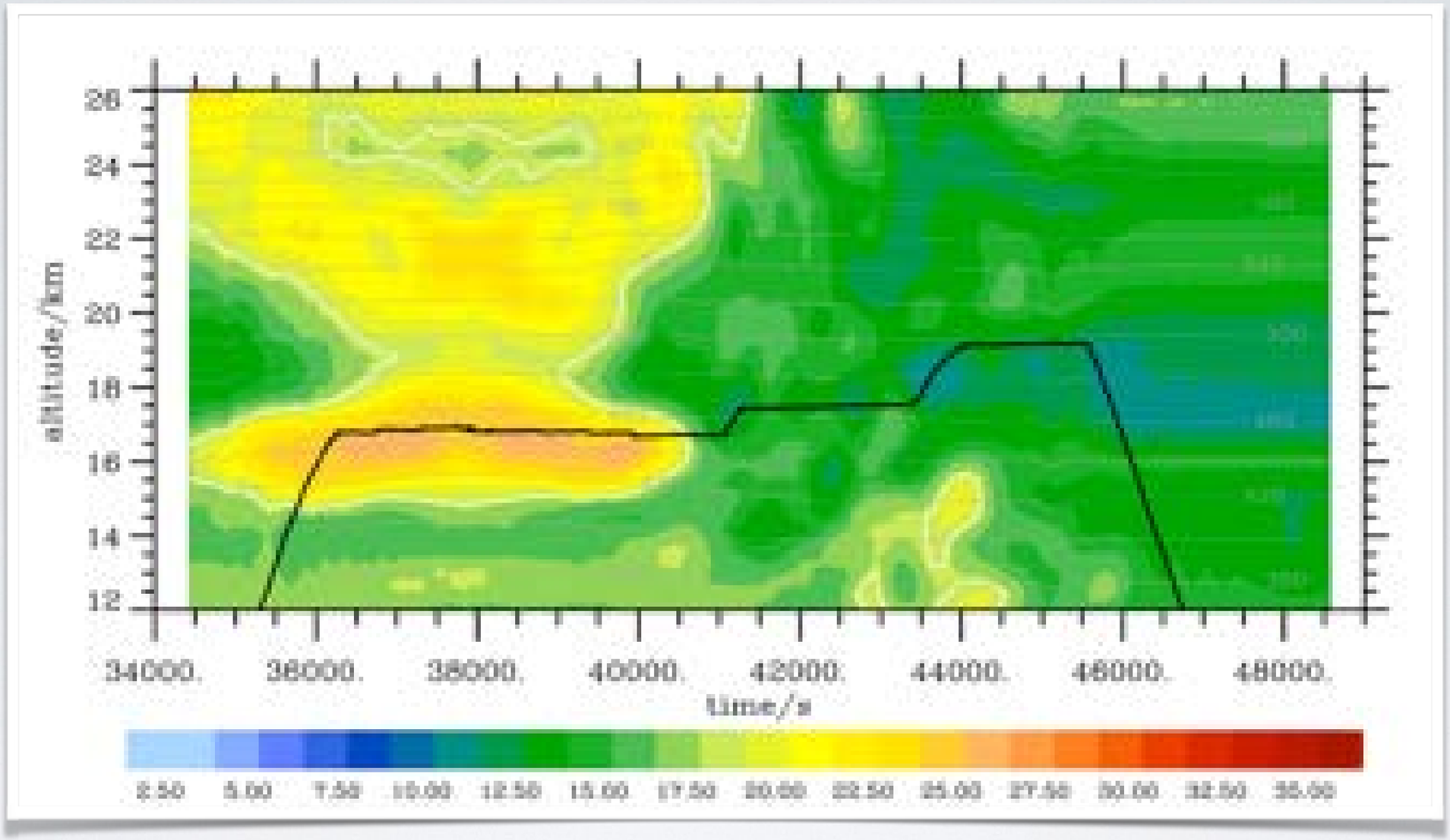
STRENGTHS OF THE M-55

- Military registration means it’s easy and cheap to modify or include additional instruments
- High ceiling altitude allows stratospheric science and simulation of satellite observation capabilities
- Unmatched payload capacity for stratospheric aircraft, which means:
- Comprehensive payload (lots of correlative measurements on each flight!)
- Cheapest stratospheric platform (1 Flight = €40k)
- It’s Russian, so every problem can and will be fixed (albeit with a screwdriver and crowbars)

DRAWBACKS OF THE M55

- Military registration means restricted overflight permissions and restricted choice of airbases (in combination with lack of collision warning system)
- Pilot doesn’t speak English means trouble with air traffic controllers (banned to fly at Munich in 2009)
- Age of aircraft means technical failures start to multiply (engines reaching end of life; inadequate avionics, collision evasion system, transponder; tyres blow when landing on ice, i.e. ESSENCE 2011)
- Mix of remote sensing and in-situ payload makes flight planning… interesting
- Sparse documentation (i.e. power surges during engine startup)
- No access outside of campaign operations
- Uncertainly of future availability (Telecom platform)

EXAMPLE FLIGHT PROFILE



- Endurance with full payload: max. 4.5 hours
- Ceiling increases as fuel is spent (17 km to max. 19.5 km)

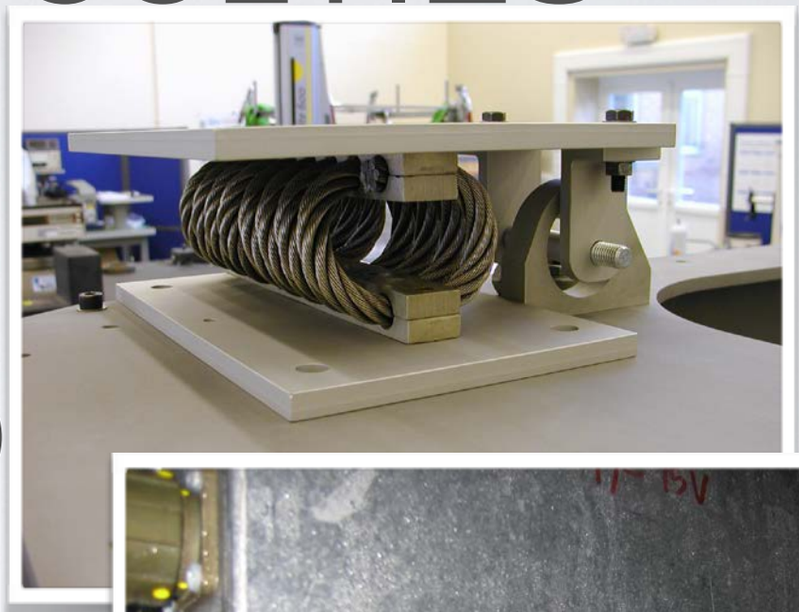
SCHEDULE OF A TYPICAL FLIGHT

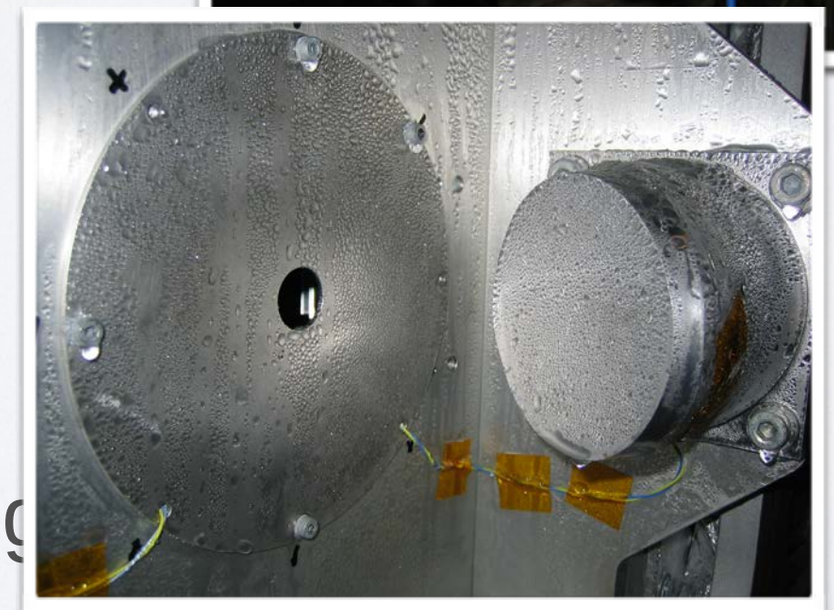
- T0 - 72h: Start flight planning
- T0 - 24h: Final flight plan to pilot
- T0 - 6h: Start instrument preparation
- T0 -1.5h: Hands off, cowlings on
- T0 - 1h: Roll out
- T0 - 0.5h: Roll-out and MIPAS calibration
- T0 : Take off
- T0 + 4.5h: Touch down
- To + 5h: Aircraft back in hangar
- T0 + 6h: Acces to instruments

Min. required instrument autonomy is 6 hours!

SOME EXPERIMENTAL DIFFICULTIES

- Vibration!
- Cold and Humidity (-90 to +40 Celsius in 20 minutes)
- “Dirty” engine power (voltage cuts out on engine start)
- No data downlink
- No pilot interaction
- Lack of access for testing





HALO

- New German research aircraft http://www.halo.dlr.de
- More frequent flight opportunities and direct access
- Longer flight duration (exceeding 10,000km or 10 hours)
- Not a true stratospheric platform (ceiling 15 km)
- Long lead time for new instruments (currently 2 years)


Photo: Erik Kretschmer (FZ