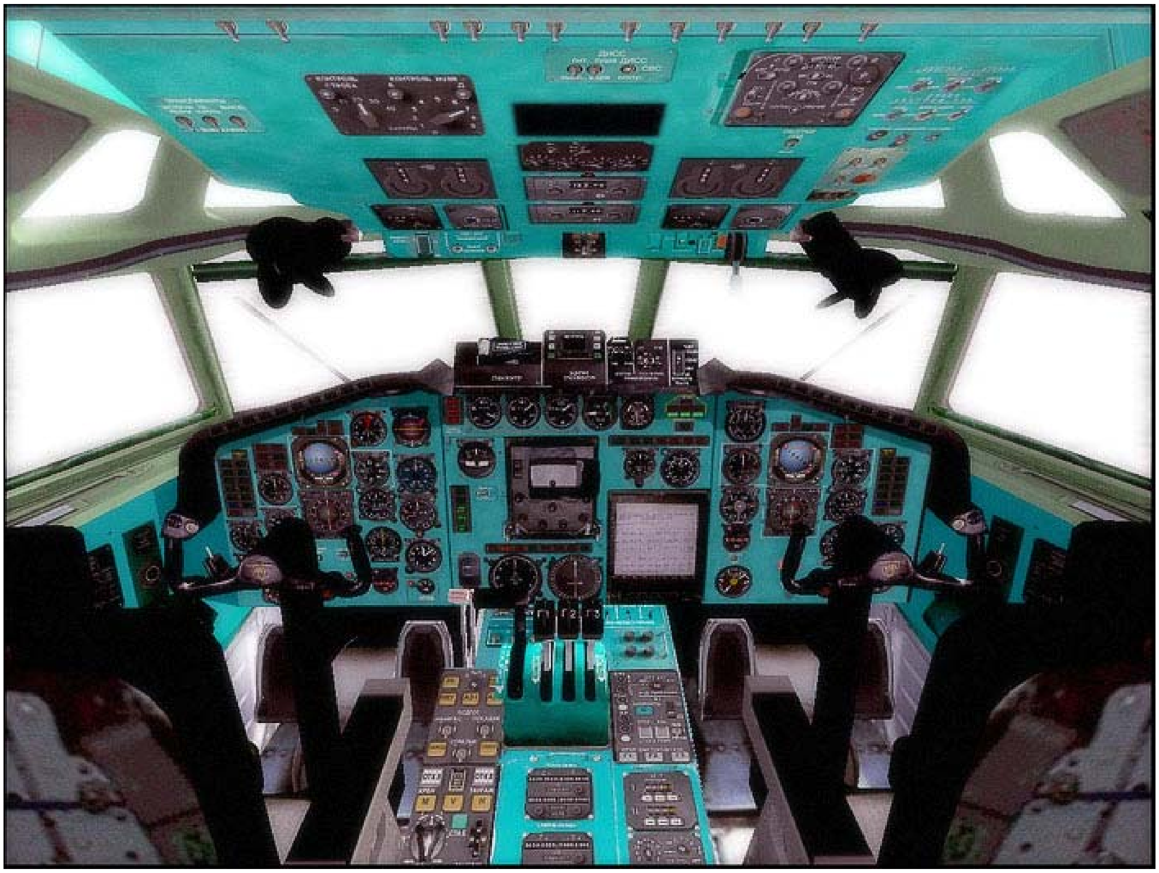
Project Tupolev



Tupolev Tu-154B2

English manual

Contents :

Introduction :

Welcome to one of the most advanced Jet Airliner simulation ever created for Microsoft Flightsimulator. You are only around 165 pages away from the very advanced operation of the backbone of Russian commercial aviation – the Tupolev Tu-154, here simulated in the B2 variant with Kuznetsov NK-8-2U engines.

Take place in the Captains seat, fly the plane and enjoy the outstanding flight dynamics. The custom Joystick routine not only recreates that special “heavy” hydraulic feel, the Project Tupolev team did not stop at other Microsoft limitations. You will notice e.g. the custom elevator trim/stabilizer handling, switchable nosewheel steering modes, authentic reverse thrust, a custom Autopilot, the PA-56 control system, and much more. Let the virtual Navigator take care of the navigation along the route.

Or take the fascinating Navigator job yourself down to the smallest detail. Operate the unique TKS-P2 compass system and navigate “the Russian way” with the domestic NVU navigation. It’s all up to you.

This manual is based on Version 9.4.x. All versions can be found at the Project Tupolev site – http://www.protu-154.com

Liveries, utilities and a lot of other documentation in Russian language can also be found at the Project Tupolev Website.

The Cyrillic designation of the systems, instruments and switches are left unchanged in this tutorial. That way the recognition effect in the panel is much better. To further enhance that, I strongly recommend to learn the Cyrillic characters. Everytime you press a switch, think in your mind which system you operate ! That considerably enhances the fun in the long run, although it might seem difficult at first.

Learning this advanced plane takes a lot of time. And patience. Rome has not been build in one day. Also an Airliner Captain has not yet been “build” in one day ☺

And now – have fun on the way to your virtual Tu-154B2 type rating ...

1. Installation

Start the installation by double clicking the Project Tupolev V9.4 installation exe file. Specify whether you want to install in FS 2002 or FS 2004 by pointing the installer to your FS 2002 or FS 2004 main directory.

After installation, you'll find icons on your desktop for the Loadeditor and the NVU Calculator .

In flight simulator, you'll find the Aircraft in the Aircraft folder listed under ANTK Tupolev.

Further steps :

1. Make sure you have an entry for fssound.dll in the [OLDMODULES] section in your fs9.cfg. If not, please add the following two lines in your fs9.cfg :

[OLDMODULES]
fssound.dll=1

If you can't locate your fs9.cfg use the Search function in Windows Explorer to find it. Just as an example for english Windows XP : The fs9.cfg should be located in the following folder : C:\Documents and Settings \<your username>\Application data\Microsoft\FS9.

Please do not use another version of fssound.dll than the one provided in the Project Tupolev package, it might lead to incompatibilities.

2. If you don't have a registered version of FSUIPC, go to START -> Programs -> Project Tupolev Tu-154 B2 -> install notes and follow the instructions.
Skip this step if have a registered FSUIPC !

Animations for the visual model :

Door : Shift - E
APU door : At APU start (currently FS2002 only)
Landing Lights extension/retraction : with corresponding switch (main panel, switch 103, see below)
Engine replenishment Inlets : open automatically at high temperature and high AOA

2. General airplane data

2.1. Geometrical data

wing span	37,55 m
length	48,0 m
height	11,4 m
maximum fuselage diameter	3,8 m
wing sweep (1/4 profile chord)	35^o
wing area	201,45 m^2
wing dihedral.	-1^{o}10 ’
mean aerodynamic chord	5.285 m
angle of wing setting	+3^o
horizontal tail scope	13.4 m
horizontal tail area	40,55 m^2
vertical tail area	31.72 m^2
angle of elevator deviation	
- upwards	29^o
- downwards	16^o
angle of aileron deviation	20^o
angle of rudder deviation	25^o
wheel track	11.5 m
longitudinal landing gear wheel base	18.92 m
max. Cabin width	3.58 m
max. Cabin height	2.02 m

2.2. LIMITATIONS

maximum taxi weight		98500 kg
maximum take-off weight		98000 kg
maximum landing weight		78000 kg
maximum zero fuel weight		72000 kg
maximum fuel weight	(fuel density of 0.8 g/cm^3)	39750 kg

limitations for take-off and landing

Maximum allowable winds

a) tailwind		10 m\s
b) crosswind (angle 90^o to runway)	- for dry runway	17 m\s
	- for wet runway	5 m\s

allowable airplane center-of-gravity positions

Extreme forward	- on take-off	21 % CoG (CAX)
	- on landing	18 % CoG (CAX)
Extreme backward		32 % CoG (CAX)

Flying the airplane with a center-of-gravity position to 40 % CoG at a take-off mass up to 80 t and AFCS working only in a wheel mode, flight altitude should not exceed 10200 m.

Speeds and Mach numbers

(1) maximum operating speed
- 600 km/h at altitudes from ground up to 7000 m
- 575 km/h at altitudes from 7000 m up to 10300 m
- M = 0.88 at altitudes more than 10300 m

(2) computational speed limit
- 650 km/h at altitudes from the ground up to 7000 m
- 625 km/h at altitudes from 7000 m up to 10300 m
- M = 0.95 at altitudes more than 10300 m

(3) maximum speed of flight with flaps extended

- angle 15°	420 km/h
- angle 28°	360 km/h
- angle 45°	300 km/h

(4) maximum speed at landing gear extension/retraction (normal operation): 400 km/h

(5) maximum speed of flight at deviation of center spoilers not limited

(6) maximum speed of flight at rearrangement of stabilizer position	425 km/h
(7) maximum speed of flight at completely rejected slats	425 km/h
(8) speed of flight at headlights extension of headlights, no more than	340 km/h

Usage of ВСУ (APU) in flight:

(1) maximum altitude on for ВСУ operation	4000 m
(2) maximum altitude on for ВСУ start	3000 m
(3) maximum speed of flight with working ВСУ	525 km/h

3. Basic Panel Operation

To get the panel in the correct state, load the default Cessna first, shutdown engines, set the Master switches and avionics switches to off and then load the Project Tupolev ANTK Tu-154B2.

1. **Captains panel**. Main operation panel. All additional panels are optimized in size and arrangement to work inside the Captains panel. Transfer to Captains panel from Copilot or Flight engineer panel is done with the “Space” key.

2. **Copilot panel**. Located in the back/right/up view. Can be opened using Ctrl-NUMPAD**3** (with NUMLOCK switched OFF). If the Ctrl key is released before the “3” key, the view remains fixed. A mouse clickspot to open the Copilot panel from the Captains Panel is provide on the right centerpost.

3. **Flight engineer panel**. Located in the back/up view. Same method as for Copilot panel, just CTRL-NUMPAD**2** instead of CTRL-NUMPAD**3**. A mouse clickspot to open the Copilot panel from the Captains Panel is provide on the middle centerpost.

4. **Overhead panel**. Located in the ahead/up view. Same operation as above, just CTRL-NUMPAD8 is used. The Overhead Panel is also available as additional panel using SHIFT-4, but in that case it blocks the externel view. Depending on the situation, it might be convenient to use the overhead panel and keep the external view, that’s the reason for this panel incl. a set of basic flight instruments. A mouse spot to open this panel is located on the top of the screen on the post to the left of the nosegear switches.

Additional Panels :

1. Shift-1 : Checklists. A clickspot is provided on the upper left Autopilot mode/warning lights board.
2. Shift-2 : РУД Panel. Besides РУД (thrust levers) it contains the basic Autopilot (АБСУ) control panels. A clickspot is provided on the upper left icons.
3. Shift-3 : НВУ Panel. Main НВУ Navigation control. A clickspot is provided on the upper left icons.
4. Shift-4 : Overhead panel.
5. Shift-5 : Copilot HSI (ПНП).
6. Shift-6 : КМ-5 panel, used for correction mechanisms
7. Shift-7 : Joystick service panel.
8. Shift-8 : virtual navigation assistant.
9. Shift-9 : internal НВУ calculator panel.
10. СПУ transponder panel. Can only be activated by mouse using clickspot on the lights panel above the speed indicator.

3.1. Special features regarding panel control

Mouse functionality : The right mouse button is widely used for instrument control. The right mouse button fulfils two functions :

1. On the ТКС, НВУ panels, the ПНП (HSI) and in some other cases the left mouse button is used for slow parameter changes, while the right mouse button provides rapid changes.
2. The right mouse button is used to open switch covers, often used in the flight engineer panel.

4. Description of main instrument panels

4.1 Main Panel (Captains panel)

Mouse Clickspots

A	Subpanel Switcher – Autopilot, HBY, Main panel
B	Autopilot Parameter panel
C	Load/Save Flight
D	Flight Engineer Panel
E	Copilot Panel
F	Checklist panel
G	Transponder Panel
H	Overhead (includes Transponder, different than Shift-4 Key)

101. switch to enable the nosewheel steering modes
102. switch nosewheel steering mode between 10 deg (takeoff and landing) or 63 deg (taxi)
103. switches to control the landing and taxi lights (upper switch – extension/retraction, lower switch to select between landing lights (up) and taxi lights (down)
104. Flaps lever
105. Pointer operating mode (VOR / ADF).
106. Backup emergency gear extension switch (protected with cap)
107. Main gear lever
108. manual Stabilizer handle
109. Stabilizer handle (depending on colour coded CoG zone)
110 toggle switch for aileron trim
111 toggle switch for rudder trim
112. test/control button for signal light system
113. clock АЧС-1М. A clickspot near the center synchronizes FS2004 time to system time.
114. various Autopilot (АБСУ) mode indicators (see Chapter 7.4. for details)
115. various warning indicators (e.g. speed limit, exceeded angle of attack, G-overloads). Transferred from Copilot warning panel.
116 various failure lights, incl. “not ready for takeoff” and “fire warning”
117. e.g. bank limit, terrain warning indicators. See page 90 for detailed description of the signal lights.
118. Indicated airspeed indicator УС-И-6. The red index refers to commanded speeds for the Autothrottle system. With Autothrottle switched off, the index is slaved to the actual speed.
119. Mach Indicator УМ-1, feeded from the СВС system (system of air signals).
120. External air temperatur indicator ТНВ-15, shows True Air Temperature (TAT). Based on airflow and speed dependent.
121. Left Attitude Director indicator (ADI , ПКП)
122. Left Horizontal Situation Indicator HSI (ПНП)

123. Angle of attack and G-Load indicator УАП-12 from the АУАСП system. The instrument memorises achieved G-Loads. A clickspot in the center of the instruments resets memorized G-Loads.
124. Vertical speed indicator BAP-30.
125. Metric Altimeter УВО-15, feeded from the CBC system. The pressure input for the CBC system can be only made from here, not from the copilot panel.
126. Radio Magnetic indicator ИКУ-1 , controlled from the compass system TKC-1 and Course system Курс-МП-2.
127. Turn coordinator ЭУП (electrically driven)
128. Radar altimeter PB-5M.
129. Altimeter УВИД-15, indication in feet. This electrical device is independent from the CBC system.
130. Distance measuring indicator ИДР-1 (DME).
131. Selection of device for the ИДР-1 (DME). It differs a bit from the real plane. In the real plane the indicators are independent and have their own panels for different frequency input. Due to the limited channels in the simulator the indicators are blocked from the Course system Курс-МП. The Курс-МП system is the Russian equivalent to VOR navigation and has been added for international flights. It was decided to use one channel for the Russian short range Navigation System PCБH. The switch 131 toggles betwen DME-1, DME-2 and PCБH.
132. Turbine rpm. Main engine control instrument. It shows N2 rpm. On Russian aircraft thrust settings are given in N2 percentage !
133. Stabilizer and elevator position indicator.
134. Flaps position indicator
135. Landing Gear status indicator .
136. Leading edge Flaps retracting lights
137-138 . various Flaps, stabilizer, spoilers and flight spring loader signal lights. See Chapter 7.4. for details.
139. Engine failure warning lights
140. Indicator of true air speed and groundspeed УСВП-К. This device can work in two modes. In the true air speed mode the value comes from the CBC system. The speed in this mode is relative to the air. In the groundspeed mode the Doppler measuring instrument ДИСС (DISS) is responsible. In this mode speed relative to the ground is shown.
141. Indicator of range and azimuth of the PCБH ППДА-Ш system.
142. Switch to toggle the active heading bug (used by the "ЗК" Heading select mode of the Autopilot) between left and right HSI.
143. HBУ navigation system lights. The light for "Отказ МГВ контрольной" (МГВ failure) has been moved here, in the real plane it's in a different place.
144. The navigation instrument УШ-3 of the compass system TKC-П2. The pointer "K" (with plane silhouette) shows always the position of the main gyro unit of the compass system. The indicator "ПУ" shows the drift angle from the Doppler system ДИСС. In summary with the heading on the indicator we see the actual track. The

triangular index shows the heading from the reserve gyro unit. The lights at the bottom of the instrument show the actual mode.
Due to the low resolution a digital readout is provided (clickspot in the middle of the instrument). The values show (from top to down) : The position of the main gyro, position of the reserve gyro, and the position of БГМК №1 and БГМК №2 (detailed explanation in the Navigation chapters).
145. Indicator УШДБ-2. In the АРК (ADF) mode the sharp end of the pointer shows the relative bearing of the station, while in VOR mode the bottom end of the arrow shows the radial of the station, on which the aircraft is currently located.
146-148. Hydraulic system 1-3 pressure gauges and low pressure warning lights
149 Emercengy brake system pressure gauges and low pressure warning light
150. Trim indicator ИН-3. Again differs a bit from real plane. With an active vertical Autopilot mode it shows the elevator position management of the Autopilot. At manual management, joystick movements and during autopilot flight a zero position of the indicator means, that the plane is trimmed and and will not move up or down when switching the Autopilot off. So this indicator allows to supervise the automatic trim work of the Autopilot.

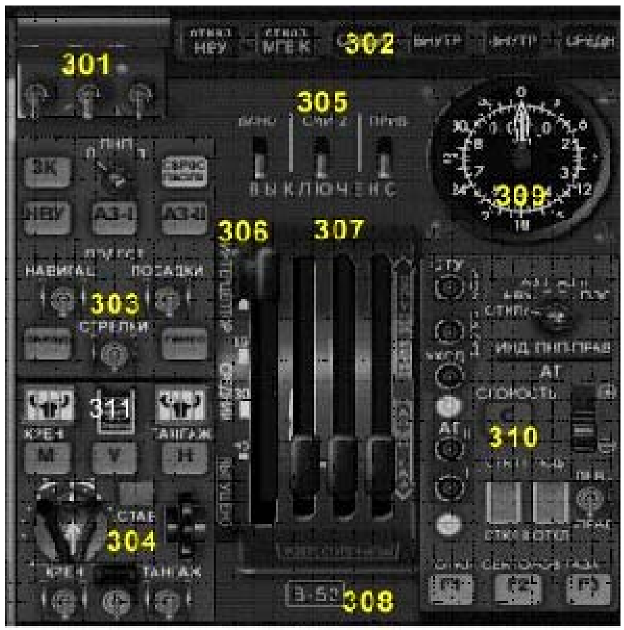
4.2. Overhead panel

201. Electrical power for АУАСП device (Angle of Attack and G-Load indicator).
202. Control switch for АУАСП. Upper position – control, lower position – reset of verification/test mode.
203. Electrical power for УВИД-15 (electrical altimeter in feet)
204. Electrical power for turn coordinator ЭУП.
205. Electrical power for standby horizon АГР
206. Test switch for the monitoring system of the vertical gyros БКК-18. After the coordination of the vertical gyros this monitoring is necessary. The monitoring system remembers malfunction, a reset can be done by using the verification mode.
207. Electrical power for the vertical gyro monitoring system (БКК-18).
208. Electrical Power for the Autopilot АБСУ (Pitch and Roll System САУ and navigation computer СТУ)

209. Electrical Power for the reference vertical gyro. It sends a reference signal for the monitoring system, thus giving the possibility for the БКК-18 system to compare this pitch and bank signal with the same signal from the Captains and Copilots artificial horizons. In case of any difference the system shows a warning signal.
210. Electrical Power for the main vertical gyro (МГВ).
211. Electrical Power for the main and reserve gyro compass system.
212. Electrical power for heating of the gyro compass system (not modelled).
213. Electrical power for including the first and second gyromagnetic heading units (БГМК) of the compass system.
214. Mode switch for the heading of left and right HSI (ПНП). In the top position the heading scale shows a heading corresponding to the gyro compass system. In the bottom position it shows a heading corresponding to the БГМК gyromagnetic compass blocks. The left HSI always uses the БГМК №1, the right HSI always the БГМК №2.
215. Test button, electrical feed switch and heating of the CBC system (system of air signals). If the electric supply for CBC is ON and you press the control button you can check the following indications : On the altimeter 12000 +/- 40 m (pressure 760mm Hg) , M= 0.8+/-0.01, true airspeed 900+/-10 km/h (for УСВП-К in "ВОЭД" position).
216. Electrical power for the first and second Курс-МП devices (VOR1, VOR2/RSBN)
217. Electrical power for the PCБH short range navigation system. It is important to mention that Курс-МП and PCБH work on one of the simulator radionavigation channels (NAV-2). PCБH has higher priority, so with the inclusion of PCБH on NAV2 the Курс-МП can not receive anything. If PCБH is switched off, the Курс-МП works on both channels. PCБH needs to be included in operative range of a PCБH beacon.
218. Switch for the PCБH ident system . Not modelled.
219. Electrical power for the radar altimeters of captain and copilot.
220. Electrical power of VHF radio stations, not involved in model.
221. Switches for first and second APK-15 (ADF) systems. These switches are not present in the real plane, chosen here for layout reasons.
222. Switches for a stabilization mode of the external frame gyro compass system.
223. Cabin signs switches (for seatbelts, no smoking signs and emergency exit lights).
224. PCБH control board. Serves for a choice of PCБH channels. Left switch tens, right switch single units. The handles in the top number simulate only the control of PCБH parameters, adjustment of parameters is not modelled.
225. Selectors APK-15 (ADF)
226. Panel for ДИСС system (Doppler measurement of speed and drift). The left switch supplies electrical power for the system. The middle switch sets land or sea mode. This switch is not involved. The right switch sets the operating mode. In the top position the HBУ works with signals from ДИСС, in the middle position the HBУ works from CBC. The bottom position is a ДИСС test mode.
227. Control panel of the compass system TKC-П2.
228. Radial selector for first and second Курс-МП.
229. Frequency selector for first and second Курс-МП.
230. VHF radio station selector (УКВ)
231. Electrical power for pitot heat (ППД).

4.3. The РУД panel

On this panel named РУД, besides thrust and speedbrake levers also Autopilot (АБСУ) and Autothrottle (AT) control panels can be found.



301. Electrical power switches for the inclusion of booster channels. All switches should be switched on and the cover must be closed with the right mouse button. Without boosters the control surfaces won't operate.
302. Important warning lights from captains panel. Indicates also НВУ failure.
303. Autopilot Panel ПН-5 АБСУ (lateral modes)
304. Autopilot Panel ПУ-46 АБСУ (vertical modes)
305. Electrical power for (from left to right) : NAV lights (БАНО), beacons (both beacons feeded by one electrical power switch) and panel lighting.
306. Speedbrake lever.
307. Throttle panel and thrust levers РУД. Mouse operation is not provided.
308. Icon to call the additional B-52 НВУ panel.
309. ППДА-Ш instrument (Indicator for РСБН Navaids, range and bearing).
310. Autothrottle panel ПН-6 АБСУ.
311. Buttons for fast PKP (ADI) alignment (under cap)

4.4. НВУ Navigation panel

The НВУ panel contains controls for the navigation computer (НВУ-Б3). Additionally some important devices, desirable to work with the system, are duplicated.

401. distance measuring indicator ИДР-1 (DME), corresponding selector (402)
403. Engine turbine rpm
404. Angle map for РСБН correction, Б-8М.
405. ППДА-Ш from РСБН system (Indicator for РСБН Navaids, range and bearing).
406. Panel ПН-5 АБСУ.
407. Panel ПУ-46 АБСУ.
408. Several system status Lights.
409. Panel В-52 №1 НВУ.
410. Panel В-52 №2 НВУ.
411. Additional В-52 panel. This device is not present in the real plane, needed for several reasons

a) One of the most important information during flight is the deviation Z from the orthodromic course LZP (ЛЗП) and the distance S to the next waypoint point PPM (ППМ). These infos are always accessible for crews on the В-52 panels. But the configuration of devices on the screen do not allow to continously present this information, because the НВУ panel can't be held open all the time. So this additional panel continously provides ЛЗП and ППМ information.

The small part of the screen does not allow accurate readout of the B-52 counters, so the additional panel provides more accuracy.
On the additional panel the data for the active counter for the input of both B-52 panels (according B-51 switch) is displayed. For the management of switching also from the additional B-52 board, the mouse zones are designated “+” and “-”. The type of the deduced information is designated by symbols below the counter window.

412. Panel B-140 НВУ. This panel serves for input of the orthodromic tracks
413. Panel B-51 НВУ. This panel serves for data input into the B-52 counters, input of linear turn anticipation (ЛУР), electrical feed for НВУ, the notation mode and a mode of НВУ correction using РСБН stations.
414. Panel B-57 НВУ. In the НВУ operating mode from ДИСС (DISS) both strenght and direction of wind can be entered. Strenght and direction of wind can be entered manually, independent of НВУ.

4.5. Copilot panel

Some instruments have been created especially for this panel. Their indications are independent from their counterparts on the captains panel. These are УС-И-6 (airspeed), УМ-1 (Mach) , ИДР-1 (DME), ПКП (ADI), ПНП (HSI), УВО-15 (metric alt.), ИКУ-1 (RMI) , РВ-5М (radio alt.). The other instruments duplicate the analogous instruments of the captains panel.

KM-5 Panel

This panel (Shift-6) provides the instruments КМ-5 №1 и №2, used for specific corrections when using the НВУ Navigation and manual data input. Correction mechanisms make it possible to introduce the magnetic declination to transfer magnetic into true heading. The correction is done with the mouse, mouse zones are on the instrument handles. A mouse click in the center of the instruments provides a digital readout for more accuracy. The prompt shows the declination introduced into the instrument. With digital indication active, click on the upper instrument housing and an additional prompt will appear. It shows the magnetic declination of the aircraft location. This information can be used as reference for the alignment of the compass system regarding the true course.

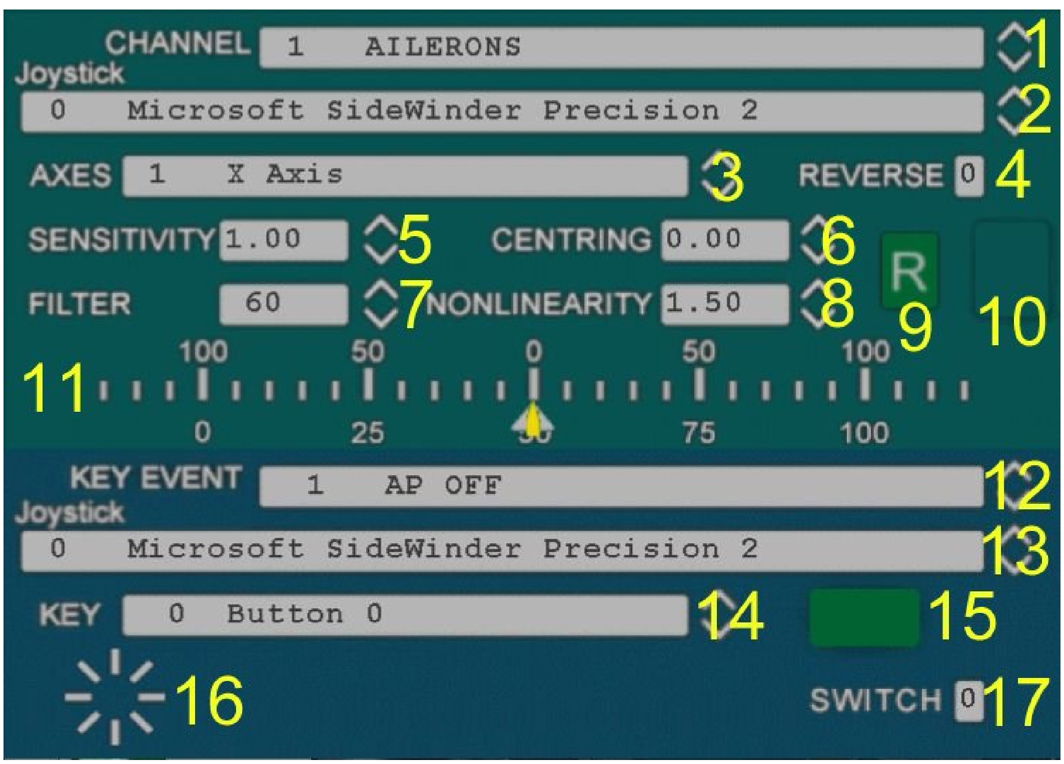
5. System startup and Navigation

5.1. Preparation of hardware

This release requires a special handling of input devices. The joystick control system in FS 2002/2004 doesn't make it possible to simulate many special control features of the airplane. The custom autopilot designed for the Tu-154B2 might further introduce difficulties due to Joystick noise. So it was decided to deactivate input devices in FS 2002/2004 and read the settings directly from the Windows operating system.
With this procedure sophisticated features such as authentic nosewheel steering modes, delay of airplane device reaction, trimming, reverse thrust and AP/AT handling including the Go-Around Mode can be introduced. It might seem inconvenient at first, but the setup only needs to be done once, then the information is stored in the Tu-154 cfg file.

In Version 9.4.1. a new Joystick device is introduced. It uses access to Joystick via DirectInput instead of API functions with the benefit to increase the quantity of axes and control buttons.

As a first step, the Joystick in FS 2004 MUST be disabled either from the menu or using CTRL-K



The panel of the service device shows two colour zones, one zone for the setup of Joystick axes, the other zone for the setup of buttons.

From top to down the following fields can be found (with +/- mouse clickspots to the right of several fields !) :

1. Window of number and name of the chosen control channel. The channel number is the reference information.
2. Number of Joystick in the system and corresponding name (derived from the Joystick driver)
3. Number and name of the chosen axis.
4. Axis inversion box (0=no, 1=yes)
5. Sensitivity input (allows changing the range of control input)
6. Centering input (allows displacement from the neutral position)
7. Filter input (filters lower frequencies and therefore contributes to noise elimination and introduces a control displacement delay)
8. Nonlinearity input (adjustment of dead zone)
9. Lighted button for reading a configuration.
10. Lighted button for writing a configuration The write button is closed by a cap, opened with the right mouse button.

    Unsuccessful reading and writing is caused by absence of a folder
    … \Gauges\Tu154_cfg\JOY in which the configuration file joy.cfg is stored

11. Joystick movement indicator. The yellow indicator shows the Joystick deviation – the white indicator the control displacements of the chosen channel. The upper scale is intended for setup of control surfaces, while the lower scale shall be used for functions like throttle and brakes.
12. Number and name of the chosen button function.
13. Number and name of the Joystick
14. Number and name of the button. For convenience, the hat switches are submitted by a button set.
15. Test light of the chosen button
16. Indicator of the chosen Hat switch .
17. Input window for switch attribute

Some features of set-up of channels.

Throttle control levers.

For activation of reverse at throttle lever zero position, the white indicator should be in the negative area. The offset value depends on Joystick noise. For thrust levers it is advised to set a big filter factor.
Brakes.

Setup of brakes with Joystick axes is possible as setup of each brake with a separate axis and also as one axis for both wheels. At set-up of brakes with one axis, differential braking is provided. At more than 50% movement one wheel is disconnected.
Differential braking is also implemented for button

The configuration file :

The Joystick configuration is automatically stored in the file FS2004 \Gauges\Tu154_cfg\Joy\joy.cfg at the first record of a configuration. Some parameters in the configuration file are not accessible on the Joystick service panel. To change these parameters it is necessary to edit the configuration file.

absu_otkl_per=25
Joystick deviation for intended autopilot disengagement, in percentage of full deflection. The parameter should be increased in case of false or unwanted autopilot disengagement due to Joystick noise.

brake_ap_off=0.
Autopilot disengagement using the brake button. Intended for those with limited Joystick buttons.

rud_revers_on=0.
Reverse Thrust activation from thrust levers. For owners of Joystick with an idle detent. The reverse is activated when moving thrust levers in the negative area more than 5%.

rv_trimm_time=20

Time of moving of the elevator trim.

ap_tang_speed=10

Speed of pitch change for the Autopilot Pitch Wheel.

The switch attribute setting

This attribute is entered for distinction of "buttons" and "switches", necessary for home cockpit builders. The attribute works only on push button functions where it makes sense.

At the installation of an attribute the device treats the button as a switch. At the pressed button the switch is established in one position, at released button – in another position. Example : If you include this attribute for the button “reverse”, then the reverse function will be activated by pressing and holding the button . At button release, the reverse function will be switched off and thrust levers placed in idle position.
Three-position switches are modelled by two buttons. For both buttons it is necessary to set switch attributes. If no button is pressed, the switch is in neutral position. Example : One button switches landing lights, the another button switches taxi lights. If no button is pressed, lights are switched off in neutral position.

5.1.1. SETUP procedure

The setup is quite simple and should be done as follows :

Joystick axes

1. Choose the aircraft control “channel” (e.g. aileron, elevator, rudder, throttle1,2,3, etc.) in window (1). Use the +/- mouse clickspots to the right of the field to select the channel.
2. Check or choose the Joystick in your system (in case you have more than one, e.g. separate yoke, throttles, rudder) in window (2)
3. Choose the Joystick axes for the chosen control channel (e.g. X-Axis for aileron, Y-axis for elevator) in window (3)
4. In you observe unwanted inverse movement, set the reverse function (window 4) to the value 1.
5. Check the correct choice by moving the corresponding Joystick axis and observing movement on the indicator (11).
6. For each axis, set Sensitivity, Centering, Filter and Nonlinearity in the fields 5-8
7. Store the setup for this axis using the write button (10), open the cap with the right mouse button first !
8. Proceed with the next aircraft control channel (jump back to step 1).

9. Beware : There are three definable throttle axes for the three engines ! If you have just one slider for the throttle, you need to store it separately for the Channels Throttle1, Throttle2 and Throttle3 !
10. And once again, don't forget to store your axis setting if you are confident with one axis definition !

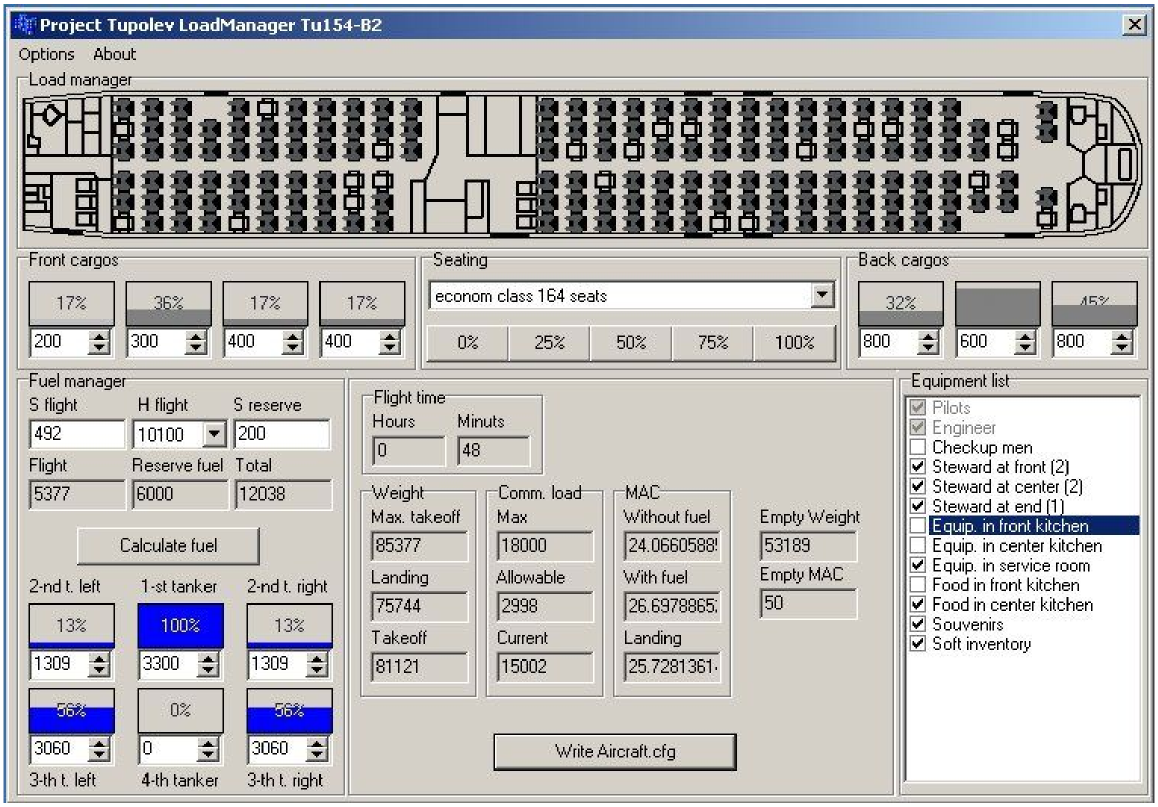
Joystick buttons

1. Choose the key event (button function) in window (12)
2. Check or choose the Joystick in your system (in case you have more than one, e.g. separate yoke, pedestal or other controller) in window (13)
3. Choose the key code suitable for that button. Change it in window (14), press the corresponding button and observe lighting up of the test light (15). If it does, you found the correct code number.
4. Store the setup for this button function using the write button (10), open the cap with the right mouse button first !
5. Proceed with the next button function/key event (window 12), until all buttons are correctly defined.
6. And once again, don't forget to store your button function each time you are confident with one definition !

CAUTION : The elevator trim function MUST be assigned to a button, the standard FS trim function shall not be used !! Much more specific Tu-154 functions can and should be defined whenever possible (e.g. Autopilot and Autothrottle disconnect on the yoke) !

5.2. Flight preparation

5.2.1. Usage of the Load Editor



The Loadeditor will start in Russian language. At the first start of the program, you'll get a Windows Explorer window. Select the directory which contains the aircraft.cfg of your Tu-154B2 (usually at <insert path to your FS main folder here>/aircraft/PT Tu154-B2). Then in the Loadeditor itself, change the Language to english using the Options Menu and follow the instruction to restart the program to get the new language setting active.

1.) select the **Seating** configuration and on board equipment using the **Equipment list** on the right side.

2) you might customize the Loadeditor for a particular plane by changing the empty weight and empty Center of Gravity (MAC).

3) In the **Fuel manager**, fill the appropriate fields (flight distance S, Cruise altitude H in meters and distance S to alternate (S reserve) and press the “calculate fuel” button. The program will calculate the necessary fuel for the flight and the necessary percentage numbers for filling the tank will be indicated (center tank first, then left and right wing tanks and the 4th tank only if necessary).
ATTENTION! The program does not fill a tank, it only shows the recommended filling. You must fill the aircraft then in the FS fuel menu :

first tank : Center 1
second tank left : Left main
second tank right : Right main
third tank left : Left Aux
third tank right : right Aux
fourth tank : Center2

4) Passengers seating can be done by clicking on the seats in the graphic with either the left (seats one passenger) or the right mouse button (seats entire row). The buttons "0%","25%" – “100%”, etc. randomly seats passengers.

5) Baggage (Cargo) can be loaded in seven sections with the corresponding up/down buttons or by entering an exact number.

6) In the Load information section you can observe a summary of your settings, incl. a flight time estimation.

7) Make sure your total Load settings are within permissible centering range and the maximum allowable takeoff and landing weight is not exceeded.

8) If finished, press the button "**write in aircraft.cfg** ". The aircraft.cfg file will be updated and the actual Loadsheet will appear and can be printed out or saved from there. It’s authentically in Russian, but when comparing to your settings, you can find out the meaning of all entries.

9) After starting simulator and plane DO NOT FORGET to fill your tanks manually using the FS fuel menu.

5.3. Plane and Panel Setup (Quick Start)

The following section is meant to get you in the air as quickly as possible. For a more realistic flow of events see the Example flight in Chapter 4.

5.3.1. Start of APU (ВСУ)

Open the flight engineer Panel. At first we need battery power or external power. Make sure all electrical consumers are switched off.

- set the switch (8) to the up position to switch on the batteries. Observe the battery discharge light (9) ВНИМАНИЕ! СЕТЬ ОТ АККУМ light up. With switch (10) in position АКК N1 you can observe 28 V on the Voltage indicator.

If external power is available, we preserve the life of our batteries and set the switch ВСУ-ВЫКЛ-РАП (15) to the lower position.

The APU (ВСУ) Start is done on the ЗАПУСК ВСУ Panel at the lower left.

- set the starting switch ЗАПУСК (1) to the upper (starting) position.
- set the switch ЗАПУСК/ХОЛ.ПРОКР (2) to the upper position.
- open the cover of the shutoff valve switch (3), switch to the up position and close the cover.
- Make sure, the following indicators on the warning panel light up : ЗАБОРНИК ОТКРЫТ (APU door opened), ГОТОВ К ЗАПУСКУ (“ready to start”) and Р ТОПЛИВА (fuel pressure).
- The indicator ТСА-6А НЕИСПР shall NOT light up at this stage.

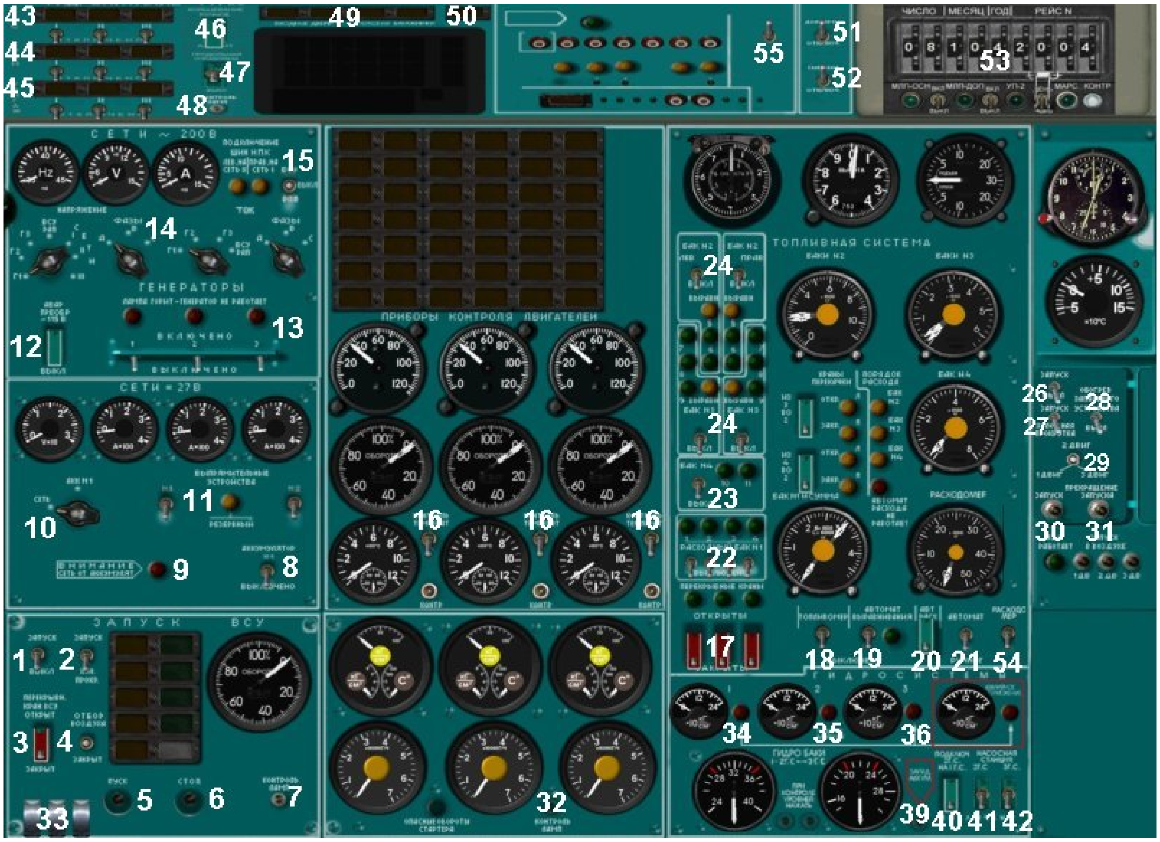
- Now start the APU using the «ПУСК» button (5).

After that connect bleed air to the cabin ventilation and engine start systems by clicking and holding (approx. 8 seconds) the «отбор воздуха» air bleed switch (4) in the upper position until the signal light ГОТОВ К ЗАПУСКУ goes out.

Set the two Avionics master switches (11) to the upper position.

Now you might continue with the hydraulic system checks as described in Chapter 7.6.4. With regards to a quick setup, you might also skip this step for now.

Make sure, all doors and luggage compartments are closed, check corresponding caution lights on the Flight Engineer Panel are out (49).



5.3.2. Preparation and start of engines

5.3.2.1. Preparation

For preparation of engine start, connect the ВСУ generators to the onboard electrical system by setting the switch (15) to the up (ВСУ) position. Observe the battery discharge light (9) go out, the two lights to the left of switch (15) and the main generator warning lights - Лампа горит- генератор не работает (13) are on. The corresponding generator switches (13) must be in OFF position (Выключено).
Press the button (32) - Контроль ламп – to make sure all warning and advisory lights are operating. On the engine operating mode panel, the following indicators shall light up : P топлива (fuel pressure), P масла (oil pressure), Клапан перепуска (bypass valve) and PHA прикрыт (inlet system closed)
Also make sure the thrust levers are in idle position.

Next step is to set the Engine Stop levers (33) in the upper position.

For temperature monitoring, include the three thermometer switches КОНТРОЛЬ ТЕМПЕРАТ (16).

Now we take care about fuel tanks (pumps and valves) and fuel system operating mode.

- Open the cover of the three shut-off valve switches ПЕРЕКРЫВНЫЕ КРАНЫ (17)
- one for each engine -, set them in the open position "ОТКРЫТО" and close the cover.
- set switch ТОПЛИВОМЕР (18) to upper position. That powers up the fuel quantity indicators
- set the center tank fuel pump switches РАСХОДНЫЙ БАК №1 (22) to the upper position
- set the fuel pumps of the wing tanks No 2 and No 3 –left and right- (24) to the upper position. Fuel pumps for tank №4 (23) is only needed if it contains fuel.
- set the switch АВТ. РАСХ (20) and close the cover. That's the fuel automation power switch.
- set the fuel management mode to automatic by setting the switch "АВТОМАТ - РУЧНОЕ" (21) in position "АВТОМАТ".
- set the Flowmeter switch «РАСХОДОМЕР» (54) to the upper position. On the Flowmeter gauge just above, set the pointer "C" to your total fuel on board, using the knob on the lower right (+/- clickspots !).

5.3.2.2. Engine Start

- turn on the beacons (305, middle switch on AP/ РУД panel, Shift-2)

- open the big engine start cover (covers switches 26-31). The clickspot (right mouse button) is slightly to the right of the cover.
- set the switches (26) and (27) to the start ("ЗАПУСК") position.
- At temperatures below +5 Deg Celsius, include the device heating switch (28) - ОБОГРЕВ ЗАПАЛЬНОГО УСТРОЙСТВА".
- now select the engine to start using the switch (29) and start that engine with the start button (30). The light "ПДА РАБОТАЕТ" comes up.
- after the light "ПДА РАБОТАЕТ" is off, the engine is started. The flight engineer will say : "ПЕРВЫЙ НА МАЛОМ" (first engine idle).

Start the other two engines accordingly. The flight engineer will let you know again, when the corresponding engine start procedure is finished : "ВТОРОЙ НА МАЛОМ" (Second engine idle) and "ТРЕТИЙ НА МАЛОМ" (Third engine idle)

If the engine start is finished, turn off the switches (26), (27), (28), set the selector (29) to the neutral position and close the cover.

After engine start, an 8 minutes warm up period is mandantory. Listen to your flight engineer again, several minutes after engine start he will say “МИНУТА ДО ПРОГРЕВА” (Minute to warm up), followed by “ДВИГАТЕЛИ ПРОГРЕТЫ” (Engine warmed up) one minute later.

5.3.2.3. Further settings and APU (ВСУ) shutdown.

- set switch (19) to АВТОМАТ position (up). This is the automatic fuel quantity equalization mode
- after preflight check, set all three main generator switches (13) to the upper position, corresponding lights go out. The preflight check consists of checking voltage of each phase (~115V) and frequency (400Hz). If normal, then turn the corresponding generator switch ON. After all three generators are switched on, the flight engineer will say : “ГЕНЕРАТОРЫ НА БОРТСЕТИ”, which stands for “Generators connected on board system”
- disconnect APU generator by setting switch (15) to the medium (neutral position).
- before APU shutdown, disconnect bleed air from the systems by pressing and holding the switch (4) to the lower position until the indicator “ГОТОВ К ЗАПУСКУ” comes up again.
- for APU shutdown, press the stop (СТОП) button (6). The flight engineer confirms APU shutdown with “ВСУ ВЫКЛЮЧЕНА”
- set the switches (1), (2) and (3) to down position. For switch (3), open cover first, then set switch and close cover.

5.3.2.4. Further Setup of panel, instruments and systems

We begin with activation of the AFCS (Automatic flight control system), make sure to exactly follow the sequence as described below.

1) On the overhead panel, turn on switch 207 (BKK Power). On the captains panel, open the РУД panel (AP and thrust levers, Shift-2), set all three Booster («БУСТЕРНОЕ УПРАВЛЕНИЕ») switches (301) to ON and close the cap.

Return to the Engineer Panel and make sure, the HYDROSYSTEM 1, 2, 3 pressure gauges show a pressure of 210 (+10,-7) KG/cm2, and the red low pressure warning lamps are not lighted up.

2) Make sure, the Crossover Switch (46) of the PA-56 control aggregates is in position "АВТОМАТ”(lower position) and the cap is closed. For activation of PA-56 hydrofeed, turn on the switches for all three channels Yaw (43) , Roll (44) and Pitch

(45) and all three hydrosystems (in total nine switches). Turn the switch (47) ПРОДОЛЬНАЯ УПРАВЛЯЕМОСТЬ (longitudinal controllability) on and close the cap.

3) Turn the switch «САУ - СТУ» and the switch " АГР " on (Overhead Panel 208, 205) . On the ПН-6 Autothrottle Panel set the autothrottle control in Preparation mode by switching «ПИТАНИЕ АТ» (page 34, switch 24) in the position «**ПОДГ**ОТОВКА» and close the cap.

4) Press the buttons «КОНТРОЛЬ ЛАМП» and check the serviceability of the signal light system (see Chapter 7.4. for explanation of all signal lights), especially check for indicated failures of the AFCS command signal system and indications regarding a possible AFCS limitation..

5) 3 minutes after turning on the switches «ПКП.ЛЕВ» and «ПКП.ПРАВ» and « МГВ КОНТР. » (overhead panel 209, 210) prepare the gyrohorizons for take-off. For this :
- open the cap «АРРЕТИР» (12 on screenshot of AP-Panel page 34) on the autopilot Panel and press the buttons until the horizon on both captain and Copilot ПКП-1 (ADI) is in level attitude.
- put the switch «БКК ТЕСТ» (Overhead panel, 206) first in upper, than in lower position.
- make sure, the «АГ» flags have disappeared on both ПКП-1 (ADI Captain and Copilot), the warning light «ОТКАЗ МГВ К» is out. Then close the cap of switch «БКК ТЕСТ» .

On the overhead panel, turn the switches 222 (ctab ГА) ON. Continue to set the following switches to ON : 201, 203, 204, 205, 211-213, 215, 216-221, 226. This will feed corresponding systems and instruments with electrical power. Do not include switch 214 for now.

Some of the instruments could have been switched on before engine start (those that need only electrical power), but the above activation of the AFCS needs hydraulic pressure, so we had to do that after engine start.

Notice with this procedure we have set the ДИСС switch to the ДИСС position, not CBC position. The switch 217 (РСБН-ПИТАНИЕ) feeds the РСБН system, it only must be switched ON if the short range navigation system is really intended to use (flight over CIS countries). Switch 218 is the РСБН Ident switch, to be used only on ATC request. Since we have a transponder, it is almost never used anymore.

The pitot heat (Heating РРД) switch 231 : It is not approved to switch it on while the aircraft is at parking, due to possible overheating and the possibility of electric heater burnout. Turn it on during taxi not less than 1.5 min prior to takeoff if the outside temperature is above +5°C and not less than 3 min prior to takeoff if the temperature is below +5°C.

5.3.2.5. Alignment and coordination of gyros

Now the lateral main and reserve gyros have to be aligned to magnetic North with the following procedure. Make sure to execute the following steps in the correct order :

On the main panel, click on the center of the navigation instrument УШ-3 (44). This will activate a set of four digital values. This shows the actual heading of the corresponding gyros.

- set the Airport latitude on the Latitude scale (1) using the control knob (2) to the right of it.
- set switch (4) to the "МК" position, switch (7) to the "осн" position. Now press and hold the fast alignment Button (8) and see the digital values on the instrument УШ-3 (144) moving. They will stop at the actual heading that can be observed using "Shift-Z" in FS2004.

- repeat the procedure for switch (4) in position МК and switch (7) in position "контр",

- repeat the procedure for switch (4) in position ГПК and switch (7) in position "осн"

After the procedure all four digital values should have the same value and correspond to the magnetic heading. Arrows and index of instrument (144) should be in the same position with correct heading, also the heading on the HSI should be correct on both Captain and Copilot side.

Complete the procedure with setting the switches 214 to on.

5.3.2.6. Further steps

- left click with the mouse in the center of the Angle of Attack/G-Load indicator. This will reset the instrument from any memorized maximum values.

Remember the Center of Gravity (% CAX in Russian or %MAC in English) in the Loadeditor ? Now we need this to set the stabilizer handle. Depending on the value, the following colour is valid :

21-27% : CAX to the Green Mark ("П")
28- 32% : CAX to the white mark ("C")
> 32% : CAX to the yellow mark (“3”, only valid for flights without passengers)

Move the selector to match your actual CoG colour setting.

Now use your vertical trim function to set the elevator trim tabs to the neutral “0” position. If the setting is correct, the corresponding light on the signal panel will turn on.

In Version 9.3 a special stabilizer handling was introduced, that deserves a more detailed explanation, given in Chapter 7.8.. For now just make sure the handle is in the correct position. If it’s not, you can get in trouble during takeoff and landing, because your effective elevator range can be seriously limited due to an incorrect automatic stabilizer setting. But it can be corrected, just read the corresponding text in Chapter 7.8.

We continue with the final steps of our plane setup :

- charge the emergency braking system. Press and hold the charge accumulator button (39) on the flight engineer panel until the manometer for the emergency braking system shows 210 KG/cm2

- use the СПУ transponder panel to set your squawk code. Four digit value, four selectors ! Notice the selectors are set to the default value 1200.
- turn on the Nav lights (305 on AP Panel, pg 14, left switch)

- put the switch for the control of nosewheel steering modes (main panel, switch 101) to the up position and close the cover. In the real aircraft it is only approved to turn the nosewheel steering switch to the on position after starting the taxi roll, because after towing the nosewheel may not be aligned with the aircraft centerline.

- for taxi use 63 deg (switch 102). During taxi, set the Flaps to takeoff position (15 or 28, depending on weight and other conditions). If you set Flaps 15, you will hear this from your Navigator: "ЗАКРЫЛКИ ВЫПУСКАЮТСЯ СИНХРОННО, СТАБИЛИЗАТОР В СОГЛАСОВАННОЕ, ПРЕДКРЫЛКИ ВЫПУСКАЮТСЯ" (Flaps out, stabilizer coordinated, slats out).

- aligned on the runway, set the nosewheel steering mode to 10 deg and close the cover.

- the warning light ""к взлету не готов" (no takeoff warning) should be out now

All warning lights in the panel are turned off now, all systems clear, instruments show correct values, also all headings are correct. The plane is ready to fly. Copilot, Navigator and Engineer will also let you know they are ready :

Flight Engineer : "ИНЖЕНЕР ГОТОВ" (Engineer ready)
Navigator : "ШТУРМАН ГОТОВ" (Navigator ready)
Copilot : "СПРАВА ГОТОВ" (on the right ready)

Now, what about a circling around your home airport to get the first impression of the outstanding flight dynamics and jet airliner flight feeling ?
Enter a corresponding ILS frequency in the KURS-MP I (VOR 1) unit in the overhead panel, set the Course on the HSI, open the Thrust/Autopilot Panel and turn the following switches on : Pitch channel (20), bank channel (19), landing computer (8). For the numbering, please refer to the screenshot in the following chapter of the Autopilot description. We have ILS indication now.

Ready to rumble ☺.

In the real plane, the flight engineer moves the thrust levers, but we have the job of all crew members and do that for him. Move the thrust levers forward to set a takeoff thrust of 95.5%. The flight engineer will let you know as soon as the corresponding thrust is reached and all looks normal : "РЕЖИМ ВЗЛЕТНЫЙ, ПАРАМЕТРЫ В НОРМЕ, РУД ДЕРЖУ" (Takeoff thrust, parameters in norm, I hold levers).

During the takeoff roll, you hear the Russian Speed Calls : speed increasing, 140, 160, 180, 200, 220 (all in km/h of course), followed by "РУБЕЖ" ("Rubezh"), which stands for boundary and means V_1, At the "ПОДЪЕМ" ("Pod'em") call, which means "rise" (at Vr) pull smothly, but steadily at the yoke or stick to lift off. Now the voice callouts get even more intense. At V_2, you will hear “БЕЗОПАСНАЯ” (“Bezopasnaja”) for “safe”.

Right after takeoff, retract the landing gear. Learn about the Tu-154 landing gear implementation in detail in Chapter 7.7.. Use the “G” key (or a stick button, if you have defined the GEAR function in the Joystick Service Panel) to set to upper position. Your copilot will say : “ШАССИ УБРАНЫ” for “Gear Up”. After a few seconds, the flight engineer will instruct : “"КРАН ШАССИ НЕЙТРАЛЬНО" (gear valves in neutral !). Put the landing gear lever to neutral immediately and continue to listen to the Copilot again. She will confirm : “КРАН ШАССИ В НЕЙТРАЛЬНОЕ УСТАНОВЛЕН” for “Gear valves established in neutral”.

Retract the landing lights (lower switch 103 to medium position, upper switch to lower position), commented by your Navigator with “ФАРЫ ВЫКЛЮЧЕНЫ, УБИРАЮТСЯ” (Lights switched off, stowed).

At a speed of 350 km/h retract the Flaps to 0 (if you used Flaps 28, set to 15 at 330 km/h). You guessed it, there is a voice callout again accompanying that : “ЗАКРЫЛКИ УБИРАЮТСЯ СИНХРОННО, СТАБИЛИЗАТОР ПЕРЕКЛАДЫВАЕТСЯ К НУЛЮ, ПРЕДКРЫЛКИ УБИРАЮТСЯ” (Flaps in/clean synchronously, stabilizer shifted to zero, slats in/clean).

Climb now to you circling altitude, level off and stabilize at a speed of e.g. 500 km/h. Don’t forget to trim, that’s the key to smooth flying of (not only) a Jet airliner. I remind again, the elevator trim functions have to be defined to Joystick buttons, it won’t work using the FS standard keys !) .
Fly your circling as desired to the downwind leg and relax a bit, it soon gets intense again. To relax a bit more, use the Pause key as desired at anytime. Eventually use the Load/Save Feature described in Chapter 5.5. to get the ability to repeat the flight from this stage. Depending on your takeoff weight and if you used the Loadeditor or not (I hope you used it ☺), you might have to reduce your weight below 78t, the maximum landing weight for the Tu-154. Eventually reduce your fuel in the FS fuel menu. Open the Checklist Panel with Shift-1, check your Center of Gravity (CAX) number and your corresponding stabilizer setting !

Before the turn to the base leg (in Russian terminology the “third turn”), reduce the speed to 370 km/h and fly the turn at that speed.

Once at the base leg, extend the landing gear by setting the landing gear lever to the lower position (key “G” or button). Your copilot will say “ШАССИ ВЫПУЩЕНЫ, ТРИ ЗЕЛЕНЫЕ ГОРЯТ” for “Gear down, three green lights”. Approx. 20 seconds after the last green lamp lighted up, you will the flight engineer instruction : “КРАН ШАССИ НЕЙТРАЛЬНО" (Gear valves in neutral !). Set the landing gear lever to neutral position then, confirmed by the Copilot : “КРАН ШАССИ В НЕЙТРАЛЬНОЕ УСТАНОВЛЕН” for “Gear valves established in neutral”.

Set the Flaps first to 15, Voice Callout : ЗАКРЫЛКИ ВЫПУСКАЮТСЯ СИНХРОННО, СТАБИЛИЗАТОР В СОГЛАСОВАННОЕ,ПРЕДКРЫЛКИ ВЫПУСКАЮТСЯ (Flaps out, stabilizer coordinated, slats out),
Then extend Flaps to 28, it will again be commented by your Navigator with : “ЗАКРЫЛКИ ДВАДЦАТЬ ВОСЕМЬ” (Flaps 28). Reduce the speed to 300 km/h, at that speed we’ll fly the turn to final. Here’s how :

On the Autopilot panel, we activate the flight director (“стрелки” , switch 10, see screenshot in following chapter) and click the Localizer mode button (“ЗАХОД”, button 9). Since we didn’t switch on the Stab button, we use the Autopilot modes to fly in director mode, not in command mode. Which simply means, we’ll fly the flight directors lateral indications manually.
Once on final leg, turn on the Glideslope Mode (“**ГЛИСС**АДА”, Glissade, Switch 11).

Switch the landing lights on in two steps (first extend from stowed position, then landing lights on), commented by your Navigator with : “ФАРЫ ВЫПУЩЕНЫ” (Lights let out) and “ФАРЫ БОЛЬШОЙ СВЕТ” (Big headlight on).

Before glidepath entrance (as soon as the Glidepath pointer will approach the center), set Flaps to 45. Your Navigator will confirm with “МЕХАНИЗАЦИЯ ВЫПУЩЕНА” for “Mechanisation is extended (let out)”. Which simply means “Full Flaps extended”.

Now follow also the vertical flight director indications at a speed of 270 – 275 km/h (Vref + 5-10 km/h). Just concentrate on stabilization on the Glidepath. You’ll hear a lot of altitude callouts, starting with “ВЫСОТА ДВЕСТИ ПЯТЬДЕСЯТ” (Height 250) down to “ОДИН МЕТР” for “one meter”. Speed at the threshold should be 265 km/h.

At the inner marker, disregard the flight director commands and continue visually. Make sure, the aircraft is well trimmed in pitch. Ideally, in “hands off mode”, the plane should just continue the descent path. Flare at 15 meters, put the thrust levers to idle at 5 meters and as soon as the main gear touches the ground, smoothly put the nose gear to the ground as well. Extend the spoilers and set Reverse Thrust. Notice only the outer engines provide reverse thrust, unique for the Tu-154 and of course (☺) also implemented in the simulation.
Immediately begin braking and before exiting the Runway, don’t forget to set the nosewheel steering angle to 63^{o}.

Congratulation. You (hopefully) successfully completed you first landing.

5.4. Autopilot modes

(1) booster switches
(2) Heading select mode 3K
(3) button to clear modes
(4) HBY Navigation mode
(5) VOR navigation mode A3-I
(6) VOR navigation mode A3-II
(7) Navigation computer
(8) Landing computer
(9) Localizer landing mode
(10) Flight Director
(11) Glideslope landing mode
(12) fast vertical gyros alignment
(13) Mach hold mode
(14) Speed hold mode
(15) altitude hold mode
(16) turn knob
(17) Stab mode
(18) climb/descend wheel
(19) bank channel
(20) pitch channel
(21) speed channel
(22) speed wheel
(23) switch Autothrust channels
(24) arm Autothrust system

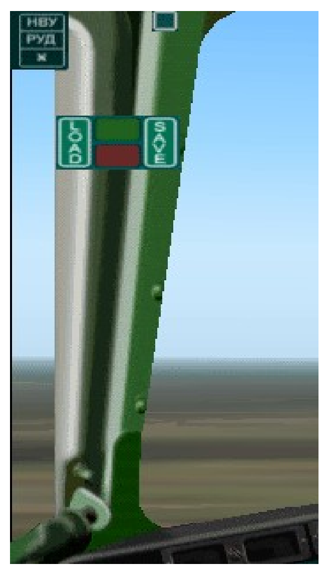
The detailed explanation of the Autoflight System is given in Chapter 7.1., at this stage a quick summary of the system :

The Autopilot works in two independent channels, bank and pitch. Before starting the AP, the channels must be included using switch (19) for the bank channel and switch (20) for the pitch channel. Notice the two pictorials left and right of (12). If they look like a yoke, it indicates you are manually controlling the corresponding channels. The Autopilot "Master Switch" is (17). You will notice the pictorials changing to the STAB indication, signalling bank and pitch are now under AP control.
Now to the vertical modes : H (15) is the altitude Hold mode. V (14) is the IAS Speed hold mode (speed in km/h). If it is activated at a certain speed, the system holds the speed by changing pitch. If you e.g. increase thrust, the plane will NOT accelerate, but increase pitch. The M mode (13) is similar, it just holds the Mach Number.
I think the lateral modes are fairly obvious except HBY, which is discussed later in all detail. But one thing is really important to know : The Modes HBY, A3-I and A3-II are connected with the Navigation computer (7), while the ILS Localizer (9) and

Glideslope Modes (11) are connected with the Landing Computer (8). Never use (7) and (8) at the same time. The usage of VOR Navigation will be illustrated in Chapter 5.6.2.
Both channels can be used independently. So you can use a vertical Autopilot mode and fly manually in the lateral axis. E.g. track a VOR manually and climb using the V mode. Or anything vice versa, it's all up to you. Another alternative : If the Master Switch (stab) is ON, you must not use any mode, but can use the turning knob (16) or climb/descent wheel (18) to control the plane. The wheel (18) is also recommended to use to smooth transitions between the IAS Modes V or M to the H mode. From V or M, slowly reduce or increase the Vertical Speed before activateing altitude Hold H.
Autothrust is ONLY used during approach, switch it on with (21) and control the speed with (22). Please note, it will override any other speed mode, such as V or M.
As this is a custom AP, I recommend to map the AP/AT disconnect switches to the yoke (or stick) as in the real plane. The Joystick Panel (Shift-7) must be used for this. There is much more fidelity in the system, which might want to know in Chapter 7.1.

By the way, the key to smooth autopilot operations is trim ! If you switch the AP off, you will receive a trimmed airplane. If you switch the AP on, please also "deliver" a well trimmed plane TO the Autopilot !
And one more tip : If you are using the side views, please initialize them on the ground by just once calling them ! This loads them into texture memory. There are more than 1000 variables and numerous calculations running in the background (of course not only regarding the Autopilot), we shall avoid disturbing them by texture load times. Depending on your memory, the texture load times can be considerably decreased by setting the parameter TEXTURE_BANDWIDTH_MULT (in fs9.cfg) much higher.

5.5. Flight Load/Save Mode



The instrument can be opened by clicking on an invisible icon on the left centerpost (see figure).

The instrument allows to store only ONE instrument state, which means a collection of flights cannot be created. This is connected with the impossibility for the developers to completely "intercept" the standard mechanism of the Load/Save functionality in the simulator.

Two buttons "LOAD" and "SAVE" can be found on the instrument, for reading and recording the state of instruments respectively. There are also two light zones indicating the success of record and read operations. A mouse clickspot in the light zone allows to close the instrument.

Order of usage :

To store a flight.

1. Open the instrument
2. Click the "SAVE" button

In this case the FS standard window for “save a flight” will be opened. It is advised to always choose the same name. It is possible to use different names, but the instrument configuration will be the same and only depending on the last saved flight.
After closing that window with the “OK” button, the green light on the instrument must light up, indicating the success of the “save” operation. If the red light should light up, the directory “FLIGHT” could not be found in the gauge folder shown above.
Additional panels are closed after recording and simulator set to Pause mode.

Loading a stored flight.

1. Load the stored flight via the simulator menu (select a flight)
2. Open the instrument
3. Click the "LOAD" button. The red light indicates the file could not be found, the green light indicates successful reading.
   If the “NO LOAD” tooltip appears, return from the pause mode for 1-2 seconds and then set the pause mode again and click the “LOAD” button.
4. Verify the state of the instruments
5. Advance the joystick thrust lever to full thrust.
6. Click the “p” key to return from the “pause” state.
7. Open and close the flight engineer panel for the automatic start of the fuel leveling automation.

The instrument is mostly intended for retaining the flight in case of a long duration or in the final approach/landing phase. To suppress the temptation to load the aircraft ready to fly on the ground, a corresponding protection has been introduced.

The possibility to save the state of instruments appears approximately after six minutes of flight at an altitude no less than 300 meters (on the radio altimeter) and a speed not lower than 250 km/h.
Reading the state of instruments is possible, if after reading of the flight specified in the simulator menu, the speedometer shows not less than 250 km/h and the terrain clearance is not less than 300 meters. In this case all systems on the flight engineer panel are also included and it it is possible to open it without the risk of an engine shutdown.
Loading and saving does not work in the "SLEW" mode. For protection of records if the aircraft is on the ground, the buttons indicates "NO SAVE" and "NO LOAD" tooltips.

Sometimes after reading the flight specified in the simulator menu, the speedometer needle didn't indicate the correct value and the correct reading of the state of any other instruments might not be possible. This is apparently an unpredictable "something" in the simulator. Repeated loading of the flight using the simulator menu is advised then, or reading the flight again from inside the aircraft.

After loading of the flight the indication of engine thrust is always under 20%, this is unavoidable. During the time of the engine output according to the assigned thrust the aircraft can considerably loose speed. For example, I wrote a flight at an altitude of 1000 meters and a speed of 450 km/h. The gross weight was 80 tons, landing gear and flaps retracted. Autopilot in the altitude hold mode (Mode "H), autothrottle active. After loading of the flight, in spite of that, the AT rapidly moved the levers forward, but according to the indication the speed got reduced to 400 km/h.
It is respectively necessary to foresee this during the procedure of the flight "retention". For example, in order to keep the flight in the circuit at a speed of 400 km/h with active AT and altitude hold mode : It is advised to turn AT off, accelerate the plane to 450 km/h. Then click "P" to pause, switch AT on and set the index on the speedometer to 400 km/h. After that save the flight to ensure a smooth transition after loading the flight back. For other modes a similar operation is recommended.

Auto-adjustment of panels.

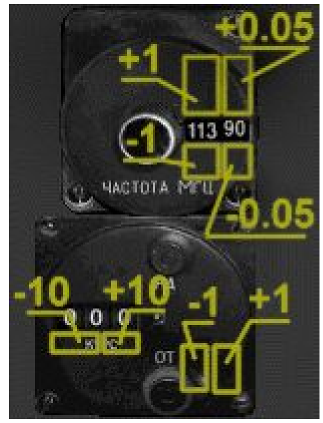
With the retention of the instrument state different problems were encountered. There are around two hundred parameters, without considering data for the virtual navigator. And if the state of equipment changes during the normal operation in the specific sequence, it is necessary to simultaneously preserve the state of all instruments. As a result it was necessary to load the parameters in two stages with a time delay. Here also the dependence of the state of instruments of subpanels must be considered during the loading process. Therefore in this version an auto-adjustment of panels during the load process is introduced. The adjustment or initialization of all subpanels as recommended in the original documentation is no longer necessary and is done automatically.
The panel auto-adjustment feature can be deactivated, for example when using a two monitor setup. For this purpose in the corresponding section of the file Tu154_gau.cfg the entry panel_auto=1 can be changed to panel_auto=0.

The state of the stopwatch and the flight time mechanism is not kept. Also a given МСРП-64 state does not remain.

The logic of some instruments has been changed a little to retain the state of instruments. For example, the tuning frequencies of the Course -MP system are read from the simulator when loading the panel.

5.6. Navigation

5.6.1. The Course-MP (Курс-МП) system



The Course-MP system is the domestic version for VOR navigation, introduced for the possibility of international flights. Two Course-MP subassemblies (NAV1 and NAV2) are installed, located on the overhead panel. Each has its own setting device for frequency and course (see overhead panel description 228 and 229). Both can work in navigation and landing modes with corresponding output to the HSI, but the automatic landing mode only works with the NAV1 (left) subassembly. For FS internal reasons NAV2 also serves for the RSBN system, in the latter case it overrides a VOR on NAV2 . The diagram shows valid clickspots.

5.6.2. VOR navigation in the Tu-154B2

The screenshot shows how the HSI of Captain and Copilot are connected to the VOR and course settings.

The modes of the right HSI can be changed using the switch on the ПН-6
The modes of the left HSI depend on buttons on the ПН-5.

If we press "Заход" (approach), the mode "СП" will be set.
If we press "АЗ-I", the mode “VOR” will be set" (from the left КУРС МП)
If we press "АЗ-II", the mode “VOR” will be set" (from the right КУРС МП)

If the switch "Подгот навигац" is on, the aircraft will automatically fly on the radial, which is necessary to advance on the appropriate КУРС МП unit. If it is not switched on, it is possible to manually fly on the VOR radial.

Just to repeat, ILS can only be controlled from the left КУРС МП, while VOR can be controlled from both. If RSBN is switched on, the right КУРС МП is inactive.
By the way, the buttons АЗ-I и АЗ-II are deciphered "Азимут первый" (azimuth first) and "Азимут второй" (azimuth second).

Now VOR Navigation in practice is different than you are probably used to. On the FS default HSI, radial and course input are combined. It is possible because the HSI shows magnetic course. But the Tu-154 HSI shows great circle (orthodromic) course.

In the Tu-154, we set the radial on the overhead panel. It is not connected in any way with the ТКС compass system, the radial is just a VOR “property”. The deviation indicator bar on the HSI shows the deviation from the radial. If we are far from the radial, the bar shows only on which side of the radial we are.

Now the logic works as follows : If we shall e.g. pick up a heading of 100 on the HSI , and the deviation bar is fixed on the right side, the airplane will (in A3-I or A3-II mode) depart with a course 100 + 30 = 130. If the deviation bar is fixed on the left side, the course will be 100 - 30 = 70. As soon as the deviation bar comes from left or right to center, the autopilot will “pass activity” to the VOR signal. It means, then the HSI course value is no longer considered.

Now practically, on the HSI we should pick up a heading corresponding to the radial. It is necessary to show the autopilot how to “leave” to the radial.
But on the HSI we have great circle course and the VOR radial is oriented to magnetic course. Therefore the course must take the “fork” into account (here between route segments, not entire route, see HBY navigation). It is necessary to compare a magnetic and great circle course. The magnetic course can be seen on the RMI (ИКУ) or by switching the right HSI to magnetic course (Overhead Panel, switch 214, the right one).
An example : For radial 55, magnetic course 63 and great circle course 72, it is

necessary to set the HSI course needle to 55 + (72 - 63) = 64. And then the airplane will "leave" to a radial with a course of 94 or 34. It corresponds to magnetic course of 85 or 25.

Another possibility is this simplified method : Switch the HSI to mode "MK" and set the course needle to the radial value, 55 in our example. Switching the HSI to MK mode means again usage of the switch 214 (but now the left one !) on the overhead panel. The MK mode on the TKC is NOT meant.

This handling of VOR navigation corresponds exactly to the real plane.

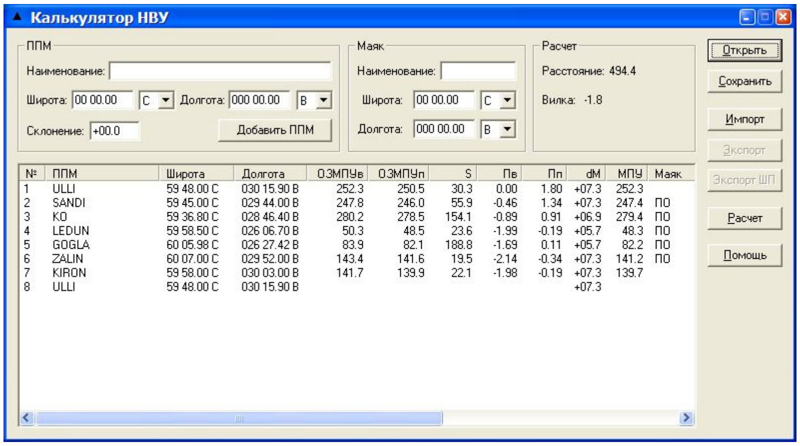
5.6.2. RSBN Navaids

After setting the switch 217 (overhead panel) to ON, you can use the inner Russian RSBN navaids. They must be installed using the supplied scenery. An RSBN station can be set using it's channel nummer. The supplied RSBN scenery package includes a doc file with a listing of all Navaids, their channel number and Lat/Lon location. In the Tu-154, the system is not intended for RSBN-RSBN-Navigation, it is primarily used in RSBN Correction Mode during HBY Navigation.
Please note, the pointer in the corresponding instruments shows the bearing from the station to the plane !

Example : RSBN Strigino (Nizhnij Novgorod) has the channel nummer 26. On the left switch set 20, on the right switch set 6 (20+6=26, you guessed that ☺).

5.6.3. НВУ Navigation Part I

5.6.3.1. The НВУ calculator



The seven buttons on the right have the following functions :

1.Open **НВУ** flight plan
2.Save **НВУ** flight plan
3.Import FS flight plan
4.Copy to clipboard
5.Choose channel number
6.Calculate
7.Help text

If the program might come up with strange characters at the first time, it's because it doesn't support Unicode. In Windows XP, go to Control Panel, Regional and Language Settings/Advanced and select "RUSSIAN" for non Unicode supporting programs. It's a bit inconvenient, since you have to reboot and it might affect your home country specific characters, but you can go back to the original setting anytime.

Open an existing HBY plan (examples are provided in our Forum), import an FS flight plan or enter the flight plan manually from scratch. In the latter case the magnetic deviations have to be entered for at least the departure and arrival airport.

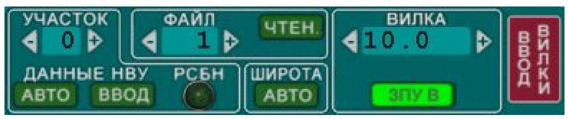
Use a program that provides magnetic variations (the help file mentions FSNavigator), but take care regarding the correct sign. By definition for the North and Eastern hemisphere positive values have to be entered (e.g. +7.3 for Saint Petersburg – Pulkovo). So the values in FSNavigator must always be reversed ! For standard HBY operation enter the magnetic variation for the departure and arrival airport using the "СКЛОНЕНИЕ" field. If you want to do RSBN corrections, include magnetic variations for each corresponding waypoint.

The first waypoint of your plan must be your departure airport. Just approx. coordinates of the waypoint, where you calibrate the gyros, are sufficient. New waypoints can be entered by filling the corresponding fields in the ППМ section and then pressing the button ДОБАВИТЫ.ППМ. Waypoints can be deleted by highlighting the entry and use the “DEL” key.

If the route is finished and the magnetic variations are set, press the РАСЧЕТ (calculate) button.

Use the button ЭКСПОРТ to copy the plan in the clipboard (and paste e.g. into MS-Word or MS-Excel) and ЭКСПОРТ ШП to select a “channel” number are now active. Choose one out of 16 channel numbers and remember it, we will use it with the Virtual Navigation assistant.

5.6.3.2. The Virtual НВУ navigation assistant



Open the НВУ panel (shift-3), and press "СЕТЬ" to power up the system. Open the Virtual Navigator panel using shift-8. Then in the ФАЙЛ field, choose the same channel number, you have used in NVUCalc when you made the export. Then press "ЧТЕН.". After that press ВВОД, and watch the НВУ panel. The Virtual Navigator will set correct values for the НВУ equipment. Then press АВТО. If АВТО is enabled, the Virtual Navigator will change waypoints automatically. The current waypoint can be seen in the УЧАСТОК -field.
You can also press АВТО under the ШИРОТА -word. The Virtual Navigator will then automatically enter (and update) the latitude at the TKS panel.

After Takeoff press the HBY button on the PN-5, this will set HBY indication to the left HSI. You may now fly the aircraft manually, or if you want to turn on the automatic mode, then do next steps:

1. Press СБРОС ПРОГРАММ button on ПН-5 (Shift+2 or shift+3 panels)
2. Turn on КРЕН and ТАНГАЖ on ПУ-46
3. Press the green button СТАБ in the center of ПУ-46. Two words СТАБ will appear in two little windows on ПУ-46
4. Now you may control the plane by using the TURN KNOB to change course and the CLIMB/DESCENT WHEEL to change pitch.
5. If you want to set automatic flight under НВУ signals then take heading to the next waypoint (if you have not did it yet ☺).
You may do it manually if you are in 'hands" mode or using the TURN KNOB if you've done operations above

- Set the TURN KNOB into neutral position (press right mouse button over the knob)
- Turn on ПОДГОТ. НАВИГ. (number 7 on ПН-5)
- Press НВУ button on ПН-5

5. If you don't want to change navdata manually you may use the Virtual Navigator for it, as it was written above.

Even easier - set the Virtual Navigator in AUTO mode in lineup position on the runway, turn on СЧИСЛЕНИЕ (automatic counting) before takeoff and forget about problems ☺

Anyway, the autopilot will take the flight path and the Virtual Navigator will automatically enter new waypoint sets in the НВУ panel. With the number selector (413, see Chapter 2.4) you can set the turn anticipation in KM. A zero value means the next waypoint will be directly overflown (no turn anticipation). For small course changes I recommend to use 5 KM, for bigger course changes use 10KM. This will avoid airway offsets.
Compare the automatic settings of the assistant with the flight plan. The virtual navigator sets the orthodromic courses ZPU and the distance S with negative values (by convention S counts “up” from negative values to 0). Observe during flight the drift is kept at or very close to 0. If you switch the HBY Autopilot mode on at a certain offset to your route, you might see non-zero Z values initially, but the system reduces them instantly by intercepting the route.
In the field “Вилка” (it means fork) you see the “fork” value. It will be explained in the following NVU chapter.This value is also shown in the upper right section of the NVUCalc program after calculation. Furthermore it is the value we have to put into the TKS-P2 system for the transfer to the magnetic meridian of the arrival airport.
Below the Вилка field, you find a switch labelled “ЗПУ-В or ЗПУ-П”. Initially ЗПУ-В shows up, reminding us the magnetic meridian of the airport of departure (where we did our compass alignment !) is “in the system”.
Now reasonably close to the arrival airport we have to transfer our compass system to the magnetic meridian of the arrival airport. For this we press on ЗПУ-В , it will change to ЗПУ-П. The virtual assistant will now load the ZPU relative to airport of arrival into the HBY. So ЗПУ-П now indicates we have the magnetic meridian of the arrival airport in the ZPU fields.
But take care : this will change ***the next*** waypoint's data. For the present waypoint we must change the heading (ЗПУ) on the active block ***manually***. If the FORK is negative then we reduce ЗПУ, if positive - increase ЗПУ.

We can also do the whole transfer procedure of TKS and HBY (the complete manual procedure is explained in detail later) fully automatically. For this we open the cover of the red button labelled ВВОД ВИЛКИ with the right mouse button and click in the field with the left mouse button. Before this operation the green ZPU field must show ЗПУ-В ! The TKC-P2 gyro units will now be transferred AND the HBY will be changed to the meridian of the arrival airport.

You can do the TKS transfer yourself and the HBY change automatically or you can do both automatically !

It is important to know the virtual navigator does not influence the working HBY ! All “his” responsibilties are loading data into the HBY and press buttons. That means you can still correct data on the V-52 and change the turn anticipation. You can switch off the ABTO mode in the virtual navigator and manually introduce data anytime. Once finished, you again switch to ABTO mode (but please make sure to change to the appropriate waypoint number in this case)

If you like, you can do the transfer to the magnetic meridian of the arrival airport manually using the following procedure :

1. Turn the НВУ automatic mode off by setting the navigation computer switch “подготовка навигации” off. The autopilot bank channel will keep the current course.
2. Set the switch “коррекция” on the ТКС-П2 panel to the position “контр”. With the aid of the course setting device the reserve gyro unit gets the total correction value, so with the currently active main gyro a course change does not occur and НВУ works correctly. The control is done with the index on the УШ-3 (The navigation instrument УШ-3 of the compass system ТКС-П2). Now without hurry the angle between the arrow “К” and the triangular index on the УШ-3 can be verified.
3. Set the switch “коррекция” on the НВУ panel to the position “осн”. Now compare the arrow “К” on the УШ-3 with the index of position of the reserve gyro unit. In this case we transfer the actually working main gyro unit. Again a course change does not occur because with disconnecting the Autopilot the mode has changed to keep the current course.
4. Set the total correction in ЗПУ on the B-140.
5. Turn the toggle switch “подготовка навигации” to the On position. If all was correct, there should be no course change.
6. After transfer of gyro units it is necessary to do the alignment for БГМК units. For this repeat the procedure described above (5.3.2.5) for the ГПК mode and the switch (7) on the TKS panel in both positions. Near the arrival airport the courses ИКУ and ПНП must now be close. Now the compass system is prepared to land at the arrival airport.

5.6.4. НВУ Navigation Part II

At this stage I assume you have already used the virtual navigator and have seen “him” changing the values in the НВУ counters, change waypoints, transfer the compass system and so on. The big question is : What does he do, why and how does it work ? What follows is an attempt (not more and not less) in my own words to answer this questions.
Pretty soon you will read something uncommon and also something fairly technical. But don’t worry, the practical operation is far less complicated than this theory sounds. You also might skip this, jump directly to the example flight in the next chapter and maybe come back here later :

Hmmm, how and where shall I start ☺ ?
The solution of many air navigation problems is directly connected with the determination of directions on the earth surface. The route of an aircraft between two given points can be plotted orthodromic or loxodromic. The choice of the method mostly depends on the corresponding navigation equipment of the aircraft, but also region specific characteristics might have an influence.
Each method has its specific properties. Orthodromy is also called the arc of the great circle, which is the shortest distance between two points A and B. Orthodromic is not only the line of the shortest distance between points on the earth surface, it also intersects the meridians at different angles as result of the convergence of meridians in the poles.
The latter point is of particular importance, because it is directly related to the choice of equipment. Flight on orthodromy is not possible using a magnetic compass, because the direction of flight would have to be changed from one meridian to the next. That’s impractical and, by the way, not really what our passengers would like.
The line, which intersects the meridians at identical track angles is called loxodromic. It is the shortest distance on a map. Only at the first view really the shortest distance, because a map is just a 2D projection of our spherical earth. A loxodromic route can be considerable longer than an orthodromic route. The longer the route, the bigger the difference. It can be flown using magnetic compass equipment.

With the particular equipment on our Ty-154 we fly on orthodromy using gyroscopes, not gyromagnetic compasses ! Two region specific facts also make that advantegous :

1. There can be magnetic storms more frequently than elsewhere in the polar regions. These are irregular or sudden changes in magnetic variation with a duration from several hours to several days.
2. Magnetic anomalies (due to deposits of magnetic cores in the earth depths) with sharp and significant changes of all elements of terrestial magnetism. The most powerful anomalies are e.g. in Kursk, Magnetogorsk or Kriyoy Rog. In the Kursk region the anomaly can extend up to 6000ft, significantly disturbing aircraft magnetic equipment.

So we fly on orthodromy using gyrocompasses and we make relative movements from one waypoint to the next along our route. For this it's always advised (☺) to know where we start and have a reference. What can we take ? Well, e.g. the takoff runway. Also we want to land on the arrival airport runway using an ILS beam. But these are on magnetic heading. So we have references at magnetic heading, but want to fly along the route with orthodromic course. How can we achieve that ?

Here the ТКС-П2 system in our Ty-154 comes into play. It will be explained very technically in the appendix using a translated text from the original manual. At this stage just a short summary, but still unfortunately a bit physics will be involved. We will work with the system in the two modes ГПК and МК. The system consists of (see picture on page 48):

- two directional gyroscopes ГА-3 (one main and one reserve unit)
- two magnetic induction sensors ИД-3 (again a main and a reserve unit), which determine the direction of the horizonal intensity of the earth's magnetic field. They are used for the correction of the gyroscopes in the azimuth if the ТКС works in the МК mode. They also issue the magnetic heading value to the gyromagnetic БГМК-2 blocks.
- the gyromagnetic compass blocks БГМК-2, delivers gyromagnetic course signals to the "consumers" (instruments) if the compass system works in the ГПК mode
- Correction mechanism КМ-5. It serves for the connection of the induction sensor with the gyro unit when the compass system works in the МК mode. It also serves for the connection of the induction sensors with the БГМК-2 block if the compass system works in the ГПК mode. The magnetic declination can be entered directly into the КМ-5 (useful for flying on true course instead on orthodromic course)

Now the ТКС-П2 working modes can be controlled on the РУ-11 panel :

1. The basic working mode ГПК : Here only one sensing element is used – the directional gyroscope.
2. The МК mode : Here the two sensing elements gyroscope and magnetic induction sensor are combined. Only for short periods for the exhibition of the gyro unit to the magnetic heading. So in this mode the gyromagnetic course is "manufactured" directly in the gyro units ГА-3 .

Enough with the physics, it all comes down to clever switching and combining and every "user" (HSI, RMI and the УШ-3) gets what we want them to indicate. E.g. our orthodromic "conditional" course on the HSI and magnetic headings on the RMI. As we have main and reserve gyros, captains and copilots instruments can have different indications.

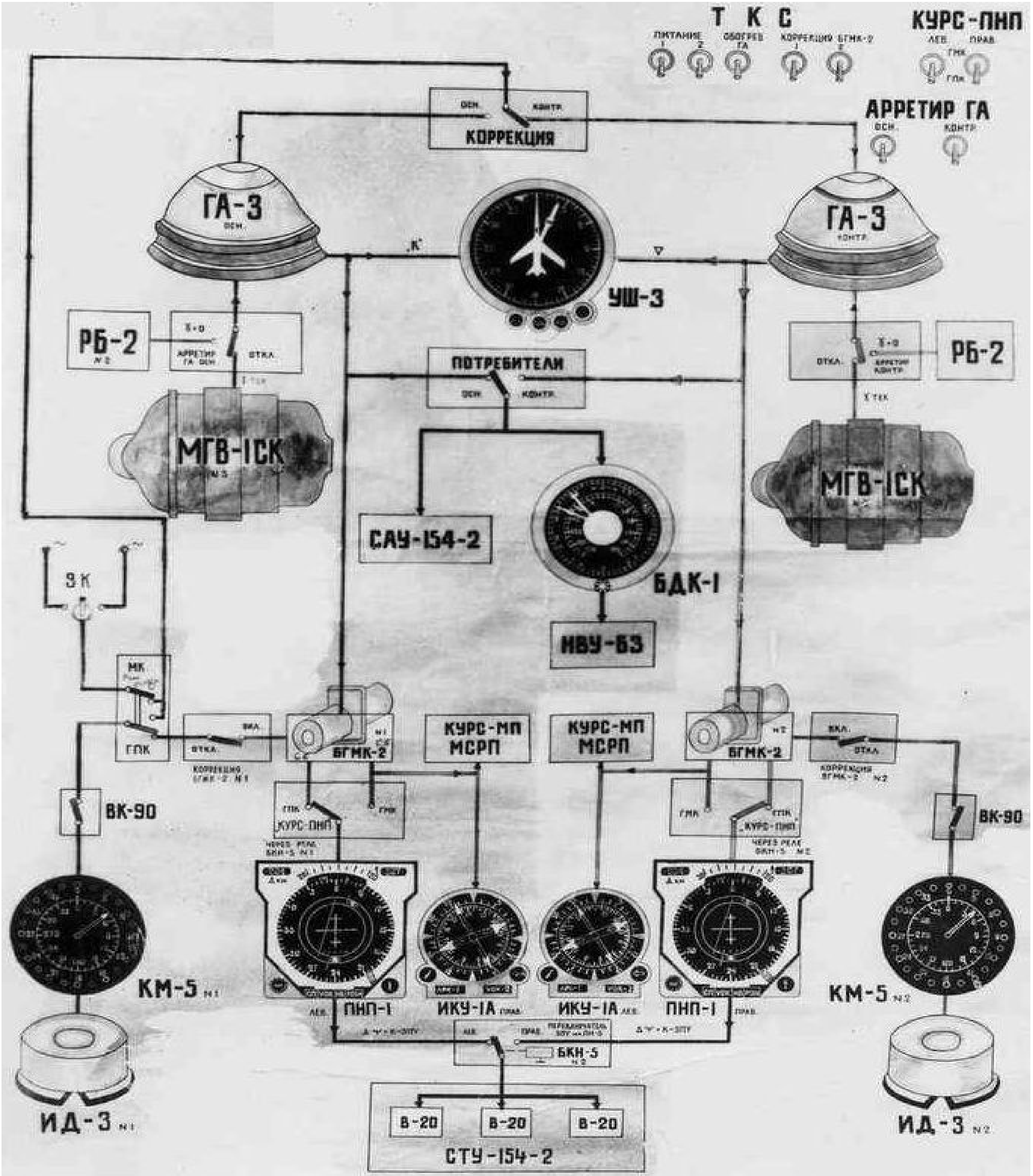
So we want to fly relative from our reference point using gyroscopes. How can the plane “observe” relative movements ? Well, the DISS system and SVS system take care for that. The primarily used DISS measures speed using a Doppler signal (frequency shift after reflection from the earth surface). That’s only effective over terrain and not that much over water. For the latter the SVS system can jump in, which relies on changes in the air (e.g. air pressure).

So we only have to do our compass system alignment as we have during preflight, determine orthodromic distance and course for the route sections and put that in the HBY counters ? No, no, not so fast ☺. We also have to consider changes in magnetic variation and the convergence of the meridians, forcing us to do azimuth corrections. At this stage let me introduce a little diagram, which helped me understanding the system. All we need is a sheet of paper, a pen, a protractor (a “Geodreieck” for the German readers) and a normal ruler.

We fly from A to B. Let’s connect the two points in the horizontal, point B to the right. Through both points we draw meridians, through A exactly vertical. These are our true meridians. Now let’s assume the magnetic declination at Point A is +10 deg. From Point A we draw a straight line to the right of the true meridian at an angle of +10 deg. This is our magnetic meridian. The straight line from A to B, intersects the true meridian at a right angle. We label it LZP to keep the Russian terminology. We will takeoff from a Runway 10 of a magnetic heading of 100 degrees. We draw it at an angle of 100 degress to the magnetic meridian.

Now take the protractor. It represents our compass system. We shall coordinate course at a true rate, which means we arrange it so that zero on the protractor scale coincides with the true meridian. On the protractor you determine the ZPU (in this case OZIPU, please label it accordingly). It is 90 deg ! Then we coordinate the course at a magnetic rate combining the zero scale of the protractor to a magnetic meridian. We define it OZMPU, it is 80 degrees.
First practical conclusion : We can set the magnetic declination in our KM-5 correction instrument, in this case it must be zero in the HBY calculator. But that’s not how it’s done in practice, because then we would fly on the true course. We leave it at zero in the KM-5 and introduce the magnetic declination in the HBY calculator. So we really fly orthodromic course.

Now we taxi to runway 10, align exactly on magnetic heading 100 and we takeoff. We advance the course with the protractor so that the LZP will coincide with 100 degrees. The zero scale of the protractor shows the magnetic meridian. So we did a compass alignment not using a magnetic instrument !
Second conclusion : The declination at the initial point of the route, which we included in the calculation, is the angle of rotation of the beginning compass system scale with respect to the true reference meridian. Just try it, the protractor is our compass system, you must move it parallel with the aid of a second stationary ruler.



ТКС-П2 system diagram

Now, that all sounds quite theoretical and sounds like we have a lot to calculate. One last example (I promise☺). The so called fork (BILKA) sums up the correction due to magnetic declination changes and the azimuth correction due to the meridian convergence. We need it for the final transfer of the compass system to the magnetic meridian of the arrival airport. Here's an example how we can calculate it :

St.Petersburg (ULLI) to Khabarovsk (UHHH).
Magnetic variation at ULLI (ΔM_{ULLI}) = +7 º
Latitude ULLI (φ_{ULLI}) = 60ºN
Longitude ULLI (λ_{ULLI}) = 30ºE
Magnetic variation at UHHH (ΔM_{UHHH}) = -11º
Latitude UHHH (φ_{UHHH}) = 48ºN
Longitude UHHH (λ_{UHHH}) = 135ºE

$$FORK = \Delta M_{ULLI} - \Delta M_{UHHH} + \left(\lambda_{ULLI} - \lambda_{UHHH}\right) \times \sin \frac{\varphi_{ULLI} + \varphi_{UHHH}}{2}$$

And that's the result :
FORK = +7 – (-11) + (30-135)×sin (60+48)/2= +18+(-105)×sin 54 = +18 – 85 = -67

Now, if we fly from east to west the FORK value must be taken positive. So, if we have made our compass system alignment according to the runway heading at ULLI, over UHHH you would have a magnetic heading of 67 degrees more than your orthodromic heading on TKS-P2. Consequently, for flight from west to east, the Fork value is taken negative and the heading will be reduced accordingly.

Hmmm, that's fine, but we want to fly and not do a math exam. Fortunately kind and wise people have solved the problem of manual calculation and have written different programs for the automatic route calculation. One of the most popular ones was Ariadna - a DOS program with a great route base, which calculates NAV settings for russian systems, shows route on chart and prints the data. But it's not very userfriendly like many programs of that period... and it is useless in MSFS because Bill Gates has his own opinion on magnificant variations all over the world - they differ from Ariadna (and Jeppesen) ones.

But to our rescue the Project Tupolev authors created programs (one internal calculator in the plane – Shift-9 -, and the external NVUCalc program) to calculate HBY data automatically. I recommend to use the external program, as explained above in Chapter 3.5.3.1 and below in the example flight.

The NVUCalc program delivers the ZPU courses and the distances S, which we can directly enter in our HBY system. By convention the S distances must be entered with negative sign. For the final transfer of the compass system to the magnetic meridian the HBY Calculator also delivers the fork (BILKA) value.

And now back to the practice, let's get it all together in an authentic example flight ...

6. Example flight Moscow – Nishny-Novgorod UUEE-UWGG

Introduction

For this example we fly from Moscow (Sheremetyevo Airport) - UUEE to Nizhniy Novgorod (Strigino) - UWGG.

We start with a quick repeat of the orthodromic concept – can't be mentioned often enough :

As we all know, the earth has the form of a geoid or a sphere, the latter being a close approximation of the first. If we look at a geographical (or navigation) map, we will quickly notice the meridians change not parallel and converge in the North and coordingly in the South.

Orthodromy is the shortest distance on the earth's surface between two points. It's a straight line, connecting two points on the earth's surface. On the map, which represents a flat projection of our geoid, it will have the form of a curve, convex to the side of pole (we "activate" our three-dimensional imagination!)

For clarity it is possible to represent this convexity in the form of a straight line. Let us connect Novosibirsk and Moscow with a straight line. What do we see? Our route intersects the meridians at different angles. Let us split the route in sections in the quantity of the meridians. Since the course of the aircraft is measured from the northern meridian at each point, let us measure the course (track angle) of each section. Again what do we see? In each section there will be a new track angle! But the line is still a straight line! Hmmm, so to fly the shortest distance we must always calculate a new track angle ?

Fortunately not, some clever brains introduced the orthodromic course.
The basis of the counting starts at the meridian of the departure airfield (it is called its reference meridian) and for the elongation of entire route course the track angle will be counted relative to it ! With this the track angle will be constant.

Finally we land at the arrival airport. For this it is necessary to lead our compass system to the meridian of the arrival airport. To achieve this we have to add (with sign!) the azimuthal correction (angle of convergence of the meridians). In this case the azimuthal correction is the angle between the meridian of the airfield of takeoff and the meridian of landing airfield. But generally the total declination is equal to the sum of declinations in each waypoint.

So we have to transfer our compass system (how this is done – see below) and that's it. Let us memorize all this and go further.

Part 1. Flight Preparation

For a “serious” flight we should have the following documents on board:

- Airport charts (taxi chart) and SIDs (Standard Instrument Departure routes) for Moscow Sheremetjevo Airport,
- Airport charts, STARs (STandard ARrival routes) and Instrument approach charts of Nizhniy Novgorod (Strigino).
- Loadsheet / fuel planning and the HBY Flightplan

Three important charts are included further below,. Complete chart sets are available at www.vatrus.net.ru, look in the download section. Our route for today will be :

BP VINLI RW DAKLO SF CW RP MB - 266 nm/ 492 km FL331,

Our cruise altitude will be 10100 m (33100 ft).
We load the HBY Calculator, enter the waypoint coordinates without forgetting to fill the magnetic declination fields of at least the departure and arrival airport (taken from maps or programs like FSNavigator – with the latter the sign must be reversed !). After calculation, we should obtain something similar to this :

А-т вылета	**А-т назначения**	**Расстояние**	**Вилка**							
UUEE	UWGG	491.1	+3.4							
ППМ	Широта	Долгота	ОЗМПУв	ОЗМПУп	S	Пв	Пп	dM	МПУ	
UUEE	55 58.59 С	037 26.55 В	111.2	114.6	17.2	0.00	-3.44	+08.3	111.2	
BP	55 54.00 С	037 41.00 В	101.1	104.5	11.0	8.50	5.06	+00.0	109.6	
VINLI	55 52.00 С	037 51.00 В	120.2	123.6	29.5	8.64	5.19	+00.0	128.8	
RW	55 42.00 С	038 13.00 В	100.4	103.9	27.7	8.94	5.50	+00.0	109.3	
DAKLO	55 37.00 С	038 38.00 В	85.1	88.5	86.2	9.28	5..84	+00.0	94.4	
SF	55 33.00 С	040 00.00 В	61.2	64.7	116.1	10.41	6.97	+00.0	71.6	
CW	55 52.00 С	041 46.00 В	82.4	85.8	87.7	11.57	8.43	+00.0	94.3	
RP	55 48.00 С	043 10.00 В	106.6	110.1	44.6	13.03	9.59	+00.0	119.7	
MB	55 36.00 С	043 47.00 В	346.7	350.1	71.2	13.54	10.10	+00.0	0.2	
UWGG	56 14.47 С	043 47.29 В						+10.1		

We study the airport charts and memorize (or outline the taxing route on the map) the taxiing route. We will takeoff from Runway 25. We study the departure chart and find we have to follow a course 246 (from 25R) right after takeoff. Our first waypoint point is Chelobit'evo (BP or in Russian БП). As we see, there are two possible routes : БП 25E or БП25Д. But we should notice a small, but important note : БП25Д is permitted ONLY in day time - 0800-.2200 h - local time. It’s always a good idea to follow the rules. In reality, aircraft very often leave the approach zone and pass above the forbidden zone.

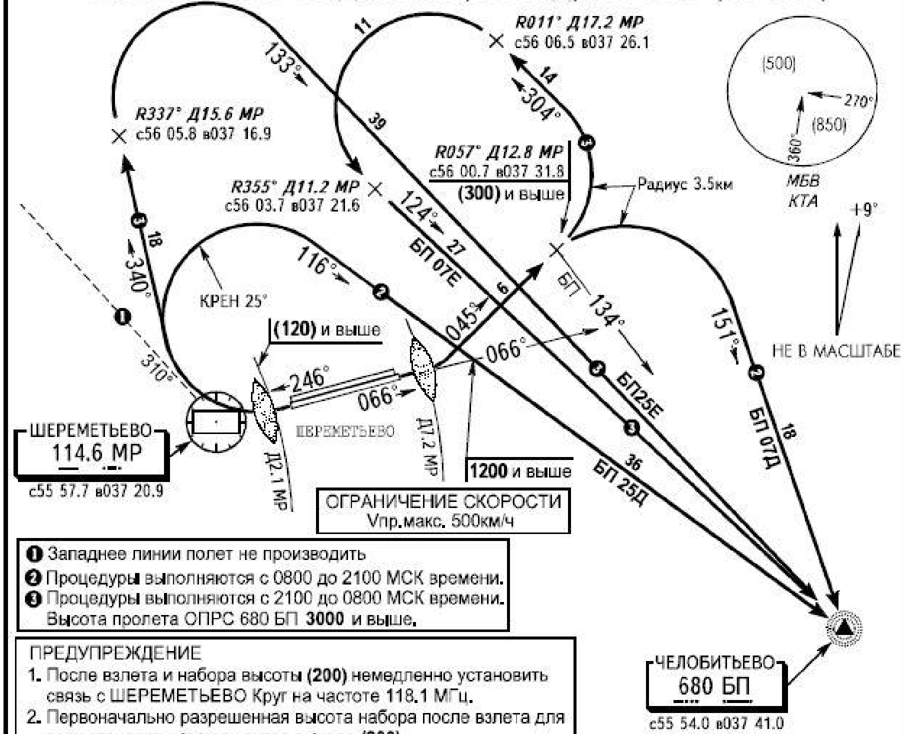
ВЫХОД | 5 сен 02 | **5В-2**

ВПП: 07Л/П, 25П/Л

МОСКВА, РОССИЯ
ШЕРЕМЕТЬЕВО

ШЕРЕМЕТЬЕВО Старт **131.5 120.7 124.0** п/з ШЕРЕМЕТЬЕВО Круг **118.1 124.4**	Эшелон перех: **по указанию** Высота перех: **(900)**

ЧЕЛОБИТЬЕВО 07 ДЕЛЬТА (БП 07Д), 07 ЭКО (БП 07Е)
ЧЕЛОБИТЬЕВО 25 ДЕЛЬТА (БП 25Д), 25 ЭКО (БП 25Е)



❶ Западнее линии полет не производить
❷ Процедуры выполняются с 0800 до 2100 МСК времени.
❸ Процедуры выполняются с 2100 до 0800 МСК времени. Высота пролета ОПРС 680 БП **3000** и выше.

ПРЕДУПРЕЖДЕНИЕ
1. После взлета и набора высоты **(200)** немедленно установить связь с ШЕРЕМЕТЬЕВО Круг на частоте 118.1 МГц.
2. Первоначально разрешенная высота набора после взлета для всех стандартных маршрутов выхода **(900)**.

W км/ч	200	240	280	320	360	400	500	600
V_B м/с	3.1	3.7	4.3	4.9	5.5	6.1	7.6	9.1

Данная процедура выхода требует выдерживать минимальный градиент набора 5.5%.

Процедуры по борьбе с шумами должны выполнять постоянно все ВС в соответствии с Приложением 16, главы 2, 3 ИКАО.

ВЫХОД	ВПП	МАРШРУТ	ВЫСОТА
БП 07Д	**07Л/П**	С курсом взлета набор высоты с максимально возможным градиентом согласно РЛЭ данного типа ВС, при пролете БРМ обратного старта (Д7.2 МР) ЛЕВЫЙ разворот на МПУ 045° **в точку R057° Д12.8 МР, ПРАВЫЙ** разворот (радиус 3.5км) **на МПУ 151°, выход на ОПРС БП с** набором заданного эшелона.	Пролет R057° Д12.8 МР **(300)** и выше.
БП 25Д	**25П/Л**	С курсом взлета набор высоты с максимально возможным градиентом согласно РЛЭ данного типа ВС, на удалении Д2.1 МР ПРАВЫЙ разворот на МПУ 116°, выход на ОПРС БП с набором заданного эшелона.	Пролет створа ВПП (R067° МР) **1200** и выше, 680 БП **1500** и выше.
БП 07Е	**07Л/П**	С курсом взлета набор высоты с максимально возможным градиентом согласно РЛЭ данного типа ВС, при пролете БРМ обратного старта (Д7.2 МР) ЛЕВЫЙ разворот на МПУ 045° **в точку R057° Д12.8 МР, ЛЕВЫЙ** разворот (радиус 3.5км) на **МПУ 304 до точки R011° Д17.2**, ЛЕВЫЙ разворот на МПУ **124°, выход на ОПРС БП с на**бором заданного эшелона.	Пролет: R057° Д12.8 МР **(300)**, 680 БП **3000** и выше.
БП 25Е	**25П/Л**	С курсом взлета набор высоты с максимально возможным градиентом согласно РЛЭ данного типа ВС, на удалении Д2.1 МР, ПРАВЫЙ разворот на МПУ 340° до точки R337° Д15.6 МР, ПРАВЫЙ разворот на МПУ 133°, выход на ОПРС БП с набором заданного эшелона.	Пролет 680 БП **3000** и выше.

For the inhabitants of Zelenograd, for example, there is a form of sport : write down identification numbers of Aircraft and report them – not to the advantage of the involved pilot ☺.
To continue, we have to climb with a maximally possible climb gradient according to the operating manual. At D2.1 MP fly a right turn with 25 degrees bank to a magnetic heading of 116 deg and go directly to Челобитьево (Chelobitevo) BP including further climb to our assigned altitude. From Челобитьево (Chelobitevo) we continue via ВИНЛИ (VINLI) and to the NDB Марьино.
The route is very short, we will not have much time to drink coffee, so it's a good idea to study the complete route right now. Let us assume the wind will blow from the south, so we prepare for a landing on Runway 18. From the charts we can see we have to approach from West, which means we will be on the corridor from Сосновское to Чернуху. Looking at the approach chart for Runway 18 we see from Чернуху we have to continue on course 004 to the intersection with radial 95 and distance 20 KM from the RSBN station. Then the base leg (third turn) at MPR (МПР) of 236 degrees.

Yes, you guessed it, we also need fuel. We use the new Loadmanager and calculate for a distance of 492KM, cruise altitude 10100 m. The result :

Total fuel – 12038 KG
Maximum takeoff weight – 85377 KG
Maximum commercial load – 18000 KG

We use a layout of 164 seats, include the kitchen, plant the passengers on the seats and load baggage, e.g. to a final result of slightly more than 81100 KG. Center of Gravity 26%. You can use more or less passengers, but not more than 85377 KG. The reason for this is the landing weight limitation. This weight will lead us after the calculated fuel consumption during flight to a landing weight of 78t. This is the maximum landing weight for normal operation.
According to our takeoff weight and estimated landing weight we extract Vr, V2 and Vref speeds from the tables in the manual (see appendix) :

For our example : Vr = 244 km/h, V2 = 255 km/h, Vref(45) = 265 km/h

Flight Preparation finished, we start the simulator.

Part II. Preparation of the aircraft for departure

First step : We load fuel in the correct order as advised in the Loadeditor. We select Gate 55, not too long taxi route then. All paperwork (charts, HBY Flightplan, VOR and NDB frequencies, checklists) on board.

Our plane is in cold and dark state, we need electricity first. We will preserve the batteries, so we set the three-way switch ВСУ-ВЫКЛ-РАП to the lower position (ground power). Let's start the BCY (APU) :

- starting switch to the position запуска
- Switch «Запуск – холодная прокрутка» - to the position «запуск» (starting)
- Shut-off valve (Пожарный кран) - to open (upward).
- press the button ПУСК (LAUNCHING) and wait 3-4 seconds.

BCY started, all excellent. If not, you might have a not registered FSUIPC version. Ok, we feed the circuits from the BCY now, set the switch ВСУ-ВЫКЛ-РАП to the upper position.

What, just 15 minutes remaining until departure ? Well, enough time to start the engines and taxi to the runway. The purser reports cabin ready, the flight engineer reports doors and hatches closed, wheel chocks removed, all ladders removed, no warning lights on the signal panel of proper working order, keys on board, seatbelts fastened and so on.

After permission for pushback, we do so and contact the controller again :

"Sheremet'yevo ground, gate 55, information alpha, request startup". The Controller permitted starting, we confirm and continue with engine start.

Part III. Starting

Engine startup has already been described, so at this stage just the necessary steps are mentioned again :

1.The engine startup area is opened by clicking on the right side with the right mouse button.
2.The РОД levers at the bottom left must be in upper position (levers below to the left)
3.The Warning light «Готов к запуску» on the BCY panel shall not be lighted. If it does, hold the «отбор воздуха» (air bleed) switch for around 8 seconds until it disappears.
4. Switch the center delivery tank (the 4 switch assembly) and the wings tanks fuel pumps on (4th tanks only if in use). For the wing tanks and the 4th tank this is really not necessary, if we put the switch АВТОМАТ РАСХОД in automatic mode (upper position).
5.Switch the shut-off valves, the fuel quantity indicator and the automation level mode on.

Engines started, so we also start the clock. Correct takeoff conditions also means the engines must warm up for 8 minutes – this can include the taxi period. After starting we don't forget to switch the generators on. And we switch the nav lights - СМИ «мигалки» on !
And oh, if we takeoff at night, we must also switch the beacons (БАНО) on, for startup already !
Even easier - For pushback we switch on БАНО and СМИ independent of the time of day !

To continue, we switch on all needed avionics and systems on the overhead panel. All switches on except the switch ПНП ГПК – ГМК : we leave it in position ГМК for now. So we do not touch the connected switches.
We switch on the heating ППД (pitot heat):
- 1 minute at positive temperatures $+5^{o}$ and above
- 3 minutes at temperatures $+5^{o}$ and below
- from the beginning of the taxiing under possible icing conditions – below $+5^{o}$, wet , snow, drizzle.

We set the ПКП (ADI) to operating position – open the panel Shift+2 or Shift+3, open the covered switch, click and hold until the ПКП (ADI) is aligned.

On the upper panel we click above and below the BKK-test switch.

Continue with the TKS-P2 alignment as described in chapter 3.3.3.2. Quick summary :

1. On the ПУ-11 control panel we set the latitude of Sheremetyevo Airport (55 degrees, 58 minutes)

Navigator remark : Such accuracy is not mandantory, +/- 10 deg for the Latitude entry is already OK. It is possible to use a route average Latitude, the error will be still within standard .

2. Switch МК-ГПК-АК to the position МК
3. Switches ПОТРЕБИТЕЛИ and КОРРЕКЦИЯ (Consumers-Koppelkurs)- to the position ОСН.
4. Press the alignment button («СОГЛАСОВАНИЕ») until the rotation of the ИКУ scale (pointer УШ-3) stops.
5. Switch КОРРЕКЦИЯ to the position КОНТР.
6. Again press «СОГЛАСОВАНИЕ» until the rotation stops on the PNP (HSI).
7. Set the switch МК-ГПК-АК in the position ГПК
8. Repeat the alignment in two steps as decribed above.
9. On the overhead panel set the ПНП switches to the position ГПК.

On the ПНП (HSI) set the takeoff course 246, we set the PB (radio altimeter) to 0.

On the УВО (altimeter) set the barometric pressure of the airfield, obtained from ATIS in millimeter of mercurys.

Set the device handle for the centering in the correct position, according to the actual centering:

From 21% to 28 - " П ", from 28% to 32% - " С ", from 32% to 40% - “ З ”

Set the trim tab neutrally.

Continue with tuning of the navigation equipment:

1. КУРС-МП № 1 on the ILS frequency of 25R - 111.3, takeoff course - 246
2. КУРС-МП № 2 – on the VOR frequency 114.6
3. Left ARK (ADF) on БПРМ (outer marker) - 770 (in the left window, switch on top - to the left).   In the right field set the frequency of the NDB following Chelobitevo along the route : This is the NDB - Марьино - at 493.0.
4.Right ARK (ADF) on NDB Chelobitevo 680
5.In the right device the second ARK (ADF) to the NDB of Cherusti -410.0

Switch DME1-RSBN-DME2 to position DME2 (VORDME Sheremet'yevo Airport on the second КУРС-МП)

Now tune the НВУ.

1. Set the НВУ - toggle switch СЕТЬ on the block В-51
2. On the block В-140 - we set the ЗПУ (ZPU) value of the first and second waypoint.

Remark : For a more precise flight I recommend in this case the start of НВУ numeration above the first waypoint, in our flight this will be BP (Chelobitevo, Челобитьево). Consequently the ЗПУ (ZPU) of the 1st section must be 101.06 (see calculation of 101.1 degree, 0.1 – this is the tenth of degree, for the installation in НВУ each tenth it is equal to 0.6)

But that means on the second block, we already have to enter the ЗПУ of ВИНЛИ (VINLI) - 120.12 degrees.

But : It is also possible to include НВУ numeration right after takeoff. In this case we have to consider, that the course of the first section is calculated from the airfield control point (КТА) to Челобитьево (Chelobitevo). It does not coincide with the pattern, which we have to fly according to the standard instrument departure to Челобитьево (Chelobitevo) in the chart. In this case there will be a certain lateral error in flight. It is possible to fly, but in any event the automatic flight on НВУ (and generally flight on НВУ) must be started at a point, which ensures a minimum error.

Sideremark : The Navigator nevertheless recommends starting the numeration right after the takeoff. In this case we consider, that the data on the НВУ *blocks must be set respectively on the first block.* ЗПУ *and distance to the first waypoint from the airfield control point from the (KTA). Even better exactly from the point where we start the numeration.*

3. On the block B–51 set the selector switch to the position S.
4. On the upper block B -52 set the distance from Chelobitevo to Vinli : 11 km with the negative sign. (it will appear in the window) to the left and below S. On the V -51 block there are buttons with pointers (click and hold with left or right mouse button !).
5. Switch to Sп, on the lower block B-52 set -S (29.5) of the following section (Vinli - RW). Use the buttons with the pointer, but now distance will appear exactly at the lower B-52, in the bottom "line".
6.Set the ЛУР switch (turn anticipation) to 5 km (the turns along the route have small angles).

With the system in Position Sп - in this case, with the introduction of distance for the following section, it will appear in the second "line" of the INACTIVE B–52 block. That means we fly the first section, then the inactive block will become active, since we fly already along the second section, and we tune on the now inactive 1st block to the third section. On the B-140 we set the ЗПУ of that section, on the B -51 we set –S with the aid the buttons. So far, so good.

Translator remark : To ensure correct data entry, I have shown the data entry for the first two waypoints again in the appendix using screenshots and numbered switches (page 129).

In the real plane we check the work of control elements or leaks at this stage (visually, with the aid of the ground-based technicians). The latter might indicate a problem in the hydraulic system.
The outside walkaround can be simulated using an exterior view (Active Camera is a useful utility here, but it's payware in FS2004 unfortunately).

We extend and set the headlights to the taxiing position. So we are ready for taxiing.

PART IV : Taxiing

Visually inspect the surroundings for interferences – captain observes to the left, copilot to the right. Report about any interferences and of course also their absence. Don't forget to include the nosewheel steering mode by setting switch on РАЗВОРОТ КОЛЕС and the 10-63 switch into the 63 position.The plane starts moving at higher than 69% thrust (a bit less in real life, but that’s not important). We advance the levers smoothly and accurately. Right after taxiing we verify proper working of brakes (by single smooth braking).

We taxi according to the taxiing chart - on the taxiways РД 20 – РД 5, on that route we do not cross other taxiways or runways (do not take an example with the AI in MSFS, which behaves like Moscow drivers in a traffic jam). During taxi we extend the flaps to 28 degrees, also we check the synchronization of release and transfer of the stabilizer to position -3 (or -1.5., if the centering is average).

Before reaching Runway 25 R we contact Ground again.

- 395 on taxiway 5
or
- 395, on the holding point.

Ground: "395, contact Tower "

We confirm and continue as instructed: "Sheremetyevo Tower, 85395, information alpha (or what is appropriate), at holding point 25 right ".

After permission to enter the runway, we turn to the runway and we align exactly with the runway heading. Then we switch the front wheel turning angle switch to the position 10. The warning light «К взлету не готов» (not ready for takeoff) must go out. If not - we check again - the wheel turn mode switch must be turned on, angle of turn - 10 degrees, boosters switches set and cover closed, Flaps in takeoff position - 15 or 28 degrees. Spoilers must be retracted.

We check if the course on ПНП и ИКУ correspond to the takeoff course of 246 degrees. If not, we must repeat the alignment on the actual course.

We look at the clock - 8 minutes of warming up after engine start for the takeoff must have passed and we look at the heating ППД... If everything looks convincing - we fly!

Part V. Takeoff, the climb, flight along the route

- 395, ready for takeoff
- 395, cleared for takeoff, pleasant flight!
- 395, cleared takeoff, thanks, all is well!

We command to the flight engineer: "takeoff (nominal) thrust, РУД (thrust levers) hold!"

84% thrust is smoothly reached, we keep the aircraft on the brakes. We set the headlights to “landing” position and start the clock again. Then we increase to the takeoff thrust, release brakes and off we go.

On wet or snowy conditions : thrust 84, release brakes, and then takeoff thrust and go ! But for the most realism in dry conditions hold the brakes until the nominal takeoff thrust is reached.

"Crew, we take off! Boundary 244" (or whatever according to the calculation). (Translator remark : With boundary here the V1 speed is meant !

In crosswind we correct by downwind pedal deflection. In really heavy crosswind we slant the ailerons against the wind. With rapidly increasing speed the reaction to the deviation will grow sharply – please keep that in mind.

At the Vr speed we decide to continue or to reject takeoff. Speeds counted, all is well, Vr reached, smoothly pull on the yoke (or stick) and the aircraft takes off. In the worst case it continues to run, which tells us something about an incorrect load, your aircraft weight is maybe 110 tons (☺) or the stabilizer is placed incorrectly.

Let us reach the safe speed V2 and at the height of 5-10 meters we retract the landing gear. We continue the climb with a simultaneous speed increase. Just calculate a bit so that the speed at the altitude of 120 meters the speed the would be 330 kmh. At an altitude of 50 m we turn off and stow the headlights.

At altitude 120m and speed 330 we retract the flaps to the position of 15 degrees, and at speed 350 we retract the flaps to 0, we accelerate the aircraft toward the end of the Flaps retraction to a speed not less than V0 - the safe flight speed in clean configuration (Flaps and gear retracted and no more limitations on the slats, stabilizer and so on (see AOM).

During all that, at 2.1 MP we execute a right turn with 25 deg bank to a course of 116 deg and continue towards BP. Again simulataneously, after reaching an altitude of 450m we set the climb thrust. But with a low takeoff weight, as in our flight, we can already set to climb thrust after Flaps retraction. But at an altitude not less than 200 m ! We accelerate to a speed of 500 km/h. At the transition altitude 900 m we don’t forget to set the pressure to 760 mm (1013 Hpa)

We fly. It is now already possible to set the autopilot in the roll capture and pitch mode. For this we set the switches on ПУ-46 : КРЕН and ТАНГАЖ and we press the СТАБ button. Now we can guide the aircraft from the РАЗВОРОТ (turn handle) and СПУСК-ПОДЪЕМ (climb-descent) wheel on the ПУ-46.

But it is also possible to fly manually – just as you please (and in conformity to the AOM !).

On route to Челобитьево (Chelobitevo) we further gain altitude and simulataneously accelerate to a speed to 550 kmh (regime MD) or 575 kmh (regime mCi). Regime MD is commonly used.
If you are in autopilot mode just press the V button on the ПУ-46 panel. This will force ABSU to keep the current indicated airspeed by changing pitch.

300 Meters prior to 3000 we report (85395 initially cleared to 3000) about approaching 3000. ATC gives permission to continue to cruising altitude (or a higher intermediate height), what we confirm.

We pass Челобитьево (Chelobitevo), it is possible to determine this according to the turn of the ADF pointer. We switch the HBY numeration on (if the first section is Chelobitevo – Vinli, as discussed earlier !).

Navigator Sideremark: And nevertheless I insist to start of numeration in the takeoff process... Author: Yes if you please, no one against that. Just as you please. ☺

Now we can rest and set automatic flight on HBY signals. For this :

1.) We click the button СБРОС ПРОГРАММ on the ПН-5
2.) We include switch «Подг. навигации»
3.) We click the НВУ button on the ПН-5.

On the НВУ administration block we set the turn anticpation (ЛУР) to 5 KM (or 10KM if you please)

We switch the first ADF (ARK) to Марьино (set to the right) and we tune it to the following after the Черустей route.

We have two ADF (ARK). For each ADF we can set two frequencies, so we have two frequencies we can set preliminary. For convenience, we can tune the ADFs as follows: Let us designate NDBs on our route sections - A, B, C, D, E, F. We tune the ADF windows in this order : A, C, B, D.   So : When we pass section A, the yellow pointer of the first ADF will turn itself and indicate downward, the thick pointer of the second ARK will show upward to the frequency of B. The pointer of the second ARK will turn downward after the flight to station B. On the panel of the first ADF we place the switch in the right position – the yellow pointer will indicate upward to station C.

Since station B is no longer necessary, we tune the frequency of station D and so on. This is nowhere in the instructions - we simply do it this way, as we feel it is convenient. It is a creative process though, so everyone can handle that as he pleases.

All is great, but we do not rest and think about noise avoidance, as we fly over very crowded regions. We pass ВИНЛИ (VINLI), the change of blocks occurs automatically on the НВУ. The aircraft turns to the right to ОМПУ 120.12. We do not lose time and we tune the now inactive block B-140 and B -51. We set the ЗПУ of 100.24, the distance 27.7 (in the left S window, since we take negative values). The switch on the B-51 block must be in position Sп.

Some insider info : If we determine a route drift (e.g. from the ADF pointers, which are then not showing straight up) and Z on the active block shows 0, it is possible to correct this deviation :

1. On the B-52 block we move to the Z setting
2. Using the buttons with the pointer we introduce a lateral deviation correction into the
   (means we change Z in the window)

To keep everything smooth, we do not correct a lot – maybe 0.5 - 1 km.

Analogously it is possible to correct the current distance in the section - for example, we see a remaining distance of 140 KM to the next waypoint on the НВУ. A VOR connected to that next waypoint shows 135 KM. We move to the S setting on the B-52 and insert the correction into the current distance.

Again a creative process – but think about VOR slant ranges when you do this corrections !

... we pass Марьино (RW), blocks on НВУ were switched, we enter the ЗПУ following after the DAKLO section (85,06) and distance with negative sign 86,2 in the now inactive blocks. We do not forget to position the selector in Sп!

We foresee (“lead”) the ADF frequencies along our route, as advised above.

We approach our cruising altitude of 10100m. 200 meters before reaching it we smoothly decrease the vertical speed using the wheel on the РУ-46 (not more than 5 m/s, better only 1-2 m/s) before we switch to the Altitude Hold mode (button H).
We maintain the Mach number according to the MD regime for the assigned weight.
In the real world at SIAT (Sibaviatrans) we used 0.8M, at "Siberia" we hold 0.82M.
Engine thrust 88%, which corresponds to a fuel consumption of approximately 6000 kg/hour (see the flight engineer panel).

AUTOTHROTTLE DURING CRUISE IS BY ALL MEANS FORBIDDEN !!!

We set the РСБН to Стригино (Strigino). On the РСБН control panel – we set the left switch to number 2, the right one to 6. We get 26 - 1 channels. We include the two switches on the overhead referring to РСБН. In this case we have to remember the right КУРС-МП will not work anymore (special Sim feature).

And we continue to fly further. Does it make sense to describe the НВУ blocks switching along the route and further waypoint entry ? I don't think so, everything is analogous.

Part VI. Descend and landing approach

So, our calm cruise flight soon comes to an end, we are close to the most critical part – the approach and landing phase. For a quick rule of thumb calculation regarding an ideal descent gradient we divide the distance by 20. For 200 km remaining distance we get an altitude of 10 km, for 50 KM distance we get 2500m. If we know the groundspeed, we can easily calculate the necessary vertical speed. It's ideal, because in reality the controllers might give you intermediate altitudes, but you get the idea.

We have studied the charts for «Стригино» (Strigino) already and check ATIS information. For this tutorial we just assume we will get Runway 18R. The approach according to the chart is constructed from Чернухи to the outer marker beacon.

Cruise altitude 10100, let us begin to descent 200 km prior to the third turn (turn to base leg). From Чернухи to the ILS we have 69 km, and we add from the ILS to the third turn 15 km, which sums up to 84 km. From Сосновского (RP) to Чернухи (see HBY calculation) we have 44 km, and from the CW station to Сосновского (RP) 87 km. Total summary : 84 + 44 + 87 = around 215 km. It means, we will begin the descend 15 km after passing the CW navaid (Красная Горбатка). We can check this distance on the HBY. Before the descent it is necessary to do the compass system alignment regarding the transfer to the magnetic meridian of the arrival airport.

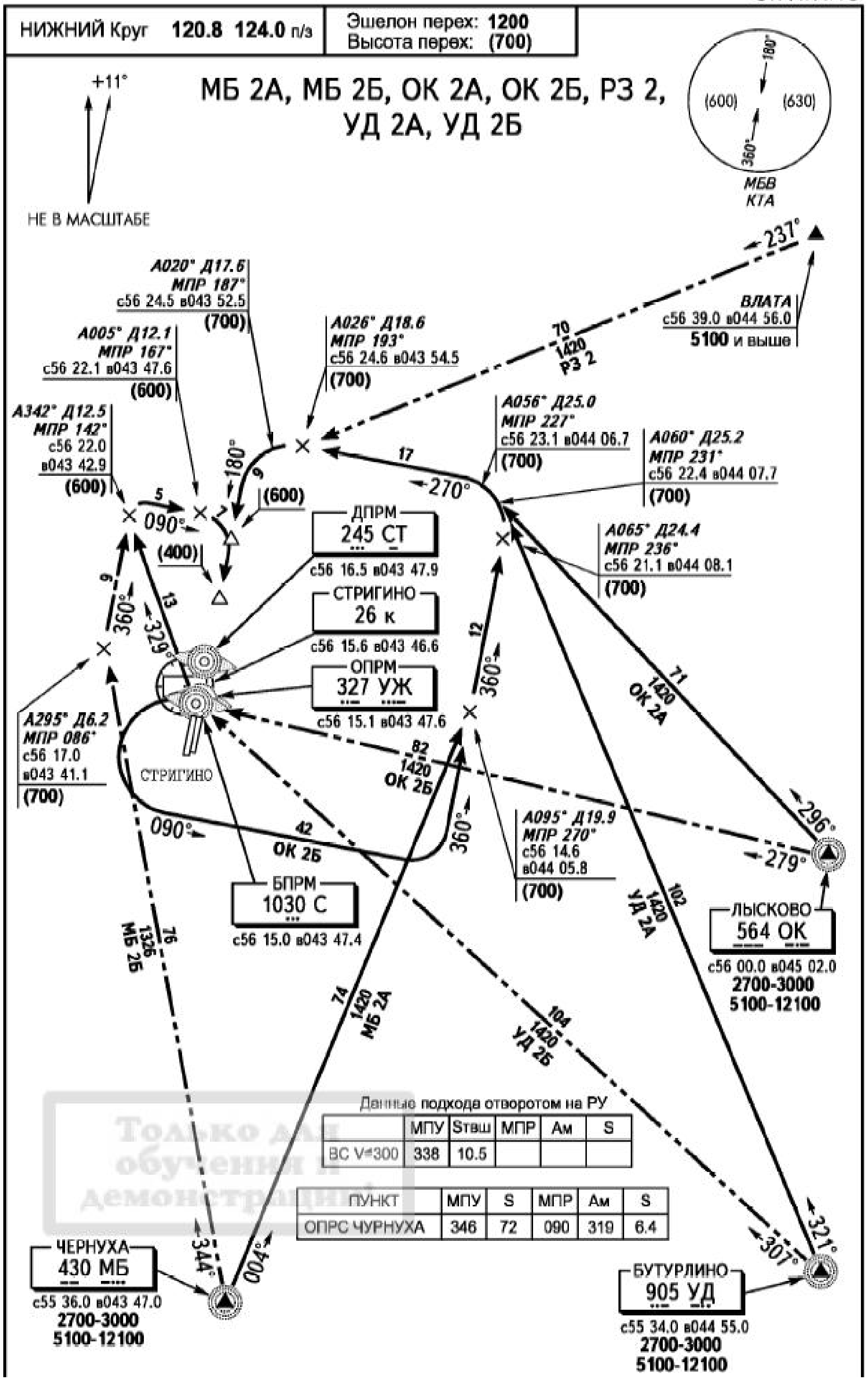
1.) First of all disconnect НВУ automatic flight (otherwise the aircraft will turn following a change in the course on the ПНП - HSI with the alignment). For this we turn the switch «Подг. Навигации» on the ПН-5 off.
2.) Transfer the reserve gyro unit - ПНП of the Copilot and the Captains ИКУ (and triangular index on the УШ-3). For this set the right switch on the ПУ-11 to the position КОНТРОЛЬНЫЙ.
3.) Our Вилка (Fork) value (summary of azimuth corrections) is +3.4 degress, more generally +3 degrees. That means after the transfer our course on the PNP (HSI) must differ from the previously flown course by 3 degrees. If we fly to Красную Горбатку with a course of 61 degrees, after transfer we should have a course of 64 degrees.

ПОДХОД
ВПП: 18Л/П

5 сен 02 | Б-1

НИЖНИЙ НОВГОРОД, РОССИЯ

СТРИГИНО



Данные подхода отворотом на РУ

	МПУ	Sтвш	МПР	Ам	S
ВС V≤300	338	10.5			

ПУНКТ	МПУ	S	МПР	Ам	S
ОПРС ЧУРНУХА	346	72	090	319	6.4

ПОСАДКА 1 янв 99 И-1

НИЖНИЙ Посадка **120.4** **124.0**

НИЖНИЙ НОВГОРОД, РОССИЯ

СТРИГИНО

ИЛС ВПП 18Л

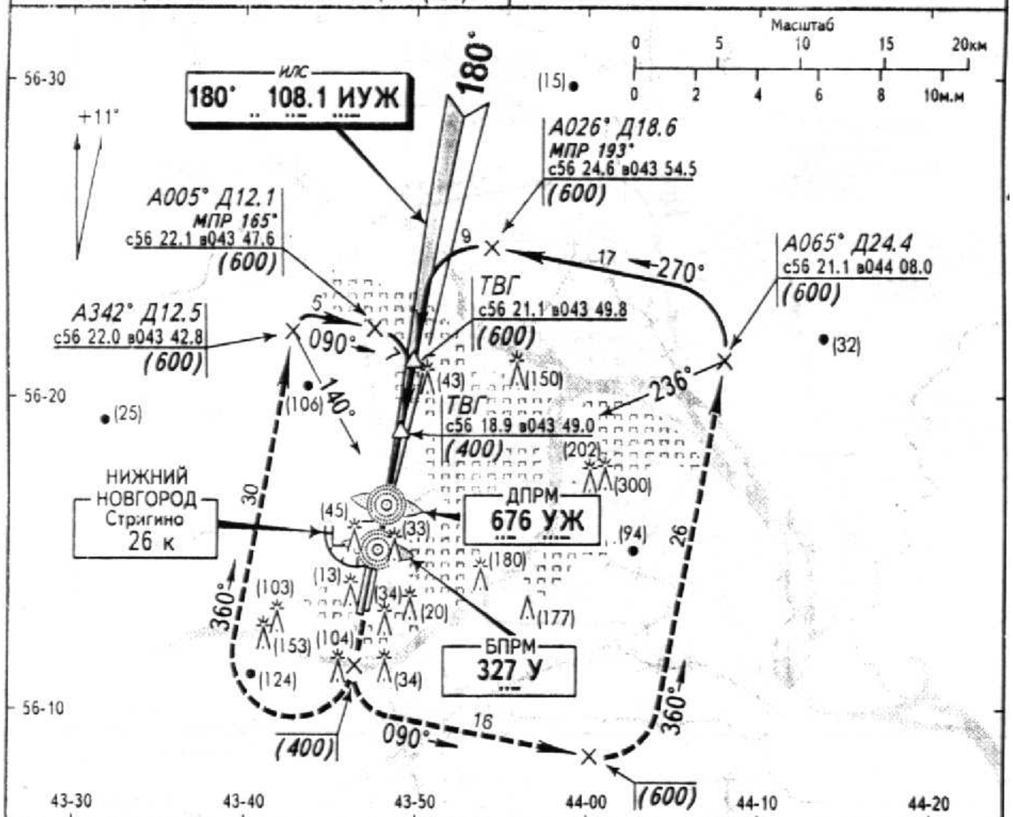
КРМ **108.1 ИУЖ**

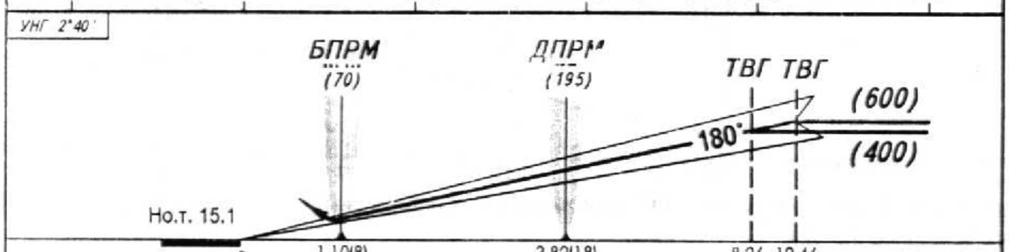
(600)

МБВ *КТА*

Нaзр. **78** *Hпор.* **77.5**

Эшелон перех: **1200** Высота перех: **(600)**





УХОД НА ВТОРОЙ КРУГ: Набор (400), ЛЕВЫЙ разворот с набором (600) на МПУ 090°, далее по схеме захода.

ПОСАДКА ВПП **18Л**

	ИЛС КАТ I	
A	60 X 800	
B	60 X 800	
C	60 X 800	
D	60 X 800	
Норм.	60 X 600	

ПОСАДКА С КРУГА
ВС V < 300 Шпм - 4.0
КРУГ 18П

	МПР	Ам	S	H
3 разв.	152	341	13.0	(600)
4 разв.	168	351	13.5	(600)

	РСБН	Zо,м	Sо,м

4.) Now the transfer. With the course knob on the РУ-11 (knob 6 on Page 29) we turn the triangular index on the УШ-3 to course 64 degrees, then we switch the right switch on the РУ-11 to the position ОСН (ОСНОВНОЙ) and we turn the pointer with the index К on the УШ-3 to course 64.
5.) We click the alignment (согласования) button

We repeat for both positions of the switch «КОРРЕКЦИЯ» to the two БГМК channels!

The heading is now transferred to the magnetic meridian of landing airfield Nizhniy Novgorod. Now on the НВУ we have to set the courses, which are given in the ОЗМПУп column . Finally on the overhead panel we disconnect the BGMK correction (two switches) and on the ПН-6 we set the switch to POS.
Work of navigator is done, now we "move" to the Copilot. We should calculate the landing data – weight, centering and speed on the glide path with flaps 45 and 28, and the landing speed Vref (see table in appendix).
With a landing weight of 78 tons we get a speed on the glide path with flaps 45 of 265 km/h, with flaps 28 of 283 km/h, and for the landing of 255 km/h (this for flaps 45).

- Moscow- control, 85395, request descent
- 85395, descent to Sosnovskoe 6900
- 395 to Sosnovskoe 6900 descending. Estimate 15 minutes

- Thrust levers to idle! Descent to 6900, control the autopilot !

We descend to Sosnovskoe (Сосновского). On the Tu-154 we usually hold a descent speed of 500 km/h (only recommendation) !
If necessary we use the speed brakes (spoilers) – below 9000 use 30 degrees, below 7000 use 45 degrees. If there is a real need – use any angle at any altitude !

We pass Сосновского and continue to Чернухи. After Чернухи we tune both КУРС-МП to the ILS of Стригино (Strigino) 108.1. Generally, if there is a VOR/DME on the Airport, we tune the second КУРС-МП set to it.

We tune the first ADF to the outer maker beacon DPRM (676), the second to the neighbour BPRM (327).

At the transition altitude (1200 for the descent) we feed our altimeters with the airfield pressure. We level off at 1200 and request further descent without forgetting to inform the Controller about the pressure setting.

- 85395, 1200, pressure 754 established on transition altitude, descend 600 at the third.
- 395, descent to 600.
- 395, descending 600

Translator remark : Here I still keep the Russian terminology for a circling pattern. In Russia the terms – first turn, second turn, third turn and fourth turn are used. This can be easily transferred to the Western terminology of Crosswind Leg, Downwind Leg, Base leg and Final (approach) leg. So “at the third (turn)” means the turn to the base leg ! Fourth turn means turn to the final approach leg.
And in Russia QFE is in use, not QNH !

We descend to 600m as instructed. It is desirable not to exceed a speed of 400 km/h, we soon have to extend the gear. It is already possible to change to manual aircraft control, but you can also continue the Autopilot. Again, just as you please !

We fly according to the chart. Abeam of the distant beacon we check distance on RSBN - 20 km. If the distance is more , let us turn to the left (to runway side) and vice versa. How much you shall think yourself… knowing distance from the beam to the third …oh well, a bit of sine and cosine and angle in a right triangle ….☺

On the ПН-5 we click СБРОС ПРОГРАММ and we set the switches ПОДГ. НАВИГАЦИЯ and СТРЕЛКИ КОМАНД (the flight director) ON. Thus far it is necessary to end automatic flight conditions on НВУ (if it was switched on) or another automatic mode requiring the switch ПОДГ. НАВИГАЦИИ, that means also VOR Navigation conditions VOR - A31 and A32.
If we already reached an altitude of 600m, we set the Altitude Hold mode H (if we fly on Autopilot). If we want to “visit” some more automation at this stage, we switch the Autothrottle on using the ПН-6 «ВКЛ» switch and check proper working order (the two lights!) and we click the three lighted buttons Г1 Г2 Г3.
Since we have a four crewmember job and don’t have a Copilot, who in reality sets the speed on the indicator, we switch the system to left operation (УС-И to «ЛЕВЫЙ»).
We assign a speed of 380-400 km/h.
We approach the third turn. We check the beginning of turn at MPR 236 or radial 56 and distance
24.4 km. Ideally all simultaneously ! Ok, third turn with bank 25, report to controller.
We continue on course 270 to the fourth turn. The circling is quite wide, so we extend the gear and Flaps to 28 after the third turn. Classically would be 5-6 km prior to the third turn and Flaps to 28 after the third turn !
Speeds : Generally, third turn at 360-370 km/h, extend landing gear. After the lights show “all three green” we extend Flaps to 28, reduce speed to 300-280 km/h. At this speed we fly the fourth turn.

Remark : With that wide circle we would have time to lower both landing gear and Flaps 28 after the fourth turn. We can save some kerosene. So did I say already : Just as you please ?

After landing gear lowering we check the PB position. It must be within the limits of the wide green scale (-3... –10 degrees). In such a situation we leave the stabilizer handle in the position П. But if the PB shows, let’s say 0, then we set it in the position С. Being in the yellow sector, it tells us all passsengers simultaneously decided to go to the rear toilet in the tail. Then we set it in the position З ☺

We control the 4-th turn with КУР (course tracking on ADF, we see it on ARK, УШДБ on the outer scale of IKU) - at the starting point of the 4-th turn it is 285-290 for planes like the Tu-154. And the МПР (Magnetic Bearing of Radiostation, inner IKU scale) will be 195-200 in this case in this airport. (193 from the charts but for Tu-154 it will be probably better 195).

- 395, on the fourth turn, 600.
- 395, continue the fourth, for landing contact Tower at 120,4.
- 395, continue the fourth, contact tower 120,4.

- Tower, 85395, on the fourth, 600
- 85395, Tower, Runway 18, continue approach.
- 395 I continue.

To execute the fourth turn in automatic mode we click the button ЗАХОД. The Aircraft begins itself to turn to the runway, and we rest (but not rust☺).

We continue the approach. We extend the headlights. Before the entrance into the glide path (as soon as the glide path pointer will approach to center) we set flaps to 45 degrees, simultaneously establishing the calculated speed in the glide path (if we go in the automaton). After the triangular index of the glide path on the ПКП (HSI) is centered, the buttonlight ГЛИССАДА on the ПН-5 will light up and the aircraft will begin to descend. If not, then the Flaps are probably not at 45 yet, so we activate it manually by clicking on it.

If we fly manually in the flight director mode – we should not forget to click the buttons for ЗАХОД during the fourth and ГЛИССАДА with the glide path entrance . Otherwise the flight director will not work.

We are stabilized on the glide path. We control : Landing gear down, flaps, slats, stabilizer position and elevator in the green sector (from -3 to -10 degrees according to the instrument), turning off of flight loaders ВЗЛЕТ-ПОСАДКА РВ and ВЗЛЕТ – ПОСАДКА РН on the warning light panel.
If the position is higher than -10, which tells about the bow heaviness of aircraft, we increase the approach speed by 10-15 kmh. If it does not help - we go around and attempt to create more stern heaviness. In reality this is done by the “transplantation” of passengers from the front seats of the first cabin into the tail. How you shall do this in the sim –argghh, yes ☺

But if the PBs are lower than -3, then we correct the elevator by hand – open the stabilizer cover and click on the little handle.

We report to the Controller

- 395 established on glide path, gear down, request landing clearance.
- 395 established on glide path, cleared to land one-eight right.
- 395 cleared to land one-eight right.

It is necessary to report readiness for the landing before passing the outer marker beacon ДПРМ , otherwise it is necessary to go around!

We continue, altitude decreases, we are getting closer to decouple the Autopilot. If we fly in the automation, we are only occupied to control the engine thrust.

- 150 meters, in the course on glide path.
- landing headlights!

If ПРЕДЕЛ ГЛИССАДЫ and/or ПРЕДЕЛ КУРСА light up on the warning panel below 100m (signal panel with the yellow pointers on the visor), then it is necessary to stop the automatic approach mode and stop flying manually along the Flight Director pointers. If there is no Runway visibility or any other aircraft occupies the Runway in non landing position, we go around and continue to the second circle (crosswind leg !). If we see the runway and there is confidence for a safe landing – we continue the approach.
At the inner marker we have to decide about the landing. The decision making criteria are:

- the landing position of aircraft,
- Runway visibility
- absence of obstacles on the Runway
- confidence in a safe landing.

If the required engine thrust for keeping the landing speed below 100 meters is lower than 70% or it's established rating, which indicates the presence of wind shear, we also have to stop and fly to the second circle. In automatic mode we disconnect the autopilot at height 60 (30) meters. Autothrottle can be disconnected during the level off.

Part VII. Landing

After the inner marker we change to visual flight, which means we no longer look at the Flight Director pointers. The aircraft shall be balanced in pitch with the trim tab at this moment. Ideally, if we fly hands off, the aircraft shall continue it's descent path.

We flare at an altitude of 10-20 meters. Ideally 15. Vertical speed should be 3-4 meters per second, not more. At an altitude of 5-6 meters we approach the level off – with smooth movements we "ride" the ground effect and place the thrust levers to idle.

Extra info for crosswind conditions : In crosswind we turn the plane (with the ailerons) into the wind, the so-called crab technique. There is a small orange arrow located on top of the ПНП – (HIS) - it shows you how much drift you have and thus to what angle to counteract.
Right AFTER the landing of main wheels align on the runway's centerline with the rudder. Sideslip is not allowed on Tu-154. In real life the rudder pedals are almost never used on this plane (in the air). Using them causes dangerous sideslip.

Landing occurs on the main gear (note - there is a technology of a three-point landing on the TU - but this needs a very large experience and aircraft feel) with the subsequent smooth lowering of the nose gear.

After the elimination of any lead angle (due to crosswind) and lowering of the nose gear, we extend the spoilers. Being confident in the safe motion of the aircraft parallel to the runway axis we set thrust reverse. We begin braking at the following speeds :

1. Not earlier than 245 at an air temperature of +15 and below
2. Not earlier than 225 at an air temperature from +15 to +25
3. Not earlier than 215 at an air temperature from +25 and above

Such regulations exist due to the very strong heating of wheels and brakes. At a speed not less than 100 kmh we turn off the reverse thrust off.

If we "get" pulled to the left (or to the right) during the braking process, we turn off reverse, correct the deviation and use reverse thrust again, if desired. If necessary, it is possible to use reverse to the end of the path, but this might damage the rotors, as the stream of air raises from the earth and all that rubbish and stones might fly into the engine.

All OK, we reduce the speed to taxiing speed, leave the runway at the assigned taxiway, retract the Flaps and set the trim tabs neutrally. You didn't forget to switch the turn of wheel to 63 degrees? If you did, you will notice pretty soon ☺. TAXI CAREFULLY!

In the real plane, if one of the engines is cooled on idle for 2 minutes after landing, it can be switched off. We can do the same.
We taxi to the gate, we stop, we turn off avionics and lights (at night beacons BANO remain ON), all switches on Overhead off, we switch off an engine...

- 395, at gate 7, thanks

- 395, the end ☺

Congratulations on the first successful flight.
Our flight is finished. If everything worked out well, the authors fulfilled the job of helping simmers with certain experience in piloting the Tu-154B2, one of the most remarkable present aircraft and the most realistic model of a Russian aircraft in the simulator.

But we have more ....

Широта Долгота	Маршрут РНС	Маяк	Sрм Zрм	ИЗПУр м	А Д
55 58.59 С 037 26.55 В	UUEE	Внуково	-5.5 41.6	119.3	194 43.3
55 54.00 С 037 41.00 В	BP	Внуково	-23.8 40.0	109.2	217 42.0
55 52.00 С 037 51.00 В	VINLI	Внуково	-38.8 45.6	128.3	230 46.6
55 42.00 С 038 13.00 В	RW	Внуково	-79.7 29.8	108.6	260 59.9
55 37.00 С 038 38.00 В	DAKLO	Внуково	-170.9 7.7	93.3	269 85.1
55 33.00 С 040 00.00 В	SF	Внуково	-275.4 -62.1	69.4	273 171.0
55 52.00 С 041 46.00 В	CW	Н. Новгород	32.6 -54.6	95.9	70 132.1
55 48.00 С 043 10.00 В	RP	Н. Новгород	-37.2 -63.2	120.2	36 63.6
55 36.00 С 043 47.00 В	MB	Н. Новгород	2.1 -0.7	0.2	360 73.3
56 14.47 С 043 47.29 В	UWGG	Н. Новгород			

What do we have here ? The first two columns are the same as in the first table, here they are just arranged to a bit different sections. The third column is the RSBN navaid designation. Fourth column contains all data for direct entry into the МАЯК field on the B-52. (they are entered during setting of the switch in position Sm and Zm on the HBY control unit)

The fifth column shows the true travelling angle of the route section, calculated relative to the site of RSBN Navaid. (it is introduced on the instrument indicating Grivation УГОЛ КАРТЫ). And finally the fifth column shows azimuth and distance from the RSBN beacon on ППМ. It is only necessary for us to refine the flight above that waypoint, means to check if these data coincides with the actual indications on ППДА-Ш at the moment of passing that waypoint. Could be all OK, if not, it is possible to estimate side and value of our deviation.

Let us now move on directly to the correction. It is necessary to refine our actual counted location. The error is the result of equipment inaccuracies, here during НВУ numeration strictly inside НВУ! As a result we get a difference between actual and counted position. The course error caused by the Doppler numeration is around 1% of the passed distance. This is not a lot at the first view, for a distance of 1000 KM only 10 KM. But this error will also contribute to the drift Z and will be approximately equal to this value. Manual correction can be done by ADF, by VOR or by РСБН. Let us examine the automatic correction using an RSBN beacon.

The following data is necessary : S of the beacon relative to the final ППМ of that section, (calculated Z analogous), and the ИПУ of the section calculated relative to the location of the РСБН beacon. This is necessary for the onboard equipment to correctly recount azimuth and distance in orthodromic coordinates relatively precise for this route section. The route is short and we will correct HBY in two sections: DAKLO-SF and RP-MB. Why this selection? In the section DAKLO-SF we remove errors arisen because of the intensive maneuvering after passing МВЗ. The section RP- MB is important as initial point of the maneuver pattern of the landing approach. We want to leave to MB as exact as possible.

What we do establish in this case in the НВУ control panels?

For the section ДАКЛО-СФ we use the RSBN beacon - established in Внуково (Vnukovo, 4th channel). First we set the ИЗПУ of that section into the Б-8М (the part with the inscription ЗПУ, established above the counters of the coordinates), taken from the column ИЗПУрм. For our section it is equal to 93.3 deg. Now we enter the coordinates of the beacon relative to the final ППМ of section. We introduce them with the position of the switch on B-51 : "Sm" or "Zm" depending on what coordinate we introduce. We see it in the illuminated window МАЯК on the B-52. In our case these will be Sm = -170.9 km (we enter 171, 0.1 km is not important) and Zm=7.7 km (we enter so that the drum of the counter would be between 7 and 8). OK, data is prepared. Now we closely look to the warning panel «АЗИМУТ АВТОН» и «ДАЛЬНОСТЬ АВТОН», they shall not light up ! We also shall not have a jerky indication on the ППДА-Ш , they shall smoothly change.

Now, if everything is normal, we turn on toggle switch «КОРРЕКЦИЯ» on the B-51, and we follow a change in the coordinates on the illuminated window «САМОЛЕТ». As soon as the accelerated rotation of the counters ceases, we immediately turn the toggle switch «КОРРЕКЦИЯ» off.
By the way we forgot to mention the button «СБРОС ПРОГРАММЫ» on ПН-5 must be pressed, or the toggle switch «ПОДГ НАВИГАЦИИ» must be switched off, otherwise the passengers fall from their seat ☺. Ok, now we set the aircraft on track (Z=0) by hand and we include the HBY mode again.

We readjust RSBN to the Стригино (Strigino) beacon (26-1 channel). In the section RP- MB. we establish data for the correction of this section. This is ИЗПУ=120.2 deg, Sм=-37.2 км, Zм=-63.2 км, and similar to the description above we turn the toggle switch «КОРРЕКЦИЯ» on. Further action coincides with the example above.

And now about using HBY and HBY correction via RSBN on approach. Before perfoming the final approach phase (before entering the pattern) - before reaching MB lets set the magnetic landing (MLH) heading (180 in our case) on the inactive B-140 . On Б-8М (#404 on Shift+3 panel, on top) lets set TRUE landing heading 190.1. (TLH)

After MB we lets imagine we have to fly to the point abeam the outer beacom (traverse point). So we must manually calculate Sm and Zm of the traverse point. Taking approach charts... Zm = +20, because the distance from RSBN to this point is 20 km and the difference between azimuth and TLH is only 95 degrees (and difference with azimuth and magnetic heading of airplane from the outer marker is only 5 degres - 95-90 = 5, so the kathet is very equal to the hypothenuse. (The triangle consists of RSBN, outer marker and traverse point). Zm is positive in this case, because we calculate from the landing course and this case RSBN is to the right from the traverse point.

"S" will be equal to +2 km because RSBN is placed towards the traverse point. We have got 2 km from the sinus formula. I've calculated it in mind and recommend this to all. The accuracy is in the limit of 100m. You also may use a calculator or the Russian Navigation Line NL-10 (oooh, it is a great thing!!!:)).
Approaching MB beacon we actively switch blocks on HBY (by switching ЛУР switch to ПРИНУД. and returning to ОТКЛ position, HBY AUTO MODE must be turned off) and in the windows upon "ПУНКТ" we set zeros.

Now turn on the "Коррециия" (correction) switch on HBY control panel (it will be better to switch it over the beacon MB) and change ЗПУ on the inactive B-140, while Z on inactive "САМОЛЕТ" will not become 0000.
The ЗПУ (heading) that will be at the end on this B-140 will be the heading we need to fly to the traverse point, about 004 degrees. So we can get to every point from any point (may be controller requested to fly to some point not approaching MB)

Meanwhile we fly to the beam. At this time, on the working «МАЯКЕ», we change the RSBN coordinate relative to the end (we take from diagram). We obtain Z = 1.28 km, S = -1.72 km. We set them with maximum accuracy. After the flight to the beam point of and further to the third turn point we can again produce an RSBN correction. We obtain the coordinate S (longitudinal distance) and Z (lateral distance) relative to the active Runway (in this case 18L) on the working «САМОЛЕТ». According to these data we check the circuit parameters (width and distance to the points of the third turn, the fourth turn and whatever might be required) .

In summary this is a creative HBY process, prompted by instructors, or found with own experience and experiments. A good example for the latter : Calculate all STAR points in the HBY calculator before flight !
So use and search your ways of using the equipment, we hope our tutorial gets you started.

7. Detailed systems descriptions

7.1. Autopilot system АБСУ-154-2.

7.1.1. The АБСУ-154-2 system features :

- stabilization of the angular position of the aircraft relative to the three major axes of stability
- stabilization of indicated airspeed or Mach number or barometric altitude
- roll and pitch control using the handles on the Autopilot panel
- automatic turns to predefined course, heading select mode ЗК
- automatic control of aircraft and flight director signals in the modes «НВУ», «VOR» (АЗ-I, АЗ-II) and in the landing mode down to the decision height
- automatic control of aircraft and delivery of flight director signals for the Go Around
- automatic stabilization and control of indicated speed with the aid of the Autothrottle
- indication of basic flight parameters and protection commands incl. light and sound warnings and advisories

The system АБСУ-154-2 consists of :
1. System of trajectory administration СТУ-154-2;
2. System of autopilot administration САУ-154-2;
3. Autothrottle АТ-6-2;
4. Equipment for Go Around mode

In simple terms, the САУ-154-2 IS the autopilot, which ensures stability of the aircraft along the pitch and roll axes. Rudder control is connected to the bank axis. Bank and pitch are independent and can work in different modes. So one axis can be under Autopilot control, while the other remains manually controlled.
Depending on the working mode of the bank axis the САУ ensures:

Stabilization of assigned bank from the turn handle
Stabilization of the current course
Yaw stabilization, assigned by setting of heading in the mode ЗК

In the navigation modes the bank channel stabilizes the given bank value, provided by the Navigation computer СТУ.

The САУ pitch channel ensures, depending on the mode :
- Stabilization of the assigned pitch from the handle “подъем-спуск” (climb-descend)
- Altitude hold function.
- Speed hold by change of pitch
- Mach hold by change of pitch.

In the landing mode the pitch channel stabilizes the given pitch value provided by the landing calculator СТУ.
The САУ system uses signals from different sensors. The heading values in the САУ system are provided by the ТКС-П2 system. The values are angular bank and pitch, provided by the vertical gyros. The aircraft uses three small vertical gyros МГВ-1СК. The values of bank and pitch from the first МГВ are shown on the ПКП (ADI) of the Captain, while the МГВ №2 is used on the ПКП (ADI) of the Copilot. The third vertical gyro is used for reserve purpose. The САУ system uses the average signal of the three gyros. МГВ works together with the control system БКК. БКК is highly simplified, as only vertical gyros are checked. БКК checks МГВ by comparison of the signals. If one МГВ fails, a flag on the appropriate ADI (ПКП) appears or a warning on the signal panel lights up. The defective МГВ is then disconnected from the system and the САУ system uses the average of only two МГВs. If a second МГВ fails, the БКК cannot determine the defective vertical gyro and declares all МГВ defective. The fail signals are memorized by the control system. The failure signals are discharged from the system after start of the БКК test mode. This must be remembered and makes the test mode always necessary after the coordination of the vertical gyros. Also the correction of the vertical gyros on the vertical sensor is simulated with the corresponding correction switch.
The trajectory control system СТУ contains the calculators for navigation and landing. The navigation calculator provides the bank values (depending on signals of the NAV system Курс-МП, НВУ-Б3 or other sensors) to guarantee the assigned flight path in the modes НВУ, АЗ-I and АЗ-II. The given bank value is entered into the САУ system and shown on the ADI (ПКП). The landing mode calculator provides values of pitch and bank in the landing approach mode along the ILS.

7.1.2. Operation of the Autopilot АБСУ

The basic АБСУ Autopilot control elements are located on the control panel ПУ-46 and on the parts ПН-5 and ПН-6.
Two signal panels for working pitch and bank mode channels are located on the ПУ-46. Three working modes of each channel are possible : Armed, manual control and stabilization. The stabilization mode is set with the button “стаб” on the ПУ-46, which then lights up. If the stabilization only of that particular channel is set, the corresponding bank or pitch toggle switch is in the on position. The lack of system preparation necessary for the stabilization mode can lead to system refusal. The stabilization mode can’t be activated without vertical gyro preparation or not activated boosters. If any modes are lighted before the stabilization mode is set, it is necessary to clear that with the button “сброс программ” (clear program). Stabilization mode for seperate channels can be set on the ПУ-46. Rapid turning off of both channels can be achieved using the Autopilot OFF button on the yoke/stick. Emergency turning off is possible

depending on certain factors. Channel deactivation is accompanied by a short term sound, emergency turn off by a longer signal. Between the mode signal indicators on the ПУ-46, two buttons for fast vertical gyro alignment can be found below the cap.
With the buttons M, V and H the corresponding pitch modes can be set. The mode V holds the actual speed using pitch. The mode M holds the current Mach number, while H is the altitude hold function. With the turn handle the aircraft can be directed into a coordinated turn with the commanded bank. The bank depends on the angle of rotation of the turning knob. Mouse clockspots for smooth turning are located on the bottom left and right of the turning knob. A quick setting to the neutral position can be achieved by pressing on the center of the knob.
In the bottom part of the ПУ-46, between the pitch/bank-channel selectors, a button with a cover is provided for “включить в болтанку”. Inclusion of this function changes the Autopilot coefficients, leading to a reduced accuracy to better handle turbulence. This leads to a more stable operation in case of turbulence. Closing the cover automatically turns the mode off.
The control elements of navigation and landing modes are located on the ПН-5. The heading select mode switch ЗК (controlled by the HSI heading bug) is also located there, although it does not require the CTY system. So the start of the navigation computer is not required. The toggle switches “**подгот**овка **навигац**ии” (for navigation) and “**подгот**овка **посадки**” (for landing) are used to include the navigation computers СТУ. A refusal of certain modes is according to test experience often related to not activated navigation computers. To avoid problems one should get used to a rule : Only one СТУ calculator can be activated at a certain time. Calculator readiness is indicated by the lights on the ПН-6. With the armed navigation calculator the light “бок” must be on, while with the armed landing computer all three lights “бок”, “прод” and “уход” must be on.

Navigation modes consist of the three modes НВУ, АЗ-I and АЗ-II. In the НВУ mode the Autopilot keeps the plane on the specified heading (ЛЗП), determined by the НВУ-Б3 system, which must be included before. In the modes АЗ-I and АЗ-II the Autopilot keeps the plane on VOR radials as specified on the NAV1 or NAV2 selectors on the Курс-МП part of the overhead panel. To set a certain Navigation mode, the CTY navigation computer must be included with the toggle switch “**подгот**овка **навигац**ии” and the corresponding button must be pressed. The toggle switch “**подгот**овка **посадки**” must be switched off.
Landing modes are set with the buttons “заход” (LOC) and “**глисс**ада” (glissada=glideslope) and the navigation computer in landing mode with the switch “**подгот**овка **посадки**”. The landing mode uses the NAV1 frequency. On the leading HSI (ПНП) the magnetic runway heading ЗПУ must be set. The selection of the active HSI is done with the switch on the ПН-5.
The switch “стрелки” sets flight director commands on both ADI.
The switch “сброс программ” turns off navigation and landing modes. The channel of bank keeps the current course in this case. If the GS mode was active, the pitch channel keeps the current pitch. In other cases the current pitch mode remains.

7.1.3. The GoAround mode "уход"

The GoAround mode can be included in the automatic or flight director landing mode from the moment of glide slope capture «захвата» together with the switches «Крен» and «Тангаж» on the ПУ-46 panel in ON position (button «Глисс.» on the ПН-5 part must burn when GoAround button «Уход» is pressed). The automatic GoAround is initiated with the throttle levers in the position «Взлетный режим». With active Autothrottle the transfer of the throttle levers in takeoff conditions is produced with the Autothrottle in the «Уход» mode. This is initiated by pressing the GoAround button «Уход» on the Yoke/Stick. With Autothrottle turned off the mode is initiated by moving at least two levers in the «Взлетный режим» position.
With the start of the automatic GoAround mode :

- on the signal panel of both pilots the lights «Уход на 2-й круг» and «Стабил. боков.» light up. The button lights «Заход» and «Глисс.» on the ПН-5 go out. The throttle levers are moved to the «Взлетный режим» position (if the GoAround mode was initiated with «Уход» button on the yoke), and the Autothrottle AT-6-2 is in the armed mode (button «C» on the ПН-6 goes out);
- Flight director commands on the ADI 1 and 2 will disappear.

In this case the aircraft is transferred :
in the vertical channel – to the climb mode (using GoAround calculator commands)
in the lateral channel – to the current course.

The automatic GoAround mode «Уход на второй круг» is disconnected by :
- ♦ Pushing the button «Отключение автопилота» on the yoke;
- ♦ Press of button «Сброс прогр.» or switch «**Подгот**овка **посадки**» on the ПН-5;
- ♦ Moving the climb/descent handle «Спуск - Подъем» on the ПУ-46.

Joystick button functionality for the GoAround Mode is provided in the Joystick Control Panel.

7..1.4. Autopilot mode indications

The Autopilot operating modes can be identified by the lighted buttons ПУ-46 and ПН-5 and on the mode signal panel, located on both Captain and Copilot instrument panel. For the modes ЗК, V, M and H (only selectable with stabilization mode active), the indication on the ПУ-46 и ПН-5 and on the main panel mode indicators is duplicated. For the navigation and landing modes on the ПН-5 the operation modes of the СТУ computer can be identified. On the main panel mode indicators only those modes can be identified, which are under automatic control of a certain channel (pitch or bank).

The conditions for СТУ mode inclusion depends if it is included in the stabilization mode. For example, to use the approach and landing mode the presence of an ILS beacon is required. In the manual control mode the approach mode can be included without the presence of a beacon. If modes including the systems Курс-МП, СВС, НВУ are used and their signals fade, then the corresponding mode is automatically deactivated.

7.1.5. Autothrust system

The Autothrust system AT-6-2 works in the modes : Speed command on airspeed indicator УС-И-6, preparation, stabilization and administration of speed and GoAround «Уход». With activation of the Autothrottle it starts working to keep the speed indicated by the index in the airspeed indicator УС-И-6. With a change in flight speed the index follows the needle. The Autothrust system works in this mode from takeoff to the landing approach.

To arm the Autothrust system it is necessary to set the switch «”**Подг**”отовка АТ» (under the cover) on the ПН-6. After approx 10 seconds the ready signal is given to the lights below the AT label (two green lights). By pushing the button «Контроль АТ» the proper working order and readiness for start of Autothrust is checked. Stabilization and speed control mode is set with the button «С» on the ПН-6. The green indicator light «Автомат тяги» on the main instrument panels lights up. The speed is stabilized with an accuracy of ± 5 km/h.
Speed control is achieved by moving the index on the airspeed indicator УС-И-6 using the wheel on the ПН-6 (+/- clickspots).

7.2. Airplane Navigation systems

If you are really interested to dive into the Navigation system down to system checks, this Chapter is for you. And if you still wonder why I recommended to learn Cyrillic characters in the beginning, than after this chapter you will know why ☺

The airplane main systems ПНК include :

1. Compass system, type ТКС-П2.
2. Navigation computation device НВУ-Б3.
3. System of air signals СВС.
4. Short range navigation system РСБН.
5. Radio Navigation system Курс-МП, to work with VOR and ILS beacons
6. Doppler system to measure speed and drift.

7.2.1. Compass system ТКС-П2 technical description

The Tu-154b2 with the Autopilot АБСУ-154-2 uses the ТКС-П2 compass system with an additional magnetic channel. Some simplifications had to be introduced, e.g. spinup and running of the gyro units, also the influence of heating of the gyro systems on the system. Errors in the magnetic systems during banks and accelerations are not simulated, but due to imperfections of the simulation of the magnetic compass in FS 2002/2004 this is no issue.
One of the interesting features of the compass system ТКС-П2 is that two gyro compasses (ГПК) and two gyromagnetic compasses (ГМК) are realized with the aid of two gyro units. In the classical gyromagnetic compasses the gyro unit is continously corrected along the magnetic sensor. In the ТКС-П2 system the magnetic heading is obtained in the gyromagnetic compass units БГМК as the sum of the orthodromic course and the correction for the difference between the orthodromic and magnetic headings. More specific, this correction is corrected along the magnetic sensor.

The system consists of :

- Induction sensors ИД-3 (2 units);
- Correction mechanisms КМ-5 (2 units);
- Gyro units ГА-3 (main and reserve);
- Gyromagnetic compass units БГМК-2 (2 units);
- Navigation indicator УШ-3;
- Control panel ПУ-11.

Nine switches located on the upper electrical switch section of the overhead panel are used to setup the system. The ТКС-П2 system has two channels. Channel №1 (left) and channel №2 (right). The basic operation mode of both channels is the ГПК regime.
The signal of the orthodromic course from the basic gyro unit ГА-3 is delivered to the БГМК-2 №1 unit and to control the pointer «К» of the instrument УШ-3. The signal of

the gyromagnetic course from БГМК-2 №1 is delivered to the ИКУ-1 instrument of the copilot. Depending on the position of the switch «Курс ПНП лев» the gyromagnetic or orthodromic course from the БГМК-2 №1 unit will be delivered to the Captains ПНП-1. The orthodromic course indication from the reserve gyro unit ГА-3 is provided to the БГМК-2 №2 unit and used to control the triangular index of the instrument УШ-3. The indication of gyromagnetic course from БГМК-2 №2 will be given to the Captains ИКУ-1 and the Copilots ПНП-1, if the switch «Курс ПНП прав» is established in position «ГМК».

In the САУ-154-2 system and through БДК-1, the orthodromic course from the main or reserve gyros will be given to the calculator НВУ-Б3 depending on the switch «Потребители» on the ПУ-11 control panel.
So, in the ГПК regime the pointer «К» of the УШ-3 identifies the orthodromic course from the basic gyro ГА-3, while by the triangular index the orthodromic course from the reserve gyro ГА-3 is identified (independent of the switch position «Потребители» on ПУ-11). The gyromagnetic course is displayed on the ИКУ-1 of the Captain and copilot. On the ПНП instruments either orthodromic of gyromagnetic course are identified, depending on the position of the switch «Курс ПНП лев» or «Курс ПНП прав».
The МК mode is auxiliary and serves for the preliminary initial alignment of the gyros. In this case the main and reserve ГА-3 units are advanced on magnetic heading ГА-3 by the signals from ИД-3 №1.
For control of the servo frame of the main gyro units ГА-3 the signal is obtained from МГВ-1СК №3, and for the reserve gyros from МГВ-1СК №2. After failure of МГВ-1СК №3 or МГВ-1СК №2 it is necessary to include the appropriate switch «Арретир ГА». In this case the servo frame of gyro unit is arrested on a zero bank signal from the corresponding РБ-2 block.

7.2.2. Panel ТКС-П2 ПУ-11.

1. Latitude scale
2. knob to change the latitude
3. switch between automatic and manual setting of latitude. Automatic setting is inoperative.
4. Operating mode switch. The celestial correction mode AK is not used.
5. consumers switch
6. switch of the compass setting device. Right mouse button is used for accelerated turn of gyro unit
7. switch for selection of gyro unit
8. button for fast alignment of gyro units and БГМК units
9. main gyro unit failure light
10. reserve gyro unit failure light.

7.2.3. Operation of the system

Before switching on the feed of the ПУ-11 system, set the following switches first : Switch «Потребители» to position «Осн», switch «Коррекция» to position «Осн», switch «Авт. - Ручн» to position «Ручн», and the scale to the Latitude of the departure airport.
Turn on the power supply for the compass system devices on the overhead panel : «Питание ТКС-П2 №1 и №2», «Обогрев ГА», «Коррекция БГМК №1 и №2»; the switch «Арретир» to the position «Откл»; the switches «Курс ПНП лев» and «Курс ПНП прав» to the position «ГПК». On the upper row include the switches «МГВ контр», «ПКП лев», «ПКП прав» for operation provision of the ВК-90 correction and the servo system of the gyro units. 3 minutes after switching on the feed by the simultaneous pushing of the two knobs «Арретир» on the control panel АБСУ-154-2 (ПУ-46) to produce exhibition of МГВ-1СК on the vertical line of earth and to control proper working order of МГВ-1СК on the ПКП-1 instruments.
The alignment of the compass system is conveniently tested with the digital prompt on the УШ-3 instrument.
To verify correct working of the compass system in the ГПК mode : On the ПУ-11 set the mode switch in position «ГПК», move the switch «Задатчик курса» to the left and then to the right. In this case the indication of the arrow «К» УШ-3 and the ПНП-1 of the Captain should increase or decrease. Set the switch «Коррекция» to the position «Контр» and with the switch «Задатчик курса» verify the index УШ-3 and the copilots ПНП-1 in a similar way.
To verify the work of the compass system in the MK mode : For this set the mode switch to the position «МК», the switch «Коррекция» in position «Осн», the switches «Курс ПНП лев. (прав.)» to the position «ГМК» and press/hold the button «Согласование». The indication of the pointer «К» on the УШ-3 is coordinated with the indication of correction mechanism КМ-5 №1. Set the switch «Коррекция» to the position «Контр» and hold the button «Согласование». The indication of the triangular index on the УШ-3 is coordinated with the indications of the correction mechanism КМ-5 №1.
The alignment of gyro units in the MK mode is simultaneously and so the preliminary exhibition of the gyro units. Put the switch on ПУ-11 in the position «ГПК», the switch «Коррекция» in position «Осн» and again press and hold button «Согласование». This includes the high rate of finalizing the servo systems in the БГМК-2 blocks. The instruments ИКУ-1А of the copilot are coordinated with the indications of the correction instrument КМ-5 №1.
Repeat the alignment with setting of the switch «Коррекция» to the position «Контр», in this case the instrument of the Captain is coordinated with the correction mechanism КМ-5 №2.
After the alignment of gyro units on the magnetic heading the indication of the pointer «К», the triangular index УШ-3, both of ПНП-1 and ИКУ-1А, КМ-5 №1 and КМ-5 №2 must be identical and correspond to the actual course of the aircraft.

After start establish the aircraft on the longitudinal axis on the runway heading and execute the final alignment of gyro units. For this set the switch «Коррекция» to the position «Контр», the switches «Курс ПНП лев. (прав.)» to the position «ГПК», the switch ЗПУ on the ПН-5 panel to the position «ПНП прав». On the Copilot HSI (ПНП-1) the second pilot sets on the counter ЗПУ the value of ЗМПУ (ZMPU) ВПП. With the switch «Задатчик курса» on the ПУ-11 the scale on the ПНП-1 (HSI) and the triangular index on the УШ-3 установить can be set to the ЗМПУ value. With the switch «Коррекция» in the position «Осн» and by the setting of the course the pointers «К» is combined with the triangular indexc УШ-3.
Set the position of the switch «Курс ПНП лев. (прав.)» to the position «ГМК». On the instruments HSI = ПНП-1 and ИКУ-1А of both pilots and the УШ-3 the value ЗМПУ (ZMPU) ВПП must be identified.
Before takeoff establish the switches «Курс ПНП лев. (прав.)» to the position «ГПК», the switch «Коррекция» to the position «Контр», correction БГМК-2 №1 and БГМК-2 №2 turned off.
In flight along the route include correction of БГМК-2 №1 и БГМК №2. Periodically through 1° changes, set in the ПУ-11 to the latitude value of the actual position. Check the work of gyro units and the correctness of the orthodromic course on the indications of the pointer «К» and the triangular index УШ-3. With normal operation of the gyro units the indication of the pointer «К» and the triangular index must be identical and coincide with the readouts on the HSI (ПНП) of both pilots. With setting of the switches «Курс ПНП лев. (прав.)» to the position «ГПК» and observe the difference from the indications of the ИКУ-1А by the value of the general correction. Equal to the angle of convergence of the geographical meridians. And the difference in the magnetic declination of the point in the initial alignment of gyro units and the actual flight location.
With a divergence of indications on then УШ-3 и ИКУ-1А of more than 3° it is necessary to make a correction on the ТКС-П2.
The correctness of the delivery of gyromagnetic compass signals to the blocks БГМК-2 №1 и БГМК-2 №2 can be checked from the ИКУ-1А indications of both pilots and the correction mechanisms КМ-5 №1 и КМ-5 №2 respectively. At a certain distance before the prelanding preparations, the gyro units must be aligned for the magnetic meridian for landing again.

7.2.4. System of air signals СВС (SVS)

From measurement of static pressure, velocity and temperatures the system of air signals СВС calculates flight altitude, flight speed, Mach number, relative density and temperature of the surrounding air. It then provides these values to the navigation and control systems. In this model the following instruments are based on the СВС systems:

- altitude indicators of type УВО-15 and the Machmeter of type УМ-1.
- The air and groundspeed indicator УСВП-К.

The СВС signal is also used from the Autopilot АБСУ to keep the barometric height and by the НВУ system for the numeration in the automatic modes and for enumerating windspeed together with the Doppler – Speed and drift meter ДИСС.
The СВС system is started using the power switch on the Overhead Panel. Pushing the button for test СВС activates test modes on the instruments УМ-1, УВО-15 and УСВП-К.

7.2.5. Short range navigation system РСБН (RSBN).

The short range navigation system РСБН-2 works similar to a VOR, but works on a polar coordinate system. At work it continously issues distance from the aircraft to the beacon and azimuth relative to the **true meridian** passing through the beacon. The system works with an accuracy of 200m (distance) and ±0,25° (azimuth).
Azimuth and distance are indicated by the instrument ППДА-Ш (141 on panel picture above). Azimuth and distance are also used for corrections by the navigation system НВУ-Б3.
The РСБН-2 system has 4 working channels. Tuning for the master frequency is done via channel selection. The system works only with the additionally scenery, provided by Andrej Prjadko.

7.2.6. The ДИСС (DISS) – System

The Doppler speed and drift meter ДИСС continously measures airspeed in flight relative to the earth and the drift angle. It works on the Doppler principle, which measures the frequency shift of the radio signal reflected from the earth. The speed value is indicated in the air and ground speed instrument УСВП-К. The drift value is used in the ADI instruments and visible in the track angle pointer УШ-3. According to the speed and drift angle data the НВУ-Б3 performs dead reckoning navigation.

7.3. НВУ Navigation once again

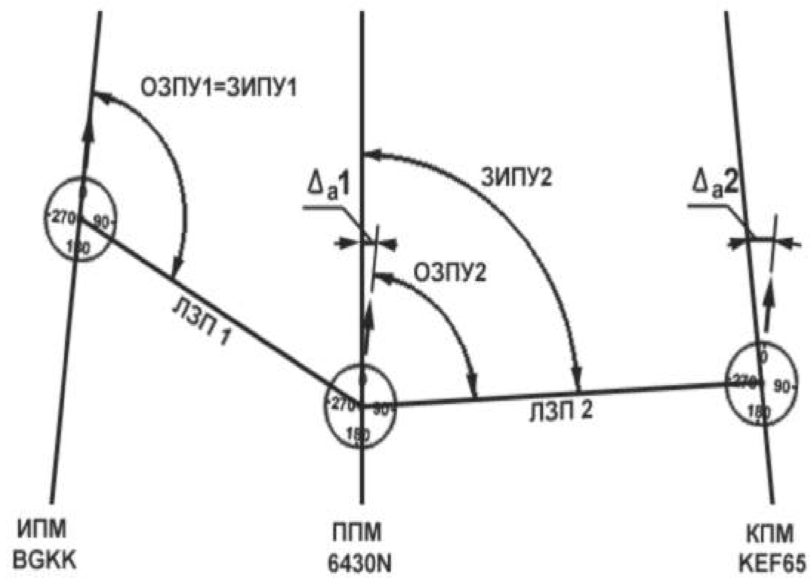
If you can't stop reading about that fascinating HBY system or weren't happy about my approach to explain the orthodromic concept and HBY in Chapter 5.6.4., here is a complete translation of this subject from the Russian Project Tupolev manual.

The navigation computer НВУ-Б3 is the basic navigation aid of the Ту-154Б2. It allows reasonable accurate navigation without the use of radiotechnical or satellite navigation systems.

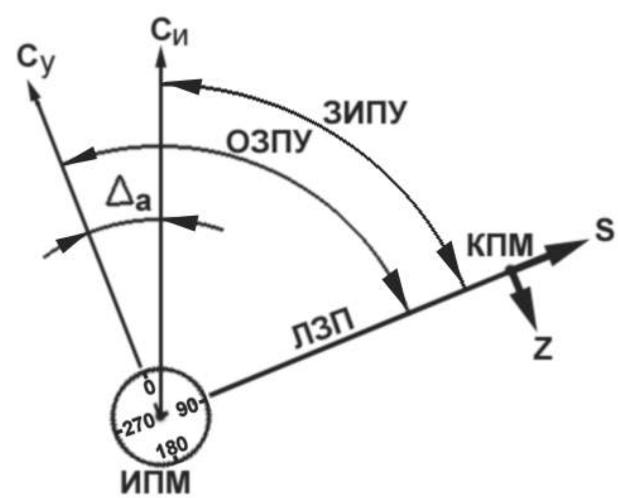
The navigation computer НВУ-Б3 is intended for continous numeration of the aircraft coordinates along the Great circle coordinate system. For further examination we examine a route of only one section. We need to fly from one point to another on the shortest possible distance, which means on orthodromy (for the Germans : Grosskreis)
We name the first point ИПМ, the second and final destination КПМ. The line which connects the points is the orthodromy (in Russian designated : ЧО. It is specified ЛЗП. The orthodromic coordinates of the aircraft are designated S and Z with S being the coordinate along orthodromy and Z perpendicular to the direction of orthodromy. The deviation of the aircraft from ЛЗП to the right corresponds to positive values of Z. The origin of the orthodromic coordinates are in the destination КПМ. Consequently any aircraft on ЛЗП will have negative S coordinates, whose absolute values show the remaining distance to КПМ. With the aircraft at ЛЗП the coordinate Z is equal to zero, while non-zero values indicate a linear deviation (ЛБУ) from ЛЗП.
The values of the coordinates S and Z are provided to the drum counters on the active В-52 НВУ panel. With an activated numeration the drum counters (proportionally to the speed) revolve the displacement of the aircraft along the orthodromy (along axis S) and along Z-axis. Numeration begins in ИПМ.
For the correct counter readout it is necessary to preliminary set the lenght of the corresponding orthrodromic route section into the counter S using a minus sign. The route starting point must show a zero value on the Z counter. The flight speed relative to the earth and the drift angle are provided by the ДИСС system and are continously transferred to the НВУ.
For the НВУ calculator the angle between the aircraft longitudinal axis and the direction of the corresponding orthodromy is necessary. This ЗПУ heading can be entered directly in the В-140 НВУ panel. From the instrument point of view, ЗПУ is the angle between the axis of the gyro unit of the compass system and the specified track, or the angle between the magnetic meridian and the specified track. In the figure the direction of the magnetic meridian is marked as conditional North Cу.
ЗПУ, which is entered into the В-140, is also called the orthodromic heading ОЗПУ. Also the terms ОЗИПУ and ОЗМПУ are often used, more regarding that later. Now according to the orthodromic course of the aircraft and the ОЗПУ value, the calculator can recount the speeds into the orthodromic coordinate system and conduct numeration along S and Z.

But on the earth's surface orthodromy is assigned by the coordinates of the initial point (ИПМ) and the angle between the direction to the end point of the route and the true meridian at the beginning of the route, means the true heading ЗИПУ.
The angle Δ_a is the angle between the conditional and true meridians, or the so called azimuth correction. This angle is determined by the position of the gyro unit of the compass system with respect to the true meridian at the current point of flight. The compass system working in the ГПК mode holds constant attitudes and the meridians in the general case are located at an angle to each other. The azimuthal correction constantly changes due to this during flight. For obtaining the true course it is necessary to deduct the azimuth correction from the orthodromic course.

For the preparation of data for the НВУ it is necessary to know надо Δ_a at the beginning of each route section. At the starting point we themselves assign azimuth correction by the method of compass system alignment. With the alignment on ТКС on the true course (meridian) the azimuth correction is equal to zero, with the alignment on the magnetic heading the azimuth correction is equal to the magnetic variation in ИПМ, where the alignment was done.



A more advanced example shall consist of two route sections : A flight from BGKK to the airport BIKF. As a waypoint in between we choose ППМ with a coordinate of N64° W030°.
At КПМ we select a point in range of the ILS of runway 11 (ILS 109,5). The landing magnetic heading is ПМПУ=112°.



Initial calculation data :

ИПМ
N65°34,42′
W037°07,42′
Magnetic variation : –32,7°
ППМ
N64°00,00′
W030°00,00′
КПМ
N63°59,05′
W023°04,30′
Magnetic variation at airport BIKF : –22,3°

The magnetic variation at the departure airport is necessary for the calculation of ОЗМПУ, if we have agreed on course on the magnetic meridian and the magnetic variation is entered on the КМ-5 №1 with alignment on the true meridian. The magnetic variation at the landing airport is necessary to transfer of the course to the magnetic heading of the landing airport. We will agree on the true course, so we can better grahically illustrate the work of НВУ.
In the above figure the position of the compass system is represented at the three points. At all three points the compass system keeps the attitude , which is the main property of the ГПК mode. At ИПМ the axis of the compass system is directed along the meridian (we agreed on that), azimuth correction is equal to zero, true and orthodromic heading coincide. Due to the convergence of the meridians the angle or azimuth correction appears at ППМ и КПМ.

Data calculation for НВУ can be performed using the build-in calculator ЦИА ГА.
The calculator ЦИА ГА allows the calculation of lenghts and ЗИПУ using the coordinates at beginning and end of route. Furthermore it calculates the opposite true heading.

First route section :
After entering the coordinates of initial and end points of the route, we obtain :
ЗИПУ1 = 114.1°, Reverse ЗИПУ1 = 300.6°
Distance 381,2 км
Since the azimuth correction is zero for the first section : ОЗПУ1 = ЗИПУ1, we get for the first route section for the НВУ:
S=-381,2
Z=0
ЗПУ=ОЗПУ1=114,1°

Lets calculate the azimuth correction accumulated in the first route section.
The true heading at the first section and the end of the section will be equal to the opposite true heading - 180°.
300,6°-180° = 120,6°
To determine the azimuth correction this is subtracted from the orthodromic track angle.
Δ_{a1} = 114,1°-120,6° = -6,5°

Second section of route.
After entering the coordinates in the calculator, we'll get :
ЗИПУ2 = 87.2°, Reverse ЗИПУ2 = 273.4°
Distance 338,9 км
Now taking the azimuth correction for the second section into account : ОЗПУ2 = ЗИПУ2 + Δ_{a1}.
ОЗПУ2 = 87,2° +(-6,5°) = 80,7°
For the second section the data for НВУ is:
S=-338,9
Z=0
ЗПУ=ОЗПУ2=80,7°
Now we calculate the azimuth correction for the second route section. The true heading of the first section at the end of the section will be equal to the opposite true heading - 180°.
273,4°-180° = 93,4°
To determine the summary of azimuth correction for two sections it is subtracted from the orthodromic true heading.
Δ_{a2} = 80,7°-93,4° = -12,7°

Lets prepare data for the transfer of ТКС and НВУ into the magnetic heading of the landing airfield.
To obtain the true course it is necessary to subtract the azimuth correction correction –12,7° from the orthodromic course. For the passage of the true course to the magnetic it is also necessary to subtract the magnetic variation of the landing airfield from the true course. In our case equal to –22,3°, leading to a total correction of +35°.
For ЗПУ it is possible to previously calculate value after transfer of ТКС into the magnetic heading of the landing airfield. For the ОЗПУ of the final segment it is necessary to add the total correction :
ЗПУ = 80,7° + 35° = 115,7°.
For the ТКС transfer ОЗМПУ cannot be precalculated since ОЗПУ in flight can differ from ЗПУ, advancing on the В-140, due to the drift angle.

The calculation of data for НВУ can also be done with the build-in calculator. The results are a bit more exact due to a more accurate globe model :

For the first section :
S=-379,8
Z=0
ЗПУ=114,2°
Δ_{a1} = -6,45°
For the second section :
S=-337,6
Z=0
ЗПУ=80,7°
Δ_{a1} = -12,68°

Now with the initial data we start at Runway 11 at the airport BGKK.
If the compass system alignment was done for the magnetic heading (as described previously), we then also make the alignment for the true heading. For this we enter the magnetic variation of the departure airport (–32,7°) in the КМ-5 №1 and we do the alignment on the magnetic gyros as decribed previously. After the ТКС alignment the magnetic variation entered in the КМ-5 №1 must be set back to zero, this is necessary for correct work of the copilots ИКУ.

We open the НВУ panel and on the B51 part turn on the power supply НВУ (toggle switch “сеть”). The active working light “испр” will come up. If it does not light up, most probably the СВС system is not active. Since the ДИСС does not work at low speeds (< 180 km/h), with a turned off СВС the НВУ has no flight speed info.
After power up “I” lights up on the B-140 and on the B-52 “самолет” lights up. This means that initially the first B-52 block is the active working one and will hold the data for the current section. The second B-52 will be used to store the data for the current section.
ЗПУ for the current and following section are entered into the B-140 block. Data is entered in degrees and minutes. 0.1 degrees corresponds to 6 minutes. On all panels data can be entered accelerated using the right mouse button.
Data for the B-52 counters is entered on the B-51. The coordinate S for the first section is introduced with the switch position “S”, for the second section with position – “Sп”. In the additional B-52 panel more accurate data can be seen, so it should be opened. After data input it is recommended to set the switch in position “S”, then in flight using

the throttle lever panel, the remaining distance to the next waypoint can be kept in view.
With the right switch on the B-51 the linear turn anticipation can be set, initially we set this to 10 KM.

НВУ operation in flight

The accuracy of the НВУ at work depends on the accuracy of the work of the compass system. To ensure that it is necessary to set the current latitude every 1-2 degrees in the ТКС panel.
Now theoretically we can takeoff from BGKK only with a maximally lightened aircraft. On the runway heading (to be established exactly !) the ТКС course must be verified again and must be 84°.
After takeoff it is necessary to turn on the toggle switch “счисл” on the B-51, this will start the НВУ numeration mode.

Activate the Autopilot at the allowed altitude and without including the switch “**подгот**овка **навигац**ии” now we press the button НВУ (must light up) on the ПУ-46. On the HSI (ПНП) the needle will show the heading (ЗПУ) of the first section and a possible lateral deviation from ЛЗП. If all looks normal the toggle switch “подготовка навигации” can be set now. The aircraft now immediately starts to reduce the lateral deviation from ЛЗП and starts to get on track. We should notice a decreasing value of Z, which should come to zero finally. The value S shall decrease in absolute value, showing distance to the active waypoint ППМ. After a distance less than 80 KM to ППМ, a coordinate transformation takes place. The calculation of S and Z for the following route section will begin on the free counter. Before next waypoint change there must be correct S and Z values for the following section entered in the windows “пункт” and ЗПУ for the following section.

The automatic waypoint change occurs at the distance specified with the linear turn anticipation, in our case 10 KM. With the turn anticipation switch in position “откл”, automatic waypoint switching will not occur. Two kilometers before waypoint switching the “смена ЧО” switch lights up and the Navigator will announce the upcoming route change. If the S value on the working counter becomes equal to the linear turn anticipation, the change occurs. On the ADI the heading ОЗПУ to the next section will appear. The other B-52 block is now the active working unit and in the other one the data of the following section can be set in the windows “пункт”. As we don’t have a following section we set the turn anticipation to the position “откл”.

Transfer of ТКС and НВУ to the magnetic heading of landing airfield :

The operation consists in the turn of the gyro unit of the compass system to the angle, which is equal to the correction the the convergence of meridians (the azimuth correction) and the difference of magnetic declinations of departure and arrival runway. To ensure a correct working подлете НВУ it is necessary to establish this correction also on the heading ЗПУ on the B-140. This is one of the most critical operations, which also must be done quickly to avoid large deviations from ЛЗП. There different procedures for the transfer of the compass system, just one is described here. The gyro units of the compass system are interchanged, to the properties of the working unit, means the units which actually feeds the instruments. Both main and reserve unit can be used. For simplicity we assume the feeding of “consumers” originates from the main gyro unit :
1. put the switch “коррекция” on the НВУ panel to the position “контр”. With the aid of the compass setting device the reserve gyro unit gets the total correction value, so with the currently active main gyro a course change does not occur and НВУ works correctly . The control is done with the index on the УШ-3 (The navigation instrument УШ-3 of the compass system ТКС-П2). So now without hurry the angle between the arrow “К” and the triangular index on the УШ-3 can be verified.
2. turn the НВУ automatic mode off by setting the navigation computer switch “подготовка навигации” off. The autopilot bank channel will keep the current course.
3. put the switch “коррекция” on the НВУ panel to the position “осн”. Now compare the arrow “К” on the УШ-3 with the index of position of the reserve gyro unit. In this case we transfer the actually working main gyro unit, which actiually feeds all “consumers”. Again a course change does not occur because with disconnecting the Autopilot the mode has changed to track the current course.
4. set the total correction in ЗПУ on the B-140.
5. reset the counter value Z to zero
6. turn the toggle switch “подготовка навигации” to the On position. If all was correct, there should be no course change.
7. After the transfer of gyro units it is necessary to do the alignment for БГМК units. For this repeat the procedure described above (3.3.3.2) for the ГПК mode and the switch (7) on the TKs panel in both positions. Near the arrival airport the courses ИКУ and ПНП must now be close.

НВУ correction using the РСБН system

The numeration process might accumulate a certain error. To eliminate the error, a correction using the РСБН short range navigation system can be added.
This correction is only possible with continous measurements oif distance and azimuth by the РСБН system. If the indicator lights "дальность автономно" or "азимут автономно" are lighted up, a correction is impossible. It could be that correction will not be included, wven if the signals are extinguished. That can happen very close to the beacons and indicates a data control system has identified unreliable data of the servo systems or the distance/azimuth values, that exceed a certain standard.
The correction can be started using the toggle switch "корр" on the B-51. Before starting the correction it must be certain that correct data has been set on the B-51 and on the "угла карты" (bearing ??) Instrument. Before correction also the НВУ autopilot mode must be switched off and shall be set again after correction.
For the correction of НВУ from РСБН it is necessary to prepare tha data. For the correction on ДИСС for each route section three parameters are needed : Great circle coordiantes of the beacons Sм and Zм and the grivation (угол карты) УК. If the station is e.g. located at the initial starting point of the route, then : Sм = S, Zм = Z, УК=ЗПУ.
Grivation (Угол карты) is assigned as the true heading relative to the meridian of the station, a parallel ЛЗП of this section. The РСБН system works only in the true coordinate system, therefore for parameter calculation only the geographical coordinates of start and end point of the route and the station are necessary. Tuning of the compass system, azimuth correction and magnetic variation have no influence on НВУ correction data.

Wind correction (and some DISS remarks)

The basic HBY operation mode is the numeration according to DISS data. With the disappearance of DISS data the system passes into a mode of off-line opeation from the system of air signals. This is a reserve mode with smaller navigation accuracy, but still sufficient to continue flight using the numeration.

In the real system a DISS failure can occur due to various reasons, in particular during flight above water surfaces. In the model the autonomous regime can only be obtained by turning the DISS system off.

For the autonomous mode the warning indication on the warning panel << memory DISS ->> is tested. This warning light also light up during takeoff, since the DISS system does not deliver data below 180 km/h. The HBY continously calculates speed and wind direction, in the DISS mode using groundspeed, after DISS failure it uses airspeed from the SVS and finally course from the TKS-P2.

The wind information can be entered into the drum counter of the wind panel B-57. Direction is entered on the left side, speed (in km/h) on the right.

The wind direction is displayed on the console. The instantaneous speed and wind direction on the B-57 values are memorized during switching of the HBY into the autonomous operating mode. The HBY System begins to conduct numeration through the airspeed from SVS and the wind parameters from the B-57 panel. In the autonomous regime switches located under the speed and direction counters become active. This makes it possible to manually introduce speed and wind direction periodically. HBY determines wind direction on the orthodromic course.

7.4. Signal Light System

1 - not ready for takeoff
2 - false trim, МЭТ Failure or МЭТ has come to a stop or attempt to work on МЭТ during Autopilot operation.
3 - Autopilot (AFCS) - failure in Bank channel
4 - Autopilot (AFCS) – failure in Pitch Channel
5 - Go Around only in non automatic mode !
6 - Landing approach СТУ failure or Airplane Glidepath deviation exceeded –
7 - Autothrottle Control Failure. Operate Thrust manually!
8 - Maximum Localizer Deviation during ILS Approach exceeded
9 - Glideslope Deviation, below 100m until DH if plane is 1 dot above glidepath
10 - Engine FIRE !

11 - Localizer Mode
12 - 3K Heading Select Mode
13 - Bank Stabilization Mode
14 - HBY Mode
15 - VOR Mode (A3-I, A3-II)
16 - Marker I (outer marker)
17 - Marker II (middle marker)
18 - Failure of the Roll Monitor Unit БКК-18
19 - Glideslope (Glissade)
20 - Autothrottle
21 - Pitch Stabilization
22 - Altitude Hold Mode (H)
23 - IAS Mode (V)

24 - MACH Mode (M)
25 - Marker III (Inner Marker) - not used

26 - Fuel Below 2500 KG Warning
27 - AOA Warning
28 - G Overload Warning
29 - Lights up when Pilots send signal about hijacked plane (of course not used in sim)
30 - Lights up if Cabin Crew sends signal about hijacked plane (not used in sim)
31 - Overspeed Warning

32 - Left bank above safe limit (33 deg)
33 - Go Around Mode
34 - Decision Height H indicator
35 - Terrain danger
36 - Right Bank above safe limit (33 deg)

37 - Stabilizer Transit
38 - First Flaps Extention Channel working
39 – Second Flaps Extention Channel working
(Flaps are operated by two parallel channels from two hydraulic systems !!)

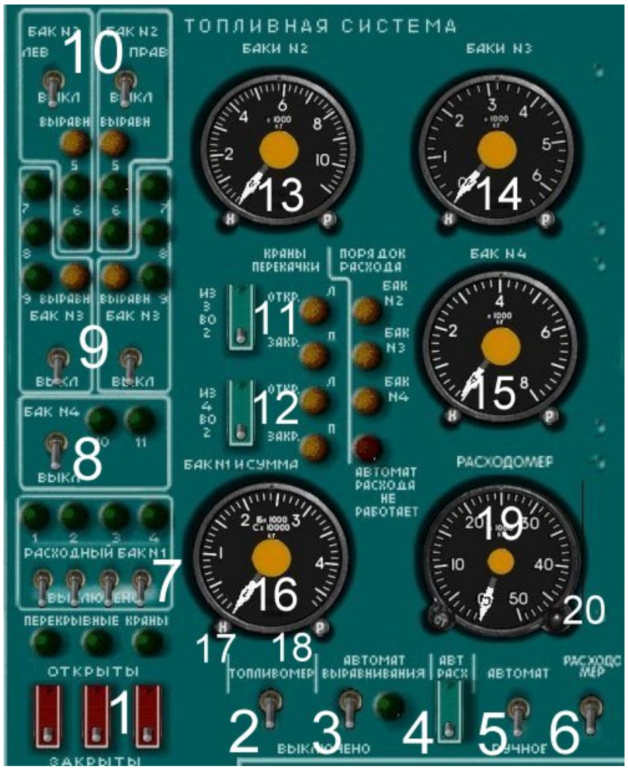
40 - Locks of the left center (left middle) spoilers open
41 - Locks of left inboard spoilers open
42 - Locks of right inboard spoilers open
43 - Locks of the right center (right middle) spoilers open
44 - Flight Loaders PB (Elevator Takeoff forces) switched off
45 - Flight Loaders PH (Rudder Takeoff forces) switched off
46 - Rudder Trim Neutral
47 - Aileron Trim Neutral
48 - Elevator Trim Neutral

49 - Engine 1 Failure
50 - Engine 2 Failure
51 - Engine 3 Failure

52 - НВУ Failure
53 - MGV (vertical gyros) Failure
54 - НВУ - VOR Autopilot Failure
55 - НВУ Correction included
56 - No RSBN Signal (or Failure) in the Range Channel (distance unavailable)
57 - No RSBN Signal (or Failure) in the Azimuth Channel (bearing unavailable)
58 - DISS memory (below 180 km/h)
59 - Waypoint Change, turn to new waypoint during HBY Navigation.
60 - Leading edge Flaps are retracting

7.5. The fuel system

7.5.1. Panel switches and gauges



1 - shut off valves (engines 1,2,3)

2 – power for fuel quantity indicators

3 – fuel level equalization automation

4 – automation power switch

5 – switch automatic / manual mode

6 – flowmeter switch

7 – fuel pumps 1,2,3,4, for tank No1

8 – fuel pump tank No4

9 – fuel pumps tank No3 (left/right)

10 – fuel pumps tank No2 (left/right)

13 – fuel quantity indicator tank No2

14 – fuel quantity indicator tank No3

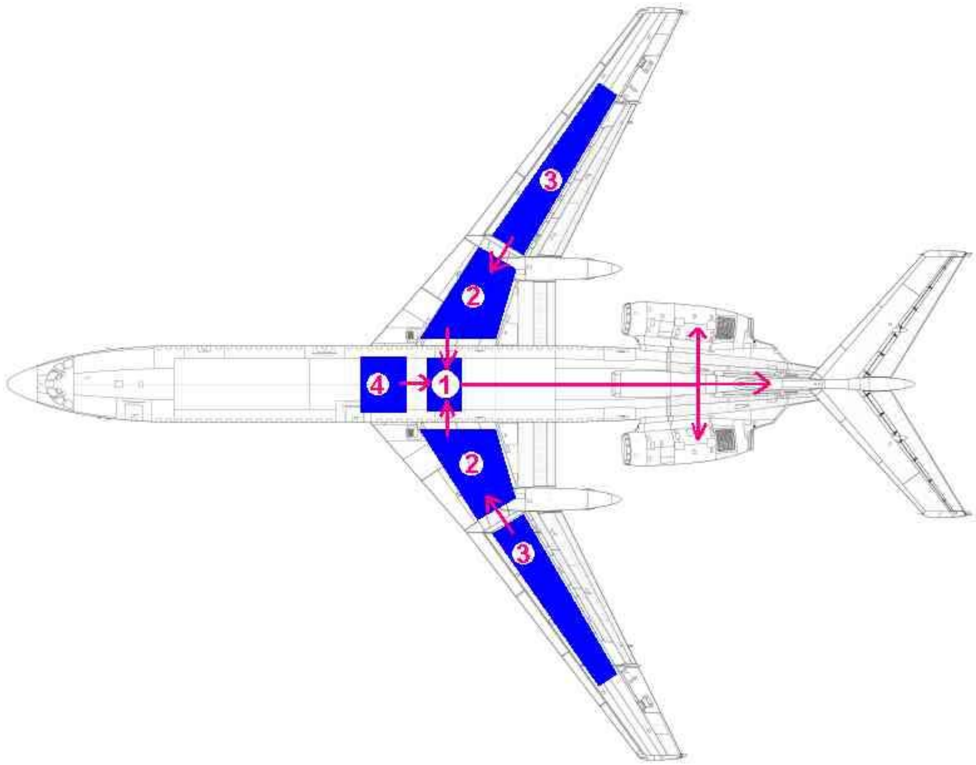
15 – fuel quantity indicator tank No4

16 – fuel quantity indicator tank No1 and total fuel quantity indicator

17 / 18 – test/check buttons (17 ‘H’ zero, 18 ‘P’max).

19 – Flowmeter

20 – Flowmeter index knob



7.5.2. General data

A total fuel capacity of 49687 l = 39750 kg (at a density of 0,8 g/cm3) can be placed in six torsion boxes-tanks:

- One sump tank № 1 in an underfuselage section of the wing center section (capacity 3300 kg);
- Two symmetrical tanks №2 in a wing center section (capacity 9500 kg);
- Two symmetrical tanks №3 in detachable sections of the wing (capacity 5425 kg);
- One tank № 4 in a wing center section in front of tank № 1 (capacity 6600 kg)

.

From five tanks the fuel is transferred on four lines by electronically driven pumps in a sump tank №1 through fuel dividers. Fuel dividers consist of four membrane valves, each located at the end of the swapping line, and two float valves. The fuel dividers, periodically opening and closing swapping lines, support constant delivery to the sump tank in all flight phases.
The tanks №1 and №2 have two pumps, tanks №3 three pumps, tank №4 two pumps.

An additional system of a manual fuel transfer is used only on the ground:

- from tanks №3 in tanks №2 for increase of the center-of-gravity margin
- from a tank № 4 in tanks № 2 for removal of fuel (partially or completely), depending on available payload.

From the sump tank №1 the fuel supply to the main engines is handled by four pumps 1, 2, 3 and 4. Additionally to the ВСУ (APU) by a fifth pump ETSN-319.

7.5.2.1. The fuel management schedule:

In flight there's a constant updating of the sump tank №1 due to fuel transfer from the tanks № 2, 3 and 4. Fuel usage begins from tanks №2 (left and right) up to a quantity of 3700 ± 250 kg.
At a remaining fuel quantity in tanks №2 of 3700 ± 250 kg, the ETSN-323 pumps of tanks №3 are activated and parallel usage from tanks №2 and №3 proceeds, until fuel from tank №2 is fully used. Empty tank №2 then corresponds to a remaining quantity of 1725 ± 250 kg in tank №3. Then after full use of tanks №3 their pumps are switched off and the pumps of tank №4 are turned on up to full transfer from tank №4. After full usage from tank №4 and corresponding pump switching, the fuel transfer from tank №1 begins.

NOTE: At usage of tank №4 for centering or ballast purpose, it is necessary to proceed to manual control («АВТОМАТ – РУЧНОЕ» in position «РУЧНОЕ») AFTER complete fuel usage from tanks №2. It is necessary to activate pumping via the pumps of tanks №3 .

7.5.2.2. The fuel system automation provides:

– Measurement of a fuel content in each tank and the total fuel amount onboard;
– Control of fuel usage under the specified program;
– Fuel equalization between symmetrical tanks № 2 and 3;
– Warning sound and signal system light at a remaining fuel amount of 2500 kg.

A few remarks on the working mechanism of the fuel dividers :
The pumps ECN-323 pump fuel from the tanks № 2,3,4 into the tank №.1. The capacity of the tank № 1 is 3300 kg. The "fuel divider" opens and closes the valves, which are placed on the pipes behind the pumps.
The mechanism follows this procedure:
If fuel level in the tank no.1 is above 2950-3050 kg then the valves are closed.
If fuel level in the tank no.1 is below those values then the valves are open and fuel runs into the tank.
If fuel level in the tank no.1 is above about 3200 kg then the valves close and fuel flow into the tank will be stopped.

Let’s proceed with all details of the practical fuel system operation :

7.5.3. Fuel system checks before flight

1) check the serviceability of the warning lamps. Before an engine start-up and in flight the switches of fuel pumps for swapping of tanks №2 and №3 should be included. Turn on the fuel quantity indicators (топливомер) and the automatic fuel consumption control unit, then the caution lights about the consumption and activities of fuel pumps should light up. The lamp «АВТОМАТ РАСХ. НЕ РАБОТАЕТ» should dim. Set the switch «АВТОМАТ – РУЧНОЕ» in the position «АВТОМАТ».. Depending on presence of fuel in tanks there can be three versions of operation of the automatic consumption control unit:

a) When the lamps «ПОРЯДОК РАСХОДА БАК №2» light up, pumping from the pumps of tanks №2 should be activated and signal lamps should burn indicating their activity.

b) When the lamps «ПОРЯДОК РАСХОДА БАК №2» and «ПОРЯДОК РАСХОДА БАК №3» light up, pumping from the pumps of tanks № 2 and №3 or only tanks № 3 should be activated and signal lamps should burn indicating their activity.

c) When the lamps «ПОРЯДОК РАСХОДА БАК №2», «ПОРЯДОК РАСХОДА БАК №3», «ПОРЯДОК РАСХОДА БАК №4» light up, pumping from the pumps of a tank №4 should be activated and signal lamps should burn indicating their activity

2) check the serviceability of the fuel quantity indicators (топливомера) by serially pressing the buttons "H" and “P” for each of the indexes, in this case:

a) by pressing button "H" the index should move to a zero scale mark;
b) by pressing button "P" the index should move to the maximum scale mark;

c) by pressing button " Н " simultaneously, the index for the total fuel quantity should move aside zero (indications of the sum of a fuel content decrease in the tank where the index button "Н" is pressed).

3) check the fuel reserve in all tanks according to the flight planning using the indices of the fuel quantity gauges “топливомера”.

a) the index «БАК №1 И СУММА» (Tank №1 and sum)
- the arrow «I» shows the fuel reserve in the №1 sump tank;
- the arrow «С» shows a total sum of the onboard fuel reserve

b) the index «БАКИ №2» (TANKS №2)
- the arrow «Л» shows the fuel reserve in the left tank №2;
- the arrow «П» shows the fuel reserve in the right tank №2.

c) the index «БАКИ №3» (TANKS №3):
- the arrow «Л» shows the fuel reserve in the left tank №3;
- the arrow «П» shows the fuel reserve in the right tank №3.

d) the index «БАКИ №4» (TANK №4) shows the fuel reserve of fuel in tank №4

4) set the switch « «АВТОМАТ ВЫРАВНИВ.» to upper position and check his serviceability by a lighted caution lamp (green).

5) set the Flowmeter switch «РАСХОДОМЕР» to the upper position and, after rotation of corresponding pointers on the total index, establish a grade of the filled fuel, and set the pointer on the general reserve of fuel, determined by pointer «С» (топливомера) on the flight engineer panel.

6) sequentially activate the Tank №1 pump switches «РАСХОДНЫЙ БАК №1» and check the activity of pumps 1, 2, 3 and 4 with their caution lights (the lamp burns — the pump works).
If the pumps are actively pumping, check the tightness of the shut-off valves with absence of signal lights « P FUEL » and «Р ТОПЛИВА» within 5 seconds.

7) check the serviceability of shut-off fuel valves by the sequential setting of the three switches in position «ОТКРЫТЫ» (open). Lighting up of the caution lights testifies opening of the valves.

8) set the switch «АВТОМАТ – РУЧНОЕ» in position «РУЧНОЕ» (manual). Check the activity of pumps for swapping of tanks №2, №3 and №4 with turning on of their caution lights after sequential activation of the pump switches . Then set the switch in position «АВТОМАТ».

9) check of activity of the ВСУ fuel pump ЭЦН-319 and activity of the pump of tank №1 actively pumping fuel to ВСУ by :

a) setting the switch" ЗАПУСК " (on the ВСУ start panel) to upper position.
b) set the switch « ЗАПУСК – ХОЛ.ПРОКР. » In the position " ЗАПУСК ".
c) lighting up of « Р ТОПЛИВА » (on the signal panel of ВСУ start) testifies to serviceability of the pump.

10) activate the switch «КРАН РЕЗЕРВН.ПЕРЕКАЧКИ В БАК №1» and check the serviceability of shut-off valves (two yellow caution lights should burn). In position «ЗАКРЫТ» (closed), the lamps should to go out.

7.5.4. Operation of a fuel system in flight

1) Control of fuel pumps

a) Automatic control of pumps:

- turn on the switches «РАСХОДНЫЙ БАК №1» (for all flight phases).
- turn on the switches of the №2 and №3 pumps (during entire flight on the automatic control unit).
- set the switch «АВТОМАТ – РУЧНОЕ» in position «АВТОМАТ» (automatic)

Control over the activity of pumps is executed on caution lights according to the fuel management schedule, see 7.5.2.1, and the activity of the automatic control unit of equalization according to 7.5.4.c

PREVENTION: AT ALL OPERATIONAL MODES AND CONTROL OVER THE FUEL SYSTEM IN FLIGHT THE SWITCH « АВТ.РАСХ. » SHOULD BE IN UPPER POSITION.

b) Manual control of pumps (applied at failure of the automatic fuel consumption control unit and to maintain a necessary center-of-gravity position).
– set the switches «РАСХОДНЫЙ БАК №1» in upper position.
– set the switch «АВТОМАТ – РУЧНОЕ» in position «РУЧНОЕ» (manual)
– the switches of pumps №2, №3 and №4 are activated and switched off according to the fuel management schedule (see 7.5.2.1.). The fuel quantity levels are determined using the quantity gauge indexes (топливомера) and the operation of pumps checked by the indicating lights.

c) Manual control of pumps at small remaining fuel quantity

Transition to manual control of pumps is made:

– at empty tanks №2, №3 and №4, in the beginning of fuel use from the sump tank №1;
– at premature switching-off of pumps of tank №4 (at a rest of fuel of around 600 KG in tank №4);
– at premature switching-off of pumps of tank №2 and №3 (with a small fuel content in these tanks), in the beginning of fuel tank depletion from №4, or tank №1 in case of absence of fuel in tank №4;
– after manual equalization of the fuel content in tanks №2 and №3, if pumps of these tanks are not activated at transition to automatic control. Manual control of pumps is executed according to 1b.

2) Fuel quantity levels (Топливомер)

a) the fuel quantity gauges (Топливомер) are activated before start and stay in active position during the entire flight.

b) the control over a fuel content in tanks is conducted using the indices "топливомера" for «БАК №1 И СУММА» (tank №1 and sum), «БАКИ №2» (tank №2) , «БАКИ №3» (tank №3), «БАКИ №4» (tank №4) and the index on the Copilot panel.

c) if in doubt of the correctness of the index indications, check the serviceability by pressing of buttons "H" and "P".

3) Flowmeter

a) Before actuation of a flowmeter make sure, that the pointer is on the general fuel reserve, determined by the pointer «C» (fuel quantity gauge, топливомера).

b) the flowmeter is activated with the switch «РАСХОДОМЕР» before flight and remains in open position until the termination of flight.

c) the value of fuel consumption per hour for each engine can be determined with the pointer of the instantaneous flow rate index УМРТ-2Т. The rest of the fuel reserve on the airplane can be determined using the total consumption index УСЗТ-5Т, whose indications will decrease and during consumption of total fuel, will be equal to zero.

During flight periodically compare the fuel reserve indications on a flowmeter to indications of the pointer «C» on the fuel quantity gauges (топливомера). The difference of indications between indexes of a flowmeter and топливомера thus should not exceed the value, equal to tolerances on these devices and no more than 3100 kg.

4) The automatic fuel consumption control unit

a) The automatic fuel consumption control unit is activated before engine start-up.

PREVENTION: THE ENGINE START-UP ON THE GROUND IS POSSIBLE ONLY AT ACTIVATED AUTOMATIC CONTROL UNIT. WITH A DISCONNECTED AUTOMATIC CONTROL UNIT THE LAMP «АВТ.РАСХ. НЕ РАБОТАЕТ» LIGHTS UP

b) The control over activity of the automatic fuel consumption control unit is executed with lighted caution lights «ПОРЯДОК РАСХОДА», and with lamps of swapping pumps, further under indications of fuel quantity indices (топливомера) according to the fuel consumption program.

c) At failure of the automatic fuel consumption control unit the lamp «АВТ.РАСХ. НЕ РАБОТАЕТ» lights up, change to manual control of swapping pumps.

5) The automatic equalization control unit

a) the automatic equalization control is activated using the switch «АВТОМАТ ВЫРАВНИВАНИЯ» on the ground before engine start-up, thus its green caution lamp lights up and remains switched on until termination of flight. The automatic equalization control unit works only with a switched on automatic consumption control.

b) the automatic equalization control unit works at occurrence of a fuel content difference in the symmetrical tanks №2 of 350 ± 150кг and tanks №3 of 300 ± 100 kg. So the automatic control unit switches off pumps of the tank with less fuel (their caution lights vanish) and activates the caution light «ВЫРАВН» of this tank.

After equalization of a fuel content in the tanks the automatic control unit switches pumps and signal lights to the initial position.

c) at a difference of a fuel content in symmetrical tanks of 800 ± 200 kg, the automatic equalization control unit is automatically disconnected, thus its caution light vanishes. Pumps are activated to transfer fuel from tanks which have been switched off by the automatic equalization control unit, thus all lamps «ВЫРАВН» light up.

d) to turn the automatic equalization control unit off :

– set its switch to “off” position,
– switch the pumps to manual control,
– equalize the fuel content in symmetrical tanks and again control of pumps switch on the automatic fuel consumption control unit in position «АВТОМАТ».

Equalizations should be repeatedly done at an occurrence of a fuel content difference in the symmetrical tanks of more than 800 kg .

7.6. The hydraulic system

7.6.1. General data

The hydraulic system consists of three hydraulic subsystems operating independently from each other.

The hydrosystem 1 contains :

- a tank to store the hydraulic fluid (AMG-10 oil) with a capacity of 48 litres
- engine driven pump (EDP), rotated by engine 1
- engine driven pump, rotated by engine 2

The hydrosystem 2 contains :

- a tank to store the hydraulic fluid (AMG-10 oil) with a capacity of 48 litres
- engine driven pump (EDP), rotated by engine 2
- electromotor driven pump 2 (EMDP)

The hydrosystem 3 contains :

- a tank to store the hydraulic fluid (AMG-10 oil) with a capacity of 24 litres
- engine driven pump (EDP), rotated by engine 3
- electromotor driven pump 3 (EMDP)

7.6.2. The hydrosystem consumers :

From hydrosystem 1

- subchannel 1 of boosters, control drives and aggregates : ailerons, elevator, rudder,
- subchannel 1 of flaps mechanism
- general gear extension/retraction mechanism
- general brake system
- emergency brake system (charging the accumulator of emergency brakes)
- control of inboard and center spoilers

For hydrosystem 2

- subchannel 2 of boosters, control drives and aggregates : ailerons, elevator, rudder,
- subchannel 2 of flaps mechanism

- emergency gear extension mechanism
- control of nose wheel steering hydraulic cylinder

For hydrosystem 3

- subchannel 3 of boosters, control drives and aggregates : ailerons, elevator, rudder,
- subchannel 3 of flaps mechanism
- backup emergency gear extension mechanism

7.6.3. Panel instruments and gauges :

1-3 Manometers for hydrosystems 1-3
4-6 Low Pressure Lights for hydrosystem 1-3
7 Manometer for emergency brake system
8 Low Pressure Light for Emergency Braking system
9 Level indicator for Tank 1 (summa for hydrosystem 1 and 2) with level check button to the right
10 Level indicator for tank 3 with level check button to the left
11 Emergency brake system accumulator charge button
12 Closure valve for feeding hydrosystem 1 from hydrosystem 2 (protected under cap)
13 Engine motor driven pump (EMDP) 2 turn on/off toggle switch
14 Engine motor driven pump (EMDP) 3 turn on /off toggle switch

7.6.4. Hydraulic system checks

Check of hydraulic system before engine start

1) check the turned off position of the control switches for : electropumps, connection of hydrosystem 2 to hydrosystem 1, backup emergency gear extension and turn of landing gear forward wheel.
2) check protection of the handle « ШАССИ АВАРИЙНЫЙ ВЫПУСК » from hydrosystem 2, the switch « ВЫПУСК ОТ 3 Г/СИСТ. » (backup emergency gear extension from hydrosystem 3) is closed by the cap, the control handle of center spoilers is in a forward position on a latch and the signal lamps «СРЕДН» and «ВНУТР» (open position of locks) do not burn.
3) check normal levels of oil in the hydrosystem tanks as indicated on the gauges

- For hydrosystems 1 and 2, at zero pressure with spoilers retracted and airplane on the parking brake, there should be 48 ± 1l in the tanks;
- For hydrosystem 3, there should be 24 ± 1 l at zero pressure.

Check of the hydrosystem from ground source power supplies or after ВСУ start

1) check pressure in hydrosystems 1, 2, 3 (at presence of pressure release it up to zero) to be 0 KG/cm2.
2) connect ground source power supplies or start ВСУ and connect generator VSU to the aircraft electrical system.
3) put the electropump of hydrosystem 2 into operation and check up:
- Recompression time up to 210 (+10;–7) KG/cm2 shall be no more than 14 s;
- Stability of pressure 210 (+10;–7) KG/cm2;
- set the booster switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 2» (from hydrosystem 2) and check control of ailerons, elevator, rudder and flaps. At fast simultaneous movement of control surfaces from one extreme position in another, observe the pressure drop and low pressure warning light below 100 KG/cm2.
4) open the closure valve for feeding hydrosystem 1 from hydrosystem 2 electropump and check :
- operation of the crossfeed valve from hydrosystem 2 to hydrosystem 1;
- Stability of pressure (210 (+10;–7) KG/cm2) in hydrosystems 1 and 2 without moving the control surfaces;
- Control of the main brakes, landing gear, internal and center spoilers;
- Action of caution lights (at pressure increase in systems more than 100 ± 5 KG/cm2 the signal lamp vanishes, and below this pressure lights up).

Turn off the booster switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 2» (from hydrosystem 2). Turn on the booster switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 1 » (from hydrosystem 1) and check control of ailerons, ailerons-spoilers, elevator and rudder.

5) disconnect the electropump of hydrosystem 2 from hydrosystem 1, and then switch off the electropump of hydrosystem 2 and the booster switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 1 » from hydrosystem 1.
6) check up pressure in hydrosystem 3 (at presence of pressure release it up to zero).
7) turn on the electropump of hydrosystem 3 and check up the recompression time to 210 (+10;–7) KG/cm2 should be no more than 14 s.
Turn on the booster switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 3 » (from hydrosystem 3) and check control of ailerons, ailerons-spoilers, elevator, rudder and an operating caution light of a pressure drop in hydrosystem 3 (similar to check of hydrosystems 1 and 2).
8) switch off the electropump of hydrosystem 3 and the switch « БУСТЕРНОЕ УПРАВЛЕНИЕ 3 » (from a hydrosystem 3).
9) turn the hydrosystem electropump switches and crossfeed valve on and charge the emergency braking system by pressing the button «ЗАРЯДКА АККУМ.» (11 in screenshot above) to a pressure of 210 KG/cm2. After boost charge disconnect the hydrosystem 2 from hydrosystem 1 and switch the hydrosystem 2 and 3 electropumps off.
10) after check of hydrosystems from electropumps and charging the emergency braking system be convinced:
- a normal level of oil is available in the hydrosystem tanks;
- the switches of electropumps, the crossfeed valve from hydrosystem 2 to hydrosystem 1 and all consumers are in switched off position.

Check of hydrosystems after engine start-up

Before engine start-up the pressure in hydrosystems 1, 2, 3 shall be no more than 160 KG/cm2 if electropumps were started; if electropumps were not not started, pressure in hydrosystems 1,2, 3 can be around zero.
With boosters on, move the control surfaces to bring the pressure below this limits.

2) at engine start-up, check a pressure rise on the manifold gauges in the hydrosystems:

a) After start of the first engine — in the hydrosystem 1;
b) After start of the second engine — in the hydrosystems 1 and 2;
c) After start of the third engine — in the hydrosystem 3.

The pressure in hydrosystems during engine start should increase up to 210 (+10;–7) KG/cm2 to define the hydropump of one hydrosystem serviceable.

3) after simultaneous activity of all engines turn on the boosters switches «БУСТЕРНОЕ УПРАВЛЕНИЕ 1,2,3» (from hydrosystems 1, 2, 3) and check :

a) Presence of normal pressure in all hydrosystems (without moving controls);

b) Presence of pressure feed to control drives from hydrosystems 1, 2 and 3 (it is checked on oscillations of arrows of pressure gauges of these systems at simultaneous fast movement of control surfaces);

c) After check of control surfaces, check normal oil quantity in hydraulic tanks

Control of activity of hydrosystems in flight

The flight engineer controls the activity of the hydrosystems in flight
a) by using the pressure gauges of hydrosystems 1, 2, 3 and emergency braking.
b) by controlling lights of pressure drop (lamps light up at pressure drop below 100 ±5 кгс/sm2 and 190±10 кгс/sm2 in a system of emergency braking.
c) the level of oil in hydraulic tanks is checked on level gauges which are actuated by the buttons located near the indices.

Pilots control the activity of the hydrosystems in flight
a) by using the pressure gauges of hydrosystems 1, 2, 3 (below HSI) pressure gauge of the Emergency Braking system
b) controlling the low pressure warning lights.

Some more interesting facts :

During flight, depending how intense you move the Joystick or Yoke, you might notice a slight pressure drop on the hydraulic gauges or the needles slightly trembling. During the hydraulic system checks on the ground, after electropumps and crossover switch are closed, moving the control surfaces reduces your hydraulic pressure, again depending how intense you move. At some point, the boosters fail and the control surfaces get stuck. Further movement of the Joystick or Yoke has no more effect.

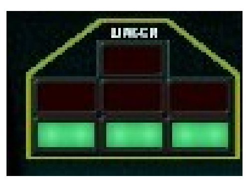
Now what would happen if all three engines fail during flight ? Total control systems failure after a certain time of movement and subsequent loss of hydraulic pressure ? No !! Due to the engine Autorotation (the turbine blades still freely move), a certain amount of hydraulic pressure is maintained (speed dependent !!). The pressure drop produced by engine driven pumps (EDP) depends on N2. Because the EDPs are equipped with an automatic gear box, there is a minimal N2 below which the pressure starts to drop. The N2 in autorotation mode in a function of indicated speed. Above some value EDP can produce a constant nominal pressure. E.g. around 20 KG/cm2 at a speed of 380 km/h. So we will not loose the boosters and control surface movement. Also this is implemented in the simulation !!

7.7. THE LANDING GEAR

7.7.1. General information

1) The system of landing gear extension/retraction consists of three kinds of control : Main, emergency and back-up emergency. The main control is feeded from hydraulic system 1, the emergency landing gear extension from hydraulic system 2, and the back-up emergency landing gear extension from hydraulic system 3. The retraction of the landing gear is feeded only from hydrosystem 1, while the extension is possible from all hydrosystems.

2) The landing gear signal light system ППС-2МК is implemented on the main instrument panel. and consists of seven signal lights. First of all, three green and three red lights. The single light above signals «ВЫПУСТИ ШАССИ» (extend landing gear). During retraction and extension of the landing gear, the three red lamps light up, signalling and intermediate position.
At finished landing gear retraction (landing gear on locks), the red lamps go out again. In the retracted position with gear on locks and gear doors closed neither red nor green lamps are lighted.



From left to right : Main landing gear lever and backup emergency landing gear extension switch, signal light system, emergency landing gear extension handle (on Copilot panel).

In completely extended position of the landing gear, the red lamps vanish and after being established on the extended position locks, the green lamps light up.

The flashing signal light «ВЫПУСТИ ШАССИ» (extend the landing gear) is activated, if the landing gear is not extended before landing and the IAS is reduced below 325 km/h and thrust is above 90% or the flaps are extended. The system can be disconnected (see below)

7.7.2. Operation of the main landing gear

1) Retraction

– set the main landing gear lever to the upper position. Your copilot will say : "ШАССИ УБРАНЫ" for "Gear Up".
In the beginning of retraction the green lamps go out and the red lamps light up. After the landing gear struts are on the locks in retracted position and the gear doors are closed, the red lamps go out again. 10 seconds later the Flight engineer will instruct : "КРАН ШАССИ НЕЙТРАЛЬНО" (gear valves in neutral !). Then put the lever in neutral position, the Copilot will confirm. He/she says : "КРАН ШАССИ В НЕЙТРАЛЬНОЕ УСТАНОВЛЕН" for "Gear valves established in neutral"

2) Extension

– set the main landing gear lever to the lower position. In the beginning of extension the red lamps light up. After installation of the landing gear legs on the extended position locks the red lamps go out and the green lamps light up; Your copilot will say "ШАССИ ВЫПУЩЕНЫ, ТРИ ЗЕЛЕНЫЕ ГОРЯТ" for "Gear down, three green lights"
- 20 s after the last green lamps lighted up (and hydraulic system 1 recompression to 210 KG/cm2), the flight engineer will again say : "КРАН ШАССИ НЕЙТРАЛЬНО" (gear valves in neutral !). Set the lever in neutral position then., commented by the Copilot : "КРАН ШАССИ В НЕЙТРАЛЬНОЕ УСТАНОВЛЕН" for "Gear valves established in neutral".

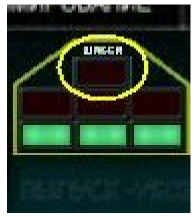
7.7.3. Operation of the emergency and backup emergency landing gear system

In case of hydrosystem 1 failure, use the emergency undercarriage extension from hydrosystem 2. Make sure the main landing gear system lever in is neutral (middle) position and on the hydrosystem 2 a pressure of 210 KG/cm2 is present. For gear extension, pull the handle « ШАССИ АВАРИЙНЫЙ ВЫПУСК » on the copilot panel.
In case of hydrosystem 1 and 2 failure use the backup emergency extension system from hydrosystem 3 using the switch « ВЫПУСК ОТ 3 Г/СИСТ. » to the left of the main landing gear lever.
The main gear lever should be in Neutral position and the emergency landing gear handle on the Copilot panel should be in the initial lower position.
Do not extend the gear from hydrosystem 3 if only the hydrosystem 1 has failed, because in that case the hydrosystem 2 has taken the "place" in the landing gear extension line.

Open the cap of the switch « ВЫПУСК ОТ 3 Г/СИСТ », set in position «ВЫКЛ.» (upper) and close the cap.

7.7.4. The signal light “extend landing gear”

Above the three green/red light signals, there’s one more important signal light (see the yellow circle below).



You might see a flashing light “Выпусти шасси”, which stands for the advisory “extend the landing gear”. It will be accompanied with a signal sound.

If you have read and flown the example flight, you might have noticed the common Russian order of approaches. The landing gear has to be extended before the Flaps are extended, usually before the third turn. Now if you attempt to extend the Flaps before extending the landing gear, you will get the above flashing warning light with the signal sound.

However, for “Western style” approaches (extend landing gear after Flaps extension) and for safety reasons (low speed margin in the third turn at Flaps and Gear extended, especially at weights around 78 t) that signal system can be disconnected in the real plane.

And guess what, we made it configurable. It’s a parameter in the file es.cfg (located at ../gauges/Tu154_cfg) :

[avionics] *– section of parameters of an avionics of engineering systems*

gear_warn_mode=2
Operational mode the signal system " Extend the landing gear ".
Possible versions:
0 – enhanced version (modernized version after adaptation under the bulletin).
2 – standard version.

Using gear_warn_mode=2, the signal system works with enhanced algorithm. Using gear_warn_mode=0, the system is active as decribed above.

7.8. Elevator Trim / Stabilizer Handling

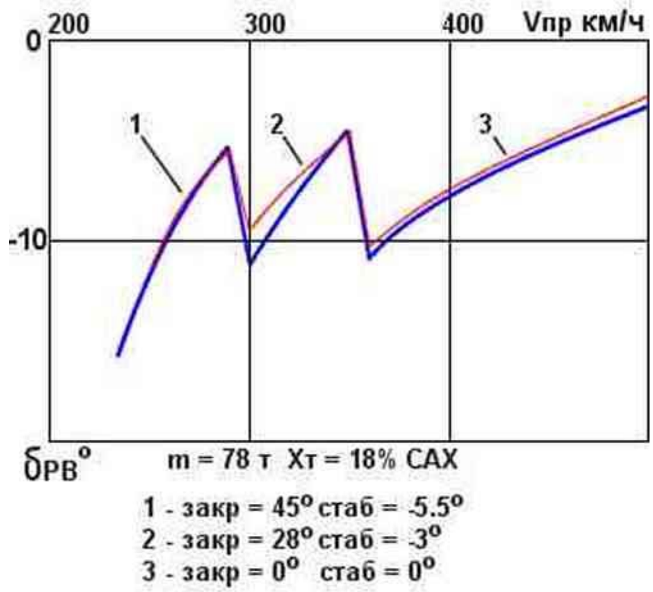
Without going too far into aerodynamics and airplane design, we just need to know a few important facts. Stabilizers on the tail (deliberately located behind the center of gravity of the airplane) are used to keep the effective elevator range in a safe and operatable margin and this over a wide range of center of gravity. If a large elevator deviation is required for balancing the aircraft in the pitch axis, it can be replaced with a smaller stabilizer deflection, thus preserving the effective elevator range in all phases of flight.
Now in the default Microsoft FS2004 we have a problem with the so called “trim”. Why so called “trim” ? Well, the Microsoft trim has no relation to the trim tab, the device which removes load from the control device (yoke, stick) during control deflection. It’s change in no way reflects the elevator position, so in essence the trim in Microsoft FS is a slanted stabilizer. This is in the first approximation acceptable for control of some aircraft like the B-737, where that “stabilizer” control is sufficient for balancing the aircraft. But it is completely unacceptable for aircraft like the Tu-154 (or the default Cessna, which doesn’t even have a stabilizer !). Also the default Autopilot governs pitch with the aid of the Microsoft “trim” or “stabilizer”. Both in summary remove this important real stabilizer concept from the simulation. So it is not surprising that the majority of FS aircraft are insensitive to CoG . With a stabilizer spread of +/-20% (!!) as in the default B737-400 and the not present elevator resistance (another MS special feature) it is possible to practically fly with any CoG setting.
Within the given framework the Tu-154B2 attempts to change the principle of elevator control and a trimmer mechanism in accordance to the present aircraft in versions > 9.3.

Let us examine the balancing of the real Tu-154B2. For the minimization of balancing losses, the angle of stabilizer setting is equal to –1.5 relative to the aircraft axis, or –4.5 relative to the root wing chord. In this case, under cruising conditions in all operating ranges of velocities and centerings, the elevator balancing deviation and balancing losses are at a minimum. In the takeoff and especially landing approach the effective elevator deviation range can prove to be insufficient for safe flight or necessary maneuvering. On the Tu-154B2, the stabilizer can be slanted to an angle of -1.5 to -7.0. For convenience the stabilizer position indicator scale is set to 0 for an angle of –1.5, so the stabilizer setting on the indicator changes from 0 to –5.5.
The elevator effectiveness gets significantly reduced from angles of more than 10%. Therefore values from 0 deg to 10 deg are accepted, taking possible deviation in turbulence conditions, normal balancing range during approach and glideslope intercept into account. Extension of flaps and gear increases the negative pitching “moment”, therefore with a centering of less than 35% (although in scheduled flights the maximum permissible centering is 32%), a transposition of the stabilizer is required for compensation.
Stabilizer control in the Tu-154B2 is possible in two modes : combined or manual. In the combined mode the stabilizer is set to “coincidence” automatically with flaps

extension/retraction. The coincidence is determined on the stabilizer handle depending on centering ("П" for front, "C" for average, "3" for rear), as in the following table of Flaps position (0, 15, 28, 45) vs. Centering setting.

Flaps	Centering		
	«П» (18-28%САХ)	«С» (28-35%САХ)	«З» (35-40%САХ)
0	0	0	0
15	-3	-1.5	0
28	-3	-1.5	0
45	-5.5	-3	0

The following graph shows the dependence of the elevator balancing deviation (dPB) from the speed at different flaps/centering settings. We can see how well the simulated Tu-154B2 performs the task – the red curve are test results in FS 2004, the blue is taken from the book by T.Liguma "Aerodynamics of the Tu-154B aircraft).



What does that long talk now mean in practice ? Some examples : Landing with a weight of 77t, CoG 22%. Gear down, speed 390 km/h. The elevator indicator pointer is in the green sector, therefore the stabilizer handle should be placed in position "P".

After flaps extension to 28 deg (speed 330 km/h), the stabilizer is automatically shifted to an angle of -3 deg, the elevator deviation in this case remains practically the same.

With an erronous setting of the stabilizer handle in position “C” (flaps 45, speed 275 km/h), the elevator deviation already leaves the safe range. This might lead to a rough landing with high vertical velocity. Always make sure the correct stabilizer handle position is used corresponding to CoG. A more drastic example : Flaps 45, 77t weight, V=265 km/h, CoG less than 24% and stabilizer setting of zero a landing is impossible !

In such cases it is necessary to immediately pass to the manual stabilizer control (after opening the cap of the stabilizer control). With the aid of the little device (press and hold until you reach the desired value according to the table above) the stabilizer can be transposed to a position, which ensures a sufficient reserve of effective elevator deviation.

The combined indicator for PB (elevator) and stabilizer has color markings on both scales. The color code on the PB scale is used to determining the necessary position of the switch «Задатчик стабилизатора» for the landing approach. The color code of the stabilizer indicator corresponds to the color code of the positions of the switch «Задатчик стабилизатора».
This correspondence (the location of the pointer of the indicator of stabilizer on the appropriate colored marks of the scale) is necessary for the aircraft in landing configuration (Flaps 45 !).

7.9. Tu-154 Control characteristics and the PA-56 system

The main control elements on the Tu-154 include the control of elevators, ailerons, rudder and flight spoilers. Command input is done via wheel columns (control column, yoke) and left/right rudder pedals, rigidly connected via cardan shafts among themselves and synchronously moving during airplane control by one of the two pilots.

Hydraulic boosters (actuators) are established. Pilots actually operate a position of moving rods via command-distributing control drives, converting “energy” of oilpressure in the hydrosystems, thus causing activity of the control surfaces. The control is established under an irreversible scheme, which means the control of the boosters does not demand efforts. So deviations FROM control surfaces are not reversibly transferred back to the pilot. The pilot would not get any force feedback, which is not desirable.

For this purpose, spring load/feel mechanisms (so called загружатели) are established for the imitation of aerodynamic load on the control column, proportionally to the amount of elevator deviation.There are takeoff/landing spring loaders, which always operate and create an artificial force of 6.0 to 38.5 KG (for pull) and 6.0 to 24 KG (for push).

For prevention of too instant and sharp control surface movements in flight (and thus overload of control surfaces), additional flight spring loaders are connected after flaps retraction (and consequently also removed at Flaps extension).
The forces depends on deviation of the control column. In the range up to +/- 9.0 degrees deviation, only the takeoff/landing spring loaders contribute. In the range of 8-9 degrees deviation, the activation of the additional flight spring loaders begins. At more than 9 degrees the force increases to 45 KG and with further deviation the forces proportionally increase.

The knowledge of this important real plane feature also helps to understand several signal lights referreing to the spring loaders in the panel. But ,we need to consider one more very important feature of the Tu-154 control system and the operation of the control surfaces. We concentrate on manual control of the plane.

The efficiency of a control surface is proportionally to the square of speed (drag). So the sensitivity of the control sharply grows with speed. To struggle against this, it is possible to enter the effectiveness ratio of a control surface with drag in FS. But in the real Tu154, another solution is applied. Besides the flight spring loaders a more sophisticated controllability improvement is used.

For comfortable control of the pitch channel is is necessary to provide a gradient of effort on the control column with G Load. This corresponds to maintain a constant control column travel with G Load.

The deviation of a control column with G-Load depends not only on drag (treated in FS by section 517), but also in a very strong degree from the center-of-gravity position. Especially forward center-of-gravity positions demand big "consumptions" of control column travel.

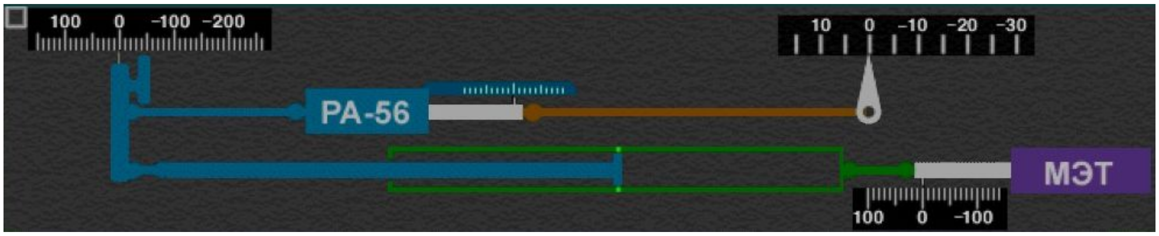
For creation of the automatic control unit in the Tu-154, one important property of the airplane is used : At zero G-Load the position of a control surface (column) remains constant in a broad range of speeds and Mach numbers. Here we have a reference point. For the Tu-154 the position of the control column of +140 mm at any weight and center-of-gravity corresponds to a G-Load of zero. Now to obtain the given value of control column deviation at a G-Load of zero in the PT Tu-154 model, it was necessary to change the angle of the stabilizer installation.

Let's designate the deviation of a control column at a G-Load of zero with x(o). In straight and level flight the control column is in balanced position x(bal). Consequently, for a given center-of-gravity position and speed the deviation of a control wheel with G-Load equals x(bal) – x(0). For trimming the airplane the deviation of the elevator trim МЭТ is equal to the deviation of the control column. Then for trimming the airplane at a given speed and center-of gravity the deviation of the control wheel with G-Load corresponds to $x_{(\text{МЭТ})} - x(o)$. This value is entered into the autopilot (AFCS) calculator to define the transfer factor from the column to the elevator. By the way, here one thing becomes immediately obvious : The airplane should always be trimmed !!

The variable factor of transfer from a column to an elevator is provided with the help of the electrohydraulic control aggregate PA-56, which is now also simulated. Therefore the deviation of a control surface is equal to the sum of deviation of the control column and PA-56 with corresponding factors. The transfer factor from a column to the elevator is 0,112 degrees/mm. The PA-56 deviation factor K_x is calculated by the Autopilot calculator depending on the МЭТ position with DPS-1 sensors. The PA-56 deviation is not made on absolute column deviation, but on the deviation from a balance position ΔX. For this purpose there is a sensor DPS-2. Here PA-56 also works on a signal of these two sensors :

$$\delta_B = K_{\text{ш}} * X + K_x * \Delta X$$

As a result, at a deviation of the control column, the PA-56 increases or reduces elevator deviation, depending on elevator trim (МЭТ) position. The PA-56 deviation is observable on the combined stabilizer and elevator position (PB) indicator ИН-3 on the main panel. At a position of МЭТ "on itself" on the ИН-3, the column deviates to the same side. At a position of МЭТ "from itself" on the ИН-3 we see a "backwards" deviation. That's also a system check described in the operating manual.
With extended Flaps, the signal of the DPS-2 sensor is disconnected.



You can observe the operation of the PA-56 in the panel. You can open this gauge by first switching on the Autopilot Parameter panel using the clickspot on the main panel and then click on the additional clickspot box on the lower left of that gauge.

On the upper right you see the position of your control device (control column, yoke, joystick). On the lower right you see the МЭТ elevator trim system. On the left side you see the elevator deviation and in the left part the operating PA-56 system and its deviation. Move your Joystick or Yoke, change the elevator trim and observe the syetem at work. Also use Autopilot pitch modes to observe the regulation of the system.

After that long theory let's sum up what is now simulated in the PT Tu-154 and what is the practical consequence in manual flight. Here it is : At any speed between 400 and 580 km/h and at any center of gravity position, the amount of control device travel for a given G-Load will be the same !!! This makes the plane much easier to control.

To give a practical value : According to tests, for creation of a G-Load of 1.3. a deviation of the control column of 33 millimeters is necessary, that at speeds from 400 to 550 km/h and center of gravity positions from 18% - 40%.

More values from the real plane :

Angles of elevator deviation

- at stabilizer setting 0 deg. 29 deg upwards, 16 deg. downwards
- at stabilizer setting 5.5 deg. 29 deg upwards, 14.5 deg. downwards

Control column travel (from neutral position) : 250 mm ... 0 .... 150 mm

Control of the PA-56 system

The PA-56 can be controlled on the upper left side of the Flight engineer panel. The PA-56 works on three independent channels yaw, roll and pitch, each feeded from the hydraulic systems 1, 2, 3. The hydrofeed is activated by setting all corresponding nine switches to the upper position.

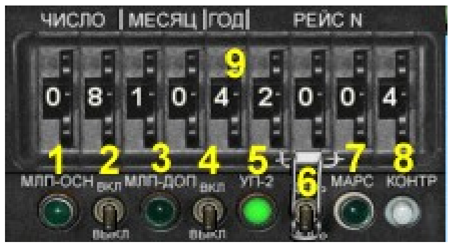
On the upper right, we find the switch "КОЛЬЦЕВАНИЕ" (crossover), which can be set in the positions automatic and manual ("АВТОМАТ"or "РУЧНОЕ"). During normal operation it is left in the position "АВТОМАТ".

This switch is also necessary for checks of the condition of PA-56 control aggregates. For each channel, there is a rod with sensors monitoring the moving rods. If the position of one rod does not coincide with the two others, this channel considers the automatic control faulty and disconnects its feed. If after that the two other rods deviate, the automatic control unit cannot define which one is faulty and then disconnects both. As the AFCS also works through the PA-56, the AFCS is also disconnected.
If the Crossover switch is set in manual position, it is possible to disconnect the faulty channels manually and to leave the working one serviceable. Then the AFCS can work in wheel mode.
If the automatic control unit has disconnected the AFCS, and one channel can work, it is necessary to open the cap, put the switch in manual position, not closing the cap and to reset (off/on) the CAY-CTY switch on the overhead panel.

Below the Crossover switch, we find the switch to activate the longitudinal controllabilty feature of the PA-56 as described above (identical control column deviation for definite G-Loads at any CoG and Speed). Simply put the switch “ПРОДОЛЬНАЯ УПРАВЛЯЕМОСТЬ” in upper position and close the cap.
The Control button at the lower right is used to check the serviceability of the signal light system.

7.10. МСРП-64 Flight Data Recorder and OCS Analyser

The МСРП -64 system of the registration of flight data is intended for the record of flight parameters for the purpose of a subsequent analysis.



Control panel. The following control elements and indications are located on the control panel МСРП-64 control panel (in the real instrument):

1. Lamp to indicate the recording of the basic tape-drive mechanism.
2. Toggle switch to start the basic tape-drive mechanism.
3. Lamp to indicate the recording of the additional tape-drive mechanism.
4. Toggle switch to start of additional tape-drive mechanism.
5. Lamp to indicate readiness of feeding.
6. Toggle switch to turn the illumination on.
7. Lamp to indicate the work of the vocal chart recorder Mars.
8. Button for the inspection the work of lamps (control).
9. Switches to set the included date and flight number.

The designation of the control elements and the signaling of the model differ a little from real. Only one recording channel is used (chart recorder). For control and signalling of the operating mode the toggle switches 2, 4, 6 and the lamp 1 and 3 are used. Lamp 5 lights up with proper working order of МСРП feeding, lamp 7 is not used.

The record of information is written into a text file in the directory .. \ \Gauges \Tu154_.cfg \MSRP \. There are two versions of the filename selection for the record, assigned in the file tu154_.gau.cfg. If in the SYSTEM section msrp_.one_.file=1 is specified, the record is always written into the file msrp.txt. If in the SYSTEM section the entry msrp_one_file=0 is used, the name of the file for the record is generated including the date and flight number.

For the start of the МСРП system it is necessary (with lamp 5 lit) to turn on the toggle switches 2 and 4 on the panel. In this case the lamps 1 and 3 will identify the MSRP operation mode. If the lamps burn continuously, it means the file is opened for the record, but data is not yet written. The record is produced if the lamps blink.
Blocking of recording with МСРП turned on is done for the purpose to decrease the file size. In the SYSTEM section of the file tu154_.gau.cfg it is possible to assign a minimum speed for the beginning of the recording , for example msrp_speed_min=100. This makes it possible to automatically block the recording of data during taxiing. The pause of recording can be manually done by turning off the switch ОДИН. With reclosing of this switch the recording will continue.
To disconnect the MSRP it is necessary to turn off both toggle switches. In this case the lamps 1 and 3 will extinguish and the file will be closed.

Usage of MSRP. Before flight set up the date and the flight number on the MSRP panel and turn on the toggle switches 2 and 4. After the flight toggle the switches off to turn off the system. For decoding of the record the OCS data analyser is available seperately on our Website.

Frequency of record. During cruise, the record is generated every three seconds. In the takeoff and landing stages, depending on height, speed and flaps, the record is produced with a frequency of one to six times per second. To force a high frequency record during any flight phase the toggle switch (6) can be used. The shielded wire clamp can be opened with the right mouse button. In this case the 10000 line limitation must be taken into account. After this, the record is produced from the beginning of the file and the previous values are overwritten. So a maximum of 10000 records are stored.

Written parameters :

Analog parameters (parameter and unit)

el_.time - time since the beginning of the work of МСРП, s
time - current time in hours, minutes, seconds
m_.kurs - magnetic heading with ТКС, degrees
kren - bank from the vertical gyros, degrees
tang - pitch from the vertical gyros, degrees
alt_.bar – barometric altitude (on standard pressure), meters
alt_.r - radio altitude with РВ-5М, meters
IAS - speed instrument, km/h
v_.y - vertical velocity, m/s
alpfa - angle of attack with АУАСП, degrees
n_.y - vertical overload with АУАСП
kolonka - position of control column in percentages of full deflection

RV_.pos - surface position height, degrees
MET_.pos - position MET in percentages of full deflection
stab_.pos - position of stabilizer, degrees
el_.pos - position of left aileron, degrees
RP_.pos - surface position turn, degrees
flaps_.pos - position of flaps, degrees
COG - centering in the percentages CAX
eng1_n1 - rpm of the first engine, percentage
teng1_n2 – rpm of the first engine, percentages
fuelflow – fuel consumption of the first engine, tons per hour
latt - current latitude, degrees
long - current length, degrees

Discrete signals

on_.ground - aircraft on the ground (reduction of basic counters)
AP_.kren – ABSU bank channel working mode
0- activated
1- manual control
2- bank stabilization
3- ЗК, heading select mode
4- HBY
5- A3-I
6- A3-II
7- Localizer (approach)
8- GoAround
AP_.tang – ABSU pitch channel working mode
0- activated
1- manual control
2- pitch stabilization
3- M (IAS Mach Mode)
4- V (IAS Mode)
5- H (Altitude Hold Mode)
6- Glidepath (Glissade)
7- GoAround
AT – Autothrottle working mode
0 - agreement
1 - preparation
2 - speed hold
3 - GoAround
Gear - landing gear extended
Spoilers – spoiler locks are opened
OMI - signal of the marker receiver

OCS DATA ANALYSER

The OCS Analyser is available as a seperate download from the Project Tupolev Website – the filename is **ocs_pt_154.rar**. Unzip the rar file, execute the exe installer and point it to an installation directory of your choice.

The program should automatically detect your language according to the windows setting. The program creates an entry in your registry at HKEY_CURRENT_USER\Software\VB and VBA Program Settings\OCS_Decryptor. Here a key *lang* is included, which contains the value *CurrentLanguageSet*,. Just in case the automatic language detection did not work : The value might be manually changed to the data value *english.*

1. Purpose.
The program is intended for processing, analysis and studying of data of records stored in flight using the MSRP-64 flight data recorder. It can be used to examine piloting techniques, educational purposes and studying of the functionality of systems, also for the analysis regarding reasons of flight incidents.

2. Loading data.

After starting the program (OCS-Decryptor.exe), execute the command File / Open from the menu and point to the MSRP-64 txt data files, usually located in the folder <FS 2004 Main>/gauges/Tu154_cfg/MSRP. As the records might contain up to 10000 lines of data, the loading can take quite some time.

3. Filtering functions.

To assist in concentrating on specific data or a quick search for particular information, several filtering functions are provided. Access to filters is avaible using the through the menu Filters. Some filters can be simultaneously involved, which further allows to narrow the search area. For a special filtering association, the operators AND, OR, XOR are provided (Filters, Conditions join ...). The filtered entries will show up in red colour by default, the colour can be changed in File/Options.

4. The options menu (File/options)

- select the parameters you want to display in the graphical parameter representation by clicking the corresponding checkboxes. For each parameter, the colour can be individually chosen. Also for every parameter the minimum and maximum margin and the axis position can be chosen.

5. The graphical display

The graphical display window is available via Analyze / Show Graph. At the first call, also depending if you have preselected parameters to be displayed in the Options menu, the graphical display might be empty.

An additional floating panel can be opened using Graphs / Panel (or F8). Here the colours of the parameters can be directly changed and their display activated by selecting using the boxes to the right of the colour. Any change will be directly displayed in the graphic window.

If you move the scroll bar on the x-axis (time axis), the values in the floating panel will change dynamically. The vertical green line can also be used to scroll through the data in the time axis. Just click on the vertical line with the left mouse and hold the left mouse button while moving the line left or right. Again, the values in the floating panel change accordingly.

Simultaneously, also the table in the main window changes and follows the change on the time axis.

To reduce the display range there is a capability to specify a particular range. The corresponding allocation can be done direclty in the data table of the main window with either mouse (Press and hold left button and move over columns) or from the keyboard using the keys Shift and Control.

5. The analyzer of violations

The analyse process can be started via Analyze / Show violations (F8). The routine will check your entire data set for violations of the real Tu-154 limitations. Found results are specified with time or time range when the violation occurred and the type of violation is listed.
At the bottom of the result window, a summary of found results related to specific subjects and the total number of violations are displayed

Use this feature to learn about the real limitations, to optimize your piloting techniques and to find out reasons for incidents. On the next page, you find all items to be checked and their specific limitations.

List of checked items, corresponding to the limits in the real Tu-154 :

Parameter Limitation

1. Excess of speed at altitudes 0 … 7000 m of 600 km/h
2. Excess of speed at altitudes > 7000 m of 575 km/h
3. Excess of speed with flaps 15 : 420 km/h
4. Excess of speed with flaps 28 : 360 km/h
5. Excess of speed with flaps 45 : 300 km/h
6. Excess of speed at gear retraction / extension of 400 km/h
7. Excess of speed with slats of 425 km/h
8. Minimum speed in clean configuration of 320 km/h
9. Minimum speed flaps 15 (at weight 72t) of 289 km/h
10. Minimum speed flaps 28* (at weight 72t) 271 km/h
11. Minimum speed flaps 45* (at weight 72t) 255 km/h
12. Excess of allowable positive G-Loads +2,5 units.
13. Excess of allowable negative G-Loads -1,0 units.
14. Definition of a rough contact (overload at compressed racks) : +1,5 units.
15. Excess of allowable bank angle 32 deg.
16. Excess of allowable bank angle during takeoff
(determined on flaps in a range 5 … 28, IAS less than 340 km/h and vertical speed more than 2 m\s),
17. Excess of allowable bank angle on landing
(it is determined by flaps more than 28, IAS less than 280 km/h)
18. Excess of allowable bank angle at altitudes less than 250 m
19. Excess of allowable vertical speed, descent 30 m\s
20. Excess of allowable vertical speed of 5,5 m\s, descent at altitudes less than 600 m
21. Excess of an allowable vertical speed of 1.6 m/s, descent at altitudes less than 250 m with retracted landing gear.
22. Extension of spoilers on glide path (determined on altitude with PB-5 less than 600 m and the Flaps extended)
23. Excess of speed on takeoff run of 300 km/h
24. Ballooning at touchdown (it is determined on an altitude with PB-5 less than 6 m, a positive vertical velocity, and extended landing gear)
25. Use of AT during climb, cruise or descent (determined on switched on AT in the modes V or M and IAS more than 450 km/h)
26. Use of AT on glide path at CAT-I approach.. In flight director mode (determined on activation of an AP approach mode). And switches прод or the modes «штурв» or «выкл» and an altitude with PB-5 less than 250 м)
27. No landing configuration (determined by an altitude with PB-5 less than 250 m, negative vertical velocity, and any condition from the following : flaps not extended to positions 15, 28, 45 or retraceted gear or open locks of center spoilers)

Project Tupolev Tu-154 b2

Appendix

8.1. FAQ – Frequently asked questions :

Q : After loading the Tu-154, FS returns error messages and can't load gauges

A : Make sure, the following entry is present in your fs9.cfg :

[OLDMODULES]
fssound.dll=1

Q : Where is the fs9.cfg, I can't find it :

A : It depends on your windows version and language. An example for Windows XP (english version) : c:/Documents and Settings/<your username>/Application Data/Microsoft/FS9/fs9.cfg. If you still can't find it, use the Windows Explorer Search function.

Q : I can't switch the Autopilot STAB mode ON.

A : You probably didn't precisely follow the start-up sequence. Set the CAY-CTY switch (208, Overhead Panel) off and then on again to "re-initialize" the Autopilot.

Q : In the 2D Panel I see both VC and 2D-Panel sideviews.

A : Again in your fs9.cfg, set **see_self=0** to remove the VC sideviews**.** But then you also don't see the landing lights anymore, unfortunately an FS limitation.
The other alternative is to remove the 2D panel sideviews in the panel.cfg. You decide …

Q : Why are there no engine smoke effects ?

A : You probably refer to the Soloviev engines in the Tu-154 M. The Kuznetsov NK-8-2U engines in the Tu-154b2 don't smoke

Q : When do the engine replenishment inlets open (visible model animation) ?

A : Exactly at the following conditions :

1. On the ground and below 100 meters:
a) At engine startup since fuel will be delivered into the engine (N2=22%) until the idle power will be reached (N2=54...56%)
b) On fast engines controls movements, until engine will be stabilized with new conditions.
c) When N2 exceeds 88% with ambient air temperature above 20^{o} Celcius.
d) When N2 exceeds 92% with ambient air temperature below zero degrees Celcius.

2. In the air, if the angle of attack exceeds 8^{o}.

Q : after loading the Tu-154B2, all panels quickly pop-up

A : This is our internal panel initialization procedure, necessary because the Tu-154 contains so many custom routines. So it is nothing to worry about ☺. Make sure not to touch the panel for a few sconds until the procedure is finished.

Q : The Virtual Cockpit seems to have some limitations :

A : In Version 9.4. an attempt was made to realize a Virtual Cockpit, although the airplane complexity and many custom functions are not ideal for Virtual Cockpit operation. There are some limitations, considered to be improved in future versions :

- the engine stop levers in 2D Panel and VC live an independent life from each other
- it is advised to start the engines ONLY from the 2D panel
- the movable control column is not disconnected from the Autopilot
- the stabilizer handles must be operated from the 2D Panel

Enjoy the atmosphere in the VC ☺

Q : Where can I get further help ?

A : Our forum is at www.protu-154.com/forum. All Tu-154 and Aviation enthusiasts are more than welcome !

8.2. HBY Pictorials

8.2.1. HBY data entry for the example flight (first two waypoints)

On the left screenshot we have the start situation. Switch (1) powers up the system. In the ZPU block the counter I (7) is already lighted up, this will be our first active waypoint. Use the arrow buttons to enter the ZPU. Please note, we have to enter the value in minutes and seconds, so for example 111.2 = 111.12 (.1 = .06, .2 = .12, ..., .9 = .54).

Now we need to enter the distance S, place the selector switch (4) to S. For more exact entry we open the B-52 panel (9) by clicking on the label. In the screenshot it is already open. The entry fields correspond to the selector (4). Now enter the S value of -17.2 using the arrow buttons (6) and make sure the 17.2 shows up above the (-) in the B-52 ! Ok, first waypoint done, we move to the second :

Enter the ZPU of the second route section (101.06) in the counter II (8) again using the arrow buttons. Place the selector switch (4) in position Sп (the B-52 also switches now) and enter -11.0 using the arrow buttons (6).

The right screenshot shows the final situation after correct entry. That’s it, the HBY is ready .

8.2.2. HBY Alignment to magnetic meridian of arrival airport

Reasonably close to the arrival airport (preferably before starting the descent), the **HBY** must be aligned to the magnetic meridian of the arrival airport. Start the procedure by opening the overhead panel. Now, on the TKC :

1- set the switch КОРРЕКЦИЯ to the position КОНТР
2 - left-click the navigation instrument YSH-3 (marked #2) to get the digital values; the second and fourth figures give the position of the control gyros.

Now add or subtract (depending on the sign) the value of the "fork" (the value is generated by the NVU Calculator, its just below the total distance) to the value in the 2nd row; i.e. new course = actual course + (fork). In our example, the fork shall be +29

3 - set the new course using the designated switch. On the YSH-3, you will see the small triangular index moving correspondingly.

Now open the **HBY** panel (Shift-3)

1- turn the navigation computer off using the switch "ПОДГОТ НАВИГАЦ", so the plane won't be affected duting the corrections. It will continue on the present heading.

2 - in the active window II, instead of the current value (should be 97,4* or 97*24') set the new value incl. the fork value. In the example it was 97,24, now will be 97,24 + 29.0 = 126.24).

Close the **HBY** panel,

1- set the switch "correction" (КОРРЕКЦИЯ) to "main" (ОСН)
2 - use the course setting switch to align the main gyro with the control gyro
3 - the arrow (K) on the YSH-3 should be aligned with the little triangular index and the number in the first row match the number in the second row

Now open the **HBY** panel again and

1 - set the rotary switch to Z and reset the value to zero
2 - the accurate control should say 0000,0
3 - as we reset the Z value to zero, the PNP (HSI) should become aligned
4 - switch the "ПОДГОТ НАВИГАЦ" on. The plane should change to the new course.

5 - in case the current COURSE is different than the one given by the HSI and flight director, use the manual autopilot control to capture the new course and then switch to "ПОДГОТ НАВИГАЦ".

Finally we align the other gyros on the TKS (Overhead Panel) :

1 - set the КОРРЕКЦИЯ switch to the position КОНТР
2 – press and hold the "agreement" button until the RMI scale stops rotating. Hold some additional seconds just to be sure it doesn't change anymore.
3 - check the alignment on the YSH-3 , the numbers for the GA gyros (row 1 and 2) should match, and so should the numbers for the BGMK (rows 3 and 4)

The transition to the magnetic meridian of the destination airport is complete.
we should now be ready to begin our descent.

8.2.3. РСБН correction

Automatic НВУ correction

Corrections are done in flight on a route segment from one waypoint to another. The data entered in НВУ for correction is intended only for this route segment, for the following (and the previous) route segment the data will be different. Correction can be executed on any route section in the flightplan. For example, at a long route segment , e.g. 800 kilometers, it is possible to correct on the first half of a route section on one РСБН beacon, and on the second half of a route section on another beacon. It is also possible, to correct on different route sections using just one beacon.
For implementation of automatic correction a presence of an active РСБН beacon is mandantory, at a distance not less than 30 … 50км and no more than receiving distance of the beacon (approximately 350км is possible). The minimum distance is necessary due to the РСБН range finder slant range, which would lead to distortion of the correction result. The beacon can coincide with a WPT. The system of the НВУ correction on РСБН works in true geographical coordinates, therefore it does not influence ТКС set-up or magnetic declinations. Correction should be executed when there are conditions for an increase of НВУ numeration errors:

- after leaving complex SIDs involving frequent turns (for example, generally in the Moscow air zone);
- after overflying water zones with inactive DISS system and therefore НВУ feeded from the CBC system (signal lamps «Азим АВТОН» and «Range АВТОН» lighted up).

Besides this, usual route corrections should be executed every 200-400км flight (just a recommendation, not a dogma).

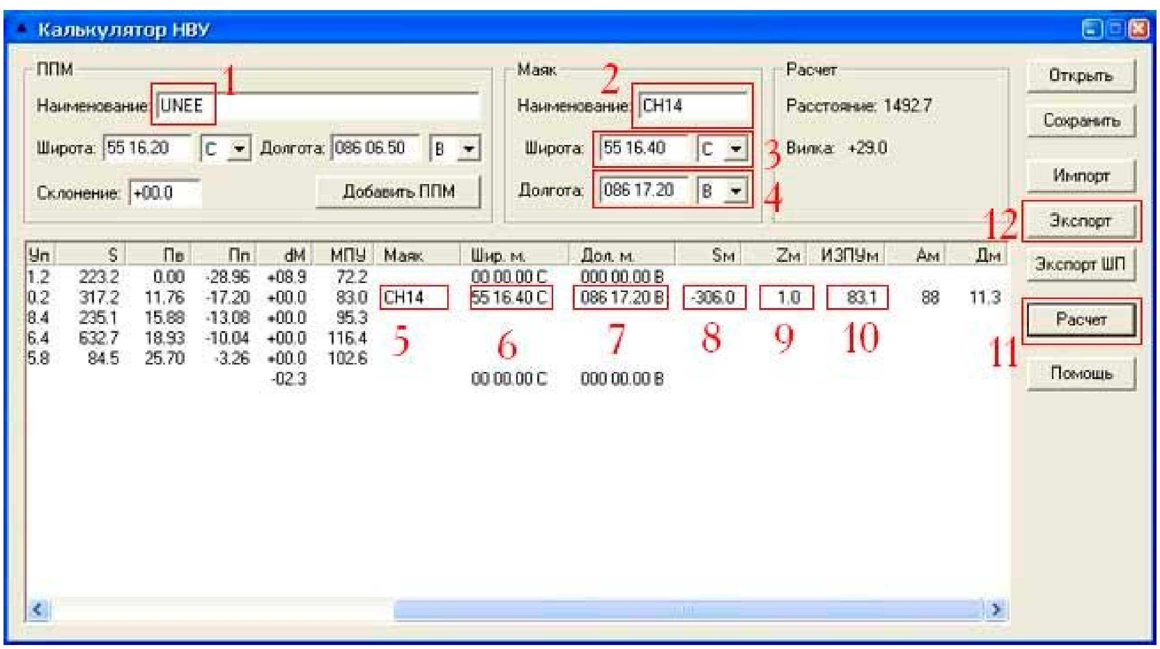
Example of flight on НВУ with use of automatic correction on РСБН

Let’s assume we fly from Novisibirsk (UNNT) to UIII with the following flightplan :

UNNT – UNEE – WN – RX – BD – UIII

and soon after activating of НВУ Navigation we observe a drift or an offset. We are lucky, at the first waypoint UNEE (Kemorovo Airport) we have an РСБН beacon on channel 14 and coordinates 55*16,40 ' (Lat.) and 086*17,20 ' (Lon.).
It is advised to include all РСБН beacons on our route in the NVU Calculator flight plan for corresponding РСБН corrections. For our example, we select the UNEE line (will appear as Number 1) in our flightplan and include the РСБН by

2 - entering CH14, it is displayed in 5;
3 – entering Latitude of СШ (55*16,40 '), it is displayed in 6;
4 – and Longitude of СIII (086*17,20 '), it is displayed in 7;
we continue with 8 :
8 – calculated Sрм for input in the НВУ counter Sм ;
9 - designed Zрм for input in the НВУ counter Zм;
10 – calculated ИЗПУрм for input in the "Угол карты" (map angle) instrument ;
11 - after input we press "Calculation" and receive results in 8, 9 and 10;
12 - we press "Export" and the plan it is copied in the buffer, allowing to paste in Excel or Word for printout.



We enter НВУ data for the correction:

1 - we enter ИЗПУрм from the flightplan;
2 - we put the selector to Sм and enter Spм from the flightplan, we set to Zм and enter Zpм from the flightplan. We take care to enter the corrrect sign +/-!
3 - with these buttons Sм and Zм are entered;
4 - we control the input of Sм and Zм;
5 - here are displayed entered Sм and Zм;
6 – now to the ППДА-Ш (PPDA-SH). The drum counter shows the current range up to the РСБН beacon in km, and the pointer shows its current azimuth. The broad arrow shows tens degrees on an external scale, the thin arrows shows degrees on the inner scale;
7 - it is not forgotten on the overhead panel to adjust РСБН channel 14-th
8 - and switch the РСБН power supply ON.

Now the range finder on ППДА-Ш shows a range less than 30-50км, therefore correction is not included yet, all over again we shall fly away from a beacon.

After having reached a comprehensible range to a beacon - we include the correction.

1 - we check the range;
2 – the toggle-switch ПОДГОТ НАВИГАЦ is disconnected;
3 - we include the toggle-switch КОРР;
4 - we put on Z;
5 - here we see, how many km we are away from a track;
6 - on the HIS, the displacement of the deviation bar corresponds to the track deviation, means here we are to the right of the track.
7 - we fly the airplane on the desired track using this handle. We are guided by 5 and 6.

After having guided the airplane on the desired track - we include the toggle-switch ПОДГОТ НАВИГАЦ

1 - on the HSI bar, we are guided on the desired track;
2 - we check the exact offset value of the track;
3 - toggle-switch ПОДГОТ НАВИГАЦ;

both lamps 4 and 5 light up, signaling that НВУ works automatic correction mode.

Right after termination of the correction we switch the toggle-switch КОРР off, we set the left selector to Zм and zero the value. .

RSBN correction is done, we continue the flight with НВУ navigation.

8.3. The Internal NVU Calculator

The internal Calculator is accessible with Shift-7. A quick summary of the most relevant functions:

1: Keypad

2: LAT/LON Waypoint A
3: LAT/LON Waypoint B

4: Magnetic Deviation Waypoint A
5: Magnetic Deviation Waypoint B

6: Entry-Fields for RSBN-Waypoints

7: Calculated Value "Z" WP A->B
8: Calculated Distance "S" WP A->B **NOT RSBN!!!**
9: Calculated Value "ZPU" WP A->B

10: Used Channel (same Function as in external NVU-Calc)
11: "LEG"-Number of the actual Route
12: Save to Channel
13: see explanation below
14: see explanation below

15: "CALCULATE"

Ok, now let´s calculate the first 2 Legs of a Route. We are departing at UUEE. The first Waypoints will be "AR"-NDB and "BG"-NDB.
First, we need values for UUEE as our "initial Waypoint" 0: LAT/LON for UUEE is N5558.30 E03724.90, Magvar is -8.3°. Now we insert this values in the NVU-Calc: insert **0555830** in the Keypad. You should see now "55 58.00" in the Line above the Keypad. The "+" left of them means that we are in the Northern Hemisphere (N="+", S="-"). Now simply "leftclick" in the first Line of the Waypoint A Datafield. Next click "C" on the Keypad to reset. Now insert the Longitude: "0372490". You should see it in the Line above (E="+", W="-"). Now click in the second Line of the Datafield for Waypoint A. Now set the Magnetic Deviation for UUEE on "4". Simply increase or decrease by using the Mousebuttons (or the Mousewheel).

We insert the Values for the NDB "AR" in the Datafield for Waypoint B. LAT/LON N5559.00/E03648.00 (MagVar 8.3). Use the same procedure as for Waypoint A. Thereafter click on the Button "14" on NVU-Calc, it should change from "0" to "1". And now click "CALCULATE" on the NVU-Calc. Now you have the first Values for the NVU. You can directly feed your NVU with them.

Now we need the NVU-Data for the second Leg from Waypoint "AR" to Waypoint "BG":

-on the NVU-Calculator click "13". Now the Vales from "AR" will be displayed in the datafield for Waypoint A. Insert LAT/LON for "BG" (LAT/LON N5550.00/E03452.00). **Don´t forget the Magnetic deviation (7.8) !** Click the Button "14" and then "CALCULATE" on the NVU-Calc. Switch to Leg "2" (11) on the NVU-Calc. Now you can see all Settings for the NVU. Using this values, you can feed your NVU counter for the second Leg.

Now you can calculate your complete Route. You can select a Channel (10) on the NVU-Calc and save your Calculated Route by clicking (12). If you want you can now use the Virtual Navigator (see the Manual) : On the Virtual Navigator panel select the same Channel as you´ve saved your calculated Route with the NVU-Calc.

8.3. Vr-, V2- and Vref Speed table, Engine thrust table

Speed	V_R		V_2		V_2	V_{REF}			
	Flaps				clean	Flaps			
Weight (tons)	28	15	28	15	0	0	15	28	45
60						290	265	247	233
62						295	268	251	237
64						300	273	255	240
66						306	277	259	245
68						311	280	263	248
70	222	231	237	246	314	316	284	267	252
72	225	234	240	250	317	320	289	271	255
74	229	237	243	253	322	324	293	275	259
76	232	240	246	256	326	328	297	279	262
78	236	243	249	259	330	332	301	283	265
80	240	246	252	262	334	336	304	286	268
82	244	249	255	266	337	340	308	290	272
84	247	252	258	269	341	344	313	294	276
86	251	256	261	272	345	348	317	298	280
88	254	259	264	275	348	352	321	301	283
90	258	262	268	279	352	356	325	305	286
92	261	265	271	282	355	360	329	308	288
94	264	268	274	285	358	364	333	312	292
96	268	271	277	288	362	368	337	315	295
98	270	274	280	292	365	372	341	318	299

Engine thrust table :

Regime	Thrust Lever, deg	H = 0 V = 0		**H = 11 100 M = 0.85**	
		ВД %	НД %	ВД %	НД %
Takeoff	114	95.5	97	--------	--------
Nominal	106	92.5	91.5	92.5	97.5
0.85 nominal	96	89.5	86.5	89.5	94
0.7 nominal	86	86.5	81.5	86.5	88
0.6 nominal	80	84	77	84	83.5
0.4 nominal	66	78.5	66	78.5	72.5
Idle	25-40	55.5	30	60.5	70

8.4. Climb, cruise and descent performance tables

Relation of distance S, time T and fuel consumption Q to (at, from) altitude

Climb performance

at takeoff weight, MCA, calm weather, 760 mm Hg, maximum range mode (РМД) – on a engines nominal mode, IAS of 550 km/h to altitude 9 450 m, further with constant mach number M=0.8

height, м	80 tons		90 tons		98 tons	
	T, min	Q, KG	T, min	Q, KG	T, min	Q, KG
6 000	4,7	1120	5,5	1310	5,9	1400
7 200	6,3	1370	7,4	1630	8	1760
8 100	7,7	1590	9	1880	9,5	2030
8 600	8,6	1720	10	2020	13,6	2210
9 100	9,6	1850	11	2170	14,7	2370
9 600	10,6	1980	12,3	2320	16	2550
10 100	11,7	2120	13,7	2500	17,6	2740
10 600	13	2280	15,5	2710	20	2990
11 100	15	2470	18	2980	-	-
11 600	16,8	2660	-	-	-	-

Cruise performance

maximum cruise mode (РМД) – engines nominal mode, IAS 550 km/h to altitude 9 450 m, further with constant mach number M=0.8

height, м	80 tons			90 tons			98 tons		
	S, км	T, min	Q, Kg	S, км	T, min	Q, KG	S, км	T, min	Q, KG
6 000	52	4,5	1190	59	5	1400	61	5,5	1430
7 200	70	6	1460	81	7,2	1720	85	7,3	1750
8 100	88	7,3	1680	100	8,5	1960	108	9	2040
8 600	100	8,2	1830	117	9,6	2150	124	10	2210
9 100	116	9,3	1990	134	10,8	2320	145	11,5	2430
9 600	136	10,6	2160	156	12,4	2520	168	13	2630
10 100	155	12	2330	184	14,2	2750	198	15	2880
10 600	181	14	2540	209	16	2960	233	17,3	3170
11 100	207	15,5	2730	237	18	3190	-	-	-
11 600	238	17,2	2910	-	-	-	-	-	-

Descent performance

Descent modes :

РМД – idle thrust with constant Mach number M=0.8 down to altitude 10 750 m, further with constant IAS 500 km/h, spoilers retracted

МКР – idle thrust with constant Mach number M=0.85 down to 9 750 m, further with constant IAS of 575 km/h, at altitudes from 7 000 m down to 3 000 m spoilers extended

Height, м	РМД, 80 tons			МКР, 80 tons		
	S, км	T, min	Q, KG	S, км	T, min	Q, KG
11 600	200	18,1	540	150	13,2	320
11 100	186	17,2	510	148	12	300
10 600	176	16,5	490	126	11,1	290
10 100	167	15,7	470	116	10	280
9 600	155	14,9	440	106	9,1	270
9 100	145	14,1	420	95	8,3	250
8 600	136	13,3	400	89	7,7	240
8 100	127	12,4	380	80	7,1	230
7 200	113	11	350	67	6,1	200
6 000	93	9,4	300	55	5,1	160

8.5. Checklists

ПЕРЕД ЗАПУСКОМ ДВИГАТЕЛЕЙ - Before engine starting	
Двери, люки Doors and hatches	Закрыты Closed
Топливные насосы Fuel pumps	Насосы подкачки включены, бак №4…т Booster pumps included, tank №4 ….tons
Задатчик стабилизатора Stabilizer handle	Положение («П», «С», «З»), по центровке In position («П», «С», «З») according to centering
Триммирование Trimming	Нейтрально Neutral
ПЕРЕД ВЫРУЛИВАНИЕМ - Before taxiing	
Электросистемы, потребители Electric systems, consumers	Проверены, включены Checked, set
КУРС МП, АРК NAV-MP, ADF	Включены, частота switched on and set
Бустера Booster	Включены, крышка закрыта Set, caps closed
ТКС Compass system	Включена, согласована, режим ГПК Set, in alignment, mode ГПК
АБСУ Autopilot	Исправна, режим штурвальный Setup, steering mode
НА РУЛЕНИИ - During taxiing	
Тормоза Brakes	Проверены, исправны checked, proper
Обогрев ППД Pitot Heat	Включен Set
ЭУП Turn coordinator	Включен, проверен Set, approved
НА ПРЕДВАРИТЕЛЬНОМ СТАРТЕ - Before takeoff	
Высотомеры Altimeters	Высота ноль, давление… мм, РВ включен Height zero, pressure …mm, elevator set
Механизация “mechanics” (Flaps, Slats)	Выпущена …, табло горит Extended, signal panel light
Интерцепторы Spoilers	Убраны, табло не горит Retracted, signal panel no light
Авиагоризонты Gyrohorizons	Проверены, риски совмещеныс checked, marks combined
Рули, элероны Ailerons	Проверены, свободны checked, free

ВСУ, топливная система BCY, fuel systems	Выключена, автомат Switched off, automation

ПЕРЕД СНИЖЕНИЕМ – Before descent	
Схема Charts	Ознакомлены Acquainted
Посадочные данные Landing data	Вес…т, центровка…%, скорость … Weight … tons, centering …%, Speed ….
ТКС Compass System	Согласована, курс…град. aligned, course … degrees
РВ задатчик Radio Altimeter setting knob	…метров … meters
Топливо Fuel	…т … tons
ПОСЛЕ ЭШЕЛОНА ПЕРЕХОДА – After pressure alt.	
Высотомеры Altimeters pressure	Давление установлено … мм Established … mm
КУРС МП NAV-MP	Включен, частота… set, frequency ….
Посадочный курс на ПНП Landing course on ПНП (HSI)	Выставлен …град. advanced …. degrees
АРК ADF	Первый … второй… First … second ….
ПН-6, ПН-5 Autopilot, Autothrust Panels	Подготовлены Prepared
ПЕРЕД 3 РАЗВОРОТОМ – Before third turn	
Интерцепторы Spoilers	Убраны, табло не горит Retracted. Signal panel no light
Задатчик стабилизатора Stabilizer handle	Установлен … согласно центровке Established …according to centering
Шасси Gear	Выпущено, три зеленые горят, кран нейтрально Extended, three green lights, valves neutral
РВ задатчик Radio Altimeter setting knob	…метров …meters
ПЕРЕД ВХОДОМ В ГЛИССАДУ – Before Glideslope capture	
Механизация “mechanics”	Выпущена, закрылки …град. extended, Flaps … degrees
Стабилизатор Stabilizer	…град. Degrees

Загружатели Flight spring loaders	Выключены, табло горят Switched off, signal panel light («Взлет Пос. РВ», «Взлет Пос. РН»)
Фары Lights	Выпущены extended

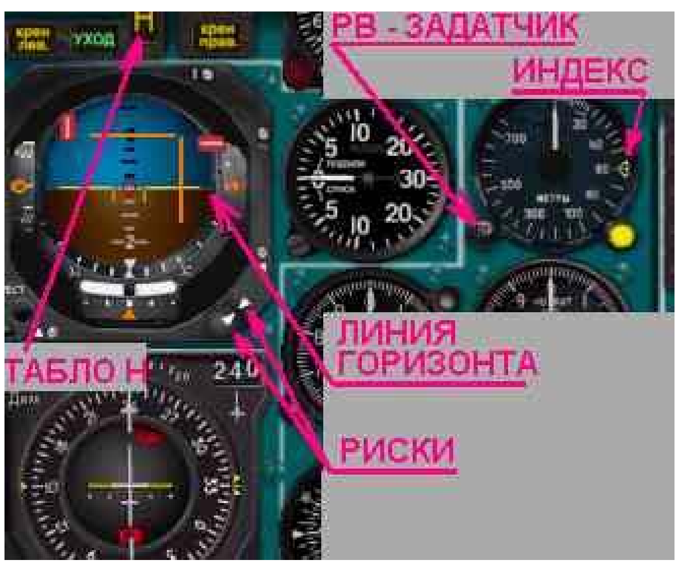
Some explanations :

Авиагоризонты Gyrohorizons	Проверены, риски совмещеныс checked, marks combined

On the ADI to the right below there is a knob with a mark (риски), the same mark is on the ADI housing. The knob can be turned by mouse. In this case the horizon line moves (calibration). If the horizon line in the center coincides with the aircraft silhouette, and the marks on knob and housing are combined accordingly, the ADI is exactly calibrated.

РВ задатчик Radio Altimeter setting knob	…метров …meters

What exactly must be done and why two times before descent and then again before third turn ? Before descent the knob (РВ задатчик) on the РВ-5 Radio Altimeter is set to the circling altitude. As soon as the Aircraft reaches that, "Н" (табло "Н") lights up on the signal panel and a signal sound can he heard.
After this, the decision height is set on the Radio Altimeter setting knob (index "индекс" - on the radio altimeter). If the decision height is reached, H lights up, again signal sound and the Navigator says "Решение!" (decision).



8.6. Summary of the Voice callouts

To learn the voice callouts, check out the wav files in the ..\gauges\Tu154_cfg\Copilot directory. Just listen to them with e.g. the Windows Media player and compare with the following table. You see the filename and what is said, when and who says it.

Filename	What ?	When ?	Who ?
Eng_1_m	ПЕРВЫЙ НА МАЛОМ First engine idle	After start of engine 1	Engineer
Eng_2_m	ВТОРОЙ НА МАЛОМ Second engine idle	After start of engine 2	Engineer
Eng_3_m	ТРЕТИЙ НА МАЛОМ Third engine idle	After start of engine 3	Engineer
Eng_gen	ГЕНЕРАТОРЫ НА БОРТСЕТИ Generators on board system	After main generators switched on	Engineer
Eng_vsu	ВСУ ВЫКЛЮЧЕНА APU switched off	After APU shutdown	Engineer
Eng_min	МИНУТА ДО ПРОГРЕВА Minute to warm up	A while after start of all engines	Engineer
Eng_prgr	ДВИГАТЕЛИ ПРОГРЕТЫ Engine warmed up	A minute after Eng_min call	Engineer
St_z_vyp	ЗАКРЫЛКИ ВЫПУСКАЮТСЯ СИНХРОННО, СТАБИЛИЗАТОР В СОГЛАСОВАННОЕ,ПРЕДКРЫЛКИ ВЫПУСКАЮТСЯ Flaps out, stabilizer coordinated, slats out	After initial flaps 15 setting	Navigator
Eng_Ready	ИНЖЕНЕР ГОТОВ Engineer Ready	After plane preflight setup complete	Engineer
St_Ready	ШТУРМАН ГОТОВ Navigator ready	After plane preflight setup complete	Navigator
2P_Ready	СПРАВА ГОТОВ on the right ready	After plane preflight setup complete	Copilot
Eng_vzl	РЕЖИМ ВЗЛЕТНЫЙ, ПАРАМЕТРЫ В НОРМЕ, РУД ДЕРЖУ Takeoff thrust, parameters in norm, I hold levers	Takeoff run, After takeoff thrust reached	Engineer

Eng_otk1	ОТКАЗ ПЕРВОГО Refusal of the first	Engine 1 failure	Engineer
Eng_otk2	ОТКАЗ ВТОРОГО Refusal of the second	Engine 2 failure	Engineer
Eng_otk3	ОТКАЗ ТРЕТЬЕГО Refusal of the third	Engine 3 failure	Engineer
St_V_up	СКОРОСТЬ РАСТЕТ speed increasing	Initial takeoff run	Navigator
St_V_140	СКОРОСТЬ СТО СОРОК – Speed 140	Speed callout – on runway	Navigator
St_V_160	СТО ШЕСТЬДЕСЯТ - 160	Speed callout - on runway	Navigator
St_V_180	СТО ВОСЕМЬДЕСЯТ – 180	Speed callout - on runway	Navigator
St_V_200	ДВЕСТИ – 200	Speed callout - on runway	Navigator
St_V_220	ДВЕСТИ ДВАДЦАТЬ - 220	Speed callout - on runway	Navigator
St_V1	РУБЕЖ – Boundary	Takeoff – at V1 Speed	Navigator
St_VR	ПОДЪЕМ - rise	Takeoff – at Vr Speed	Navigator
St_V2	БЕЗОПАСНАЯ - safe	Takeoff – at V2 Speed	Navigator
2P_G_up	ШАССИ УБРАНЫ - Gear up	Climb – gear up	Copilot
2P_Neutr...	КРАН ШАССИ В НЕЙТРАЛЬНОЕ УСТАНОВЛЕН Gear valves established in neutral	After gear retraction/extension	Copilot
	"КРАН ШАССИ НЕЙТРАЛЬНО", Gear Valves (to) neutral	After gear retraction/extension	Engineer
St_F_ub	ФАРЫ ВЫКЛЮЧЕНЫ, УБИРАЮТСЯ Lights switched off, stowed	after takeoff	Navigator
St_z_ubir	ЗАКРЫЛКИ УБИРАЮТСЯ СИНХРОННО, СТАБИЛИЗАТОР ПЕРЕКЛАДЫВАЕТСЯ К НУЛЮ, ПРЕДКРЫЛКИ УБИРАЮТСЯ Flaps clean (“in”) synchronously, stabilizer shifted to zero, slats clean (“in”)	After takeoff, flaps/slats retraction	Navigator
2P_G_down	ШАССИ ВЫПУЩЕНЫ, ТРИ ЗЕЛЕНЫЕ ГОРЯТ Gear down, three green lights	Before landing	Copilot

St_z_28	ЗАКРЫЛКИ 28 – Flaps 28	Flaps 28 are set	Navigator
St_z_Full	МЕХАНИЗАЦИЯ ВЫПУЩЕНА Mechanisation is let out	When Flaps Full are set	Navigator
St_F_vyp	ФАРЫ ВЫПУЩЕНЫ Lights let out	Landing lights in working pos.	Navigator
St_F_L	ФАРЫ БОЛЬШОЙ СВЕТ Big headlight on	Landing lights on	Navigator
St_H_oz	ОЦЕНКА – estimate/check	Check landing conditions (ILS/visual)	Navigator
St_H_vpr	РЕШЕНИЕ – decision	Landing – at decision height (60 meters)	Navigator
St_H_250	ВЫСОТА ДВЕСТИ ПЯТЬДЕСЯТ – Height 250	Altitude callout	Navigator
St_H_200	ДВЕСТИ МЕТРОВ – 200 meters	Altitude callout	Navigator
St_H_150	СТО ПЯТЬДЕСЯТ МЕТРОВ – 150 meters	Altitude callout	Navigator
St_H_120	СТО ДВАДЦАТЬ МЕТРОВ – 120 meters	Altitude callout	Navigator
St_H_100	СТО МЕТРОВ – 100 meters	Altitude callout	Navigator
St_H_80	ВОСЕМЬДЕСЯТ МЕТРОВ – eighty meters	Altitude callout	Navigator
St_H_60	ШЕСТЬДЕСЯТ – sixty	Altitude callout	Navigator
St_H_30	ТРИДЦАТЬ – thirty	Altitude callout	Navigator
St_H_20	ДВАДЦАТЬ МЕТРОВ – twenty meters	Altitude callout	Navigator
St_H_10	ДЕСЯТЬ – ten	Altitude callout	Navigator
St_H_6	ШЕСТЬ МЕТРОВ – six meters	Altitude callout	Navigator
St_H_3	ТРИ МЕТРА – three meters	Altitude callout	Navigator
St_H_1	ОДИН МЕТР – one meter	Altitude callout	Navigator
Eng_off	ВТОРОЙ ВЫКЛЮЧЕН Second switched off	Engine shutdown (Nr. 2 is last to shutdown)	Engineer
St_PPM	Подходим к ППМ Approaching waypoint (PPM)	During HBY navigation	Navigator

8.7. Engineering system parameters

***[hydraulics]** – section of parameters of hydrosystems*

init_1_P = 0
Pressure in hydrosystem №1, established at panel initialization.
Units of measurements: KG/cm2

init_2_P = 0
Pressure in hydrosystem №2, established at panel initialization.
Units of measurements: KG/cm2

init_3_P = 0
Pressure in hydrosystem №3, established at panel initialization.
Units of measurements: KG/cm2

init_1_V = 24
liquid level in the combined hydraulic tank of systems №1 and 2.
Final level of working fluid in a hydraulic tank – the sum of parameters init_1_V and init_2_V.
Units of measurements: liters l.

init_2_V = 24
liquid level in the combined hydraulic tank of systems №1 and 2.
Units of measurements: liters l

init_3_V = 24
liquid level in the hydraulic tank of system №3.
Units of measurements: liters l.

rns_flow=55
Maximum productivity НП-89
Units of measurements: l\min

ens_flow=55
Maximum productivity of electropump station НС- 46-2
Units of measurements: l\min

autorotating_rns_min_flow=100
Maximum productivity НП-89 on windmilling (autorotating) engines.
Units of measurements: (l\min) * 1000

autorotating_rns_v_koeff=3
Factor of drag for calculation of productivity НП-89 on windmilling engines. The relation of resultant productivity to instrumental speed is expressed through product autorotating_rns_min_flow on the given factor and on a square of instrumental speed with a zero point equal 250 km/h.
Resultant productivity « it is soft обрезается » on value equal 1.5 * rns_flow.
Units of measurements: 1000 / (km/h)

tank_1_min=5
The minimal rest in a hydraulic tank of systems №1 and 2, ensuring the functionality of the specified systems.
Units of measurements: l.

tank_3_min=5
The minimal rest in a hydraulic tank of the system №3, ensuring the functionality of the specified system.
Units of measurements: l.

engine_station_nominal_N2=65
Value of revolutions КВД at which nominal productivity of the НП-89 is provided. Increase of revolutions over the given value leads to switching of a shaft drive of equal speeds of the pump.
Units of measurements: %

ens_startup_time=10
Time of run-up of a rotor of НС - 46-2 with full stops up to values of nominal productivity.
Units of measurements: sec * 10.

ens_shutdown_time=5
Time of self-retardation of a rotor of НС - 46-2 up to full stops.
Units of measurements: sec * 10.

join_flow_koeff=7
Factor of a pressure by-pass through a reverse valve of connection of hydrosystem №2 to hydrosystem №1.
Units of measurements: sec * 10 / (KG/cm2)

rp_koeff=50
Pressure flow coefficient of pressure through РП-55 and РП-56.
Units of measurements: (KG/cm2) * sec

sau_pitch_drain_koeff=400
Pressure flow coefficient through РП, РВ at active stabilization on a pitch channel.

Units of measurements: 1 * 1000.

sau_bank_drain_koeff=400
Pressure flow coefficient of pressure through РП ailerons at active stabilization on a roll channel.
Units of measurements: 1 * 1000.

nose_gear_tm_drain_koeff=200
Pressure flow coefficient of pressure through a unit of turn of the nose wheel at taxiing in a mode of 63* wheel turn
Units of measurements: 1 * 1000.

[avionics] *– section of parameters of an avionics of engineering systems*

gear_warn_mode=2
Operational mode of the signal system " Extend the landing gear ".
Possible versions:
0 – the enhanced version (modernized version after adaptation under the bulletin).
2 – standard version.

[animation] *– section of parameters of animation*

apu_inlets=1
Activation (1) or cutoff (0) of animations of doors of ВСУ (APU) air intake.

engine_supplementary_air_doors=1
Activation (1) or cutoff (0) of animations of side engine replenishment doors.

[engines] *– section of parameters of monitoring systems and controls СУ*

egt_to_ambient_temp_correlation_koeff=300
Factor of correlation of EGT depending on temperature of outside air.
Units of measurements: °К * 1000

shut_on_load=1
Cutoff (1) СУ at initialization of panels.

ground_air_cond_available=0
Capability (1) or impossibility (0) of engine start-ups from a ground source of compressed air. At a parameter setting of (1) there is a capability to start engines from a ground source of compressed air : set the airplane on a parking brake, connect feed РАП or start ВСУ and connect its generator on an aircraft electrical system.

***[panel]** – section of parameters of control of panels and devices of a package*

ite_1t_1_pcode=0
code of the panel window, shown or hidden when clicked on gauge ITE-1T – (on main panel) - only suitable for multimonitor setup with special panel.cfg

ecb_panel_1_pcode=0
code of the panel window, shown or hidden when clicked on "Engine Control Block" indicators for engine No.1 (big set of lamps on the engineer panel).
- only suitable for multimonitor setup with special panel.cfg

[core] – *general parameters*

use_fsuipc_se=1
controls whether automatic FSUIPC gauge registration is used (use_fsuipc_se=1) or manual FSUIPC gauge registration is required (use_fsuipc_se=0)

8.8. The Autopilot Parameter Panel

The panel can be opened using the mouse clickspot on the top of the left centerpost (refer to clickspot B in the Panel screenshot on Page 9)

The gauge is mostly intended for designers of dynamics and devices for optimization purposes. Autopilot parameters can be changed directly in flight. If you are curious, just try to experiment with the device, althought is not really recommended to change parameters if you are not sure what you are doing !!!

The different channels related to autopilot operation can be changed using the "-" and "+" clickspots below the channel names (in the above screenshot below the KREN label). Use "-" and "+" clickspots below each parameter to change them.

Using the red "**S**" button at the lower right the set can be stored. It will be stored in the a file … \\ Gauges\Tu154_cfg\AP\ap_k.dat and can be read from there using the green **"R"** button.

The following channels are provided :

KREN (Roll) – proportional (kp), differential (kd), integral (ki), aileron deviation limitation (ogr)

TANG (Pitch) - proportional (kp), differential (kd), integral (ki), elevator deviation limitation (ogr)

KURS (Heading) - proportional (kp), differential (kd), integral (ki)

VOR (VOR) – proportional (kp), differential (kd)

ZACHOD (Approach) – proportional (kp), differential (kd)

HBY (NVU) - proportional (kp), differential (kd)

H (ALT HOLD MODE) - proportional (kp), differential (kd), integral (ki)

V, M (IAS MODE) - proportional (kp), differential (kd), integral (ki)

GLISS (Glideslope) - proportional (kp), differential (kd), integral (ki)

RYSK (Yaw) - proportional (kp), differential (kd), integral (ki), yaw deviation limitation (ogr)

Increasing the proportional link (Kp) leads to a more instant reaction of the plane to deviation of the channel, but can lead to swings, due to inertia causing overshoots in the opposite direction.

The differential link (Kd) serves as damping term, the main purpose is fast damping of oscillations. The proportional and differential links are fast links with the main purpose of quick stabilization of the intended value.

The integral link (ki) is a slow link used for elimination of residual misalignments. A too big integral factor can lead to overshoots.

Finally the limitation link (ogr) limits deviation and thus the maximum speed of the channel (e.g. roll changes). Too small speed can lead to delayed stabilization of the given parameter and also influences overshoots (oscillations).

Denis Okan ,Tu-154 Copilot, recommends to use the following optimized values :

"KREN" : 3800....700.....1.....65

"TANG" : 150....30....50....100

"RYSK" : 150....40....80....40

"ZACHOD". 12...28...0...0...0

8.9. Version History

Initial version : 9.0

Changes in version 9.1 and 9.2 :

1. The logic of the work of vertical gyros is finished.
2. For the purpose of FS 2004 compatability the possibility of finetuning some autopilot coefficients in the instrument configuration file is provided
3. HBY ground check from the pilot DISS signal according to AOM is provided.
4. Autopilot channel turnoff by “overriding” introduced. Autopilot turn off possible with keyboard brake key in case of joystick absence.
5. Joystick button tuning included in the Shift-7 Panel, making it possible to disable Joystick in FS completely (CTRL-K).
6. Output logic of the specified track in the HBY mode finished.
7. In connection with the poor readability of the latitude scale on the TKS panel, a digital value is provided (after clicking the latitude knob initially)
8. Logic changes in some warning panels
9. Navigation calculator with the introduction of some new possibilities.
10. Finished the virtual navigator assistant. New possibility for the conversion of HBY data into the meridian of landing airfield and also the possibility of TKS and HBY transition into the meridian of landing airfield.
11. Special autocoordination mode introduced (rudder usage in flight is prohibited in the real plane!).
Active above 10m. Can be switched off with rightmost booster switch (not recommended). Requires switching of FS default Autocoordination function OFF !!
12. Possibility to inverse individual joystick axes in the configuration file.

Changes in Version 9.3 :

1. Adjustable stabilizer control.
2. Fuel system logic refined, service tank No4 and ballast tank divided, additional fuel quantity indication, algorithm in automation mode changed.
3. New considerably more realistic Loadmanager.
4. Flight Dynamics refined particularly regarding the work of rudder and elevator.
5. Control system changed, elevator trim function changed according to real plane (trim tab on elevator, not stabilizer)
6. The pitch and yaw dampers introduced (switch on the flight engineer panel)
7. Inaccuracies and errors in some systems fixed

8. Service control instrument (Shift-7) is finished with several new options for button assignments and new option to control reverse thrust from thrust axis.

Version 9.4 (including changes in Versions 9.3.2. and 9.3.3.)

1. New visual model
2. Virtual cockpit (VC), version with and without VC provided
3. Hydraulic system, connected to control surfaces (boosters) and input devices (AFCS) , PA-56, landing gear and (partially) the emergency braking system
4. PA-56 Longitudinal control system
5. Main landing gear, emergency and backup emergency landing gear operation.
6. revised fuel system
7. Flight Load/Save Feature
8. MSRP-64 Flight Data Recorder
9. Autopilot Parameter Gauge
10. Flight dynamics and stabilizer settings refined and adjusted to Longitudinal control system
11. Numerous other details

Version 9.4.1.

1. new Joystick device

8.10. Optional INS System

Stepan Gritsevkij has provided a Russian INS System, which works very well with the Project Tupolev Tu-154B2. While the Tu-154B2 wasn’t originally equipped with an INS, a Triplex-INS it was optionally available for the M Version. If you don’t like to use the HBY navigation for whatever reason, the INS is your alternative.
The INS can be downloaded at www.avsim.ru, the filename is : i_21_02.zip

Installation :

1. Copy the file I21.BMP to your Tu-154 Panel directory
2. Copy the file STT_I21_V1_02.gau to your FS 2004 gauges directory
3. Copy the file I21_ppm.cfg in the directory gauges/i21_cfg

4. Open the actual panel.cfg (in the Tu-154 Panel folder) and insert the following line in the Window[00] section :

```
gaugeXX=STT_I21_V1_02!I_21_SYS, 62,0,5
```

Replace XX with the next free gauge number (e.g. for Version 9.4 it is 83)

5. Replace the Internal NVU calculator in the Tu-154 panel with the I-21 unit by replacing the corresponding section in the panel.cfg :

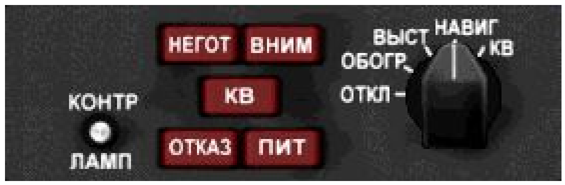
```
//-------------------------------------------------------
[Window10]
file=i21.BMP
size_mm=220,330
window_size_ratio=1.000
position=0
visible=0
ident=12600
render_3d_window=0
window_size=0.215, 0.43
window_pos=0.790, 0.57
gauge00=STT_I21_V1_02!I21_UVI, 10,61,200
gauge01=STT_I21_V1_02!I21_PUR, 35,0,175
gauge02=STT_Tu154_V3_11!AZS_NAV_I21, 8,16,15
```

Make sure, for gauge02 the actual version of the Tu-154 Navigation gauge is used. For Version 9.4., it is STT_Tu154_V3_11

Sven Gőricke kindly provided the following instruction – thanks, Sven !

If you are already used to the operation of an INS, the “И-21” can be more comfortable as the HBY-System of the Tu-154B2. The most important Restriction is a Maximum Entry of 9 Waypoints from your Route.

<u>The Panel “ПУР“</u>



Main Operation-Switch:

“откл”	-System off
“обогр”	-System “warmup”
“выст”	-System on
“навиг”	-System set to Navigation-Mode
“KB”	-not modelled

Control-Lights:

“НЕГОТ”	-after „warmup“, System ready
“ВНИМ”	-Alignment-Error, if illuminate you must restart the “И-21”
“ПИТ”	-Battery low
“КВ”	-not modelled
”ОТКАЗ”	-not modelled

Button “КОНТВ ламп“-when pushed, all Lights should be illuminated

Electrical Power: to avoid an “Battery low”-Error it is recommended that the APU or Ground Power is established and the Avionic-Main-Switches are on.

Attention!
Don´t move the Aircraft and make sure the Engines are NOT running during Alignment! Otherwise, the Alignment Process will abort!

The Panel “УВИ“

In the right upper corner there´s a Clickspot for using the Keyboard to make your Entries in the INS.

Using the Keyboard with “И-21”:

Button „0-9“ = 0-9 on Num-Pad
Button „ВВОД“ = Enter on Num-Pad
Button „ИЗМ МАРШ“ = (.) on Num-Pad
Button „ОСТ ИНД“ = (+) on Num-Pad
Button „СБРОС“ = (-) on Num-Pad

With (+) and (-) on your Main-Keyboard (NOT NUM-PAD) you can switch the Number of Waypoint “лзп“ up and down.

Operation of the “И-21”

Attention!
Don´t move the Aircraft and make sure the Engines are NOT running during Alignment! Otherwise, the Alignment Process will abort!

On the Panel **“ПУР“**, set the Main-Operation-Switch to “обогр”. If the “НЕГОТ”-Light comes up (after a few seconds) set the Switch to “выст”. Now the Alignment starts, lets go to the Panel **“УВИ“.**

Press (Shift+Z) in Flight simulator. In the left upper Corner of the Screen, MSFS shows your actual LAT/LON of your present position.

Attention!
For Degrees and Minutes, a “0”-Value will not shown by Flight Simulator! An Example:

N55*23.05 E12*3.56 shown by FS means N55*23.05 E012*03.56. The Format for insert to “И-21” would be N5523.0 E1203.5

Another:
N46*6.35 E154*68.48 shown by FS means N46*06.35 E154*68.48.
Our Format will be N4606.3 E15468.4

Set the Switch “ПАРАМЕТРЫ“ to „ ИК/ПГ“. There should be an Value of “90” in the Main display”

Set the Switch “ПАРАМЕТРЫ“ back to “φ/λ“. Now insert your present position shon by Flight Simulator. To insert a “North”-Latitude, press “N/2” first at the Num-Block of the “И-21”**,** then the Values. (for “South” press “8/S” first). Press „ВВОД“ to make yor entry. Now insert the Lontitude (for “East” press “E/6” first, for “West” press “W/4”). Verify your entry by pressing
„ВВОД“ again.

Now set the Switch “ПАРАМЕТРЫ“ to “T/t” and insert the actual Time. Press “N/2” and insert the Time in Format hh:mm. Press „ВВОД“. (I´m using UTC-Time, but ist your Choice).
With „СБРОС“ you can clear the Display if you have made an Mistake during insert your Position or Waypoints.

Attention!
You must insert your Position and Time before „ ИК/ПГ“ reached a Value of “70” . Otherwise, the Alignment will abort. But there is anough Time to make your Entries.

Now set the Switch “ПАРАМЕТРЫ“ to “ППМ“. Now you can insert the LAT/LON of your first 9 Waypoints. You can switch between the Waypoints by the two little switches over and under the Digit which shows the present Waypoint “лзп“ **DON`T USE “0”!**

If you are ready with the entry of Waypoints, set “ПАРАМЕТРЫ“ back to „ ИК/ПГ“. If it shoes “0” in the second (under) line in Main-Display, the System is ready for Navigation. In the Panel **“ПУР“** set the Switch to “навиг”. Now in the Main-Display, the Values for "От-До" should be “1” and “2”. This means that the “И-21” will navigate from Waypoint 1 to 2. Make sure that the switch "Смена ЛЗП" ist set to "авт". This will Change the Waypoints automatically. If you have more as 9 Waypoints on your Route you must insert the Next Waypoints before yor reach Waypoint 9. Otherwise you will go back (hihi), the “И-21” switches from “9” to “1”.

Manual Waypoint Change/Directs:

If you want to change the Waypoints manual, set "Смена ЛЗП" to “ручн“. Now press „ИЗМ МАРШ“ and enter the new Waypoints wher you want to fly from/to. Press „ВВОД“.

If you want to fly a Direct (i.E.: you ar flying tu WP4 but want direct to 6) set "Смена ЛЗП" to “ручн“. Now press „ИЗМ МАРШ“ end Enter 0-6. Press „ВВОД“ and set "Смена ЛЗП" back to "авт".

Other Parameters (Switch “ПАРАМЕТРЫ“):

“ЗПУ/ПУ“	-your Course to the next Waypoint
“S/Z”	-the Distance (in km) and Drift to the next Waypoint
“W/УС“	-Wind and Groundspeed?
„T/t“	-actual Time/time to reach the next Waypoint

Couple the “И-21” with the Autopilot

On the INS-Panel, set the Switch in the left upper Corner to “ИНС“. Now open the HBY-Panel (Shift+3). On the Panel B-51 press "СЕТЬ" and “СЧИСЛЕНИЕ”. The И-21 is now coupled to the HBY. After Takeoff follow your SID, then continue either flying the aircraft manually or use the Autopilot as advised on page 24 (steps 1-6).

Close to the Arrival-Airport, the Compass-System needs realignment (See Chapter 3.5.3.2)

8.11. The Cyrillic Alphabet

Groß Big	**Klein small**	**wissenschaftliche Transliteration**	**deutsche Transkription**	**english Transcript**
А	а	A a	A a	A a
Б	б	B b	B b	B b
В	в	V v	W w	V v
Г	г	G g	G g [8]	G g
Д	д	D d	D d	D d
Е	е	E e	E e (Je je)	E e (Ye ye)
Ё	ё	ë ë	Jo jo (O o)	E e (auch Yo yo)
Ж	ж	Ž ž	Sch sch (Sh sh)	Zh zh
З	з	Z z	S s	Z z
И	и	I i	I i	I i
Й	й	J j[4]	J j	Y y
К	к	K k	K k (aber: x statt ks)	K k
Л	л	L l	L l	L l
М	м	M m	M m	M m
Н	н	N n	N n	N n
О	о	O o	O o	O o
П	п	P p	P p	P p
Р	р	R r	R r	R r
С	с	S s	S s	S s
Т	т	T t	T t	T t
У	у	U u	U u	U u
Ф	ф	F f	F f	F f

Groß Big	Klein small	wissenschaftliche Transliteration	deutsche Transkription	english Transcript
Х	х	Ch ch	Ch ch	Kh kh
Ц	ц	C c	Z z	Ts ts
Ч	ч	Č č	Tsch tsch	Ch ch
Ш	ш	Š š	Sch sch	Sh sh
Щ	щ	Šč šč	Schtsch schtsch	Shch shch
Ъ	ъ	" (-) (Härtezeichen)	(-)	(-)
Ы	ы	Y y	Y y	Y y
Ь	ь	' (-) (Weichheits-zeichen)	(J) (j)	(Y) (y)
Э	э	Ė ė	E e	E e
Ю	ю	Ju Ju	Ju ju	Yu yu
Я	я	Ja ja	Ja ja	Ya ya

Little Glossary

Запуск	Start
Лев	Left
Прав	Right
Контр	Control
Вкл	On
Выкл, Выключено	Off
На	To
От	From
Азимут	Azimuth
Посадка	Landing
Угол	Angle
Расстояние	Distance
Широта	Latitude
Спуск	Descend
Подъем	Ascend (Climb)
РАЗВОРОТ	Turn
Питание	Power
Тангаж	Pitch

8.12. The Authors

Visual model - R.Skorych
Panel, Gauges - A.Artamonov, L. Gordo, S.Gritsevsky, D.Dobronravin, D.Kolesnik, A.Novikov, R.Petkevich, A. Samoshin
Structures - A.Artamonov, D.Kolesnik, R.Skorych
Sound - S.Gritsevsky, D.Kolesnik
Flight Dynamics - D.Elsukov, D.Kolesnik, V.Trifonov
Voices of Crew members - A.Beljakov, A.Bulgakov, A.Kolesnik
Navigation calculator - A.Novikov
Loadeditor – D.Okan, Valery Ё. (Noril)
Fuelplanners - D.Okan, Valery L., E. Koronovsky
Documentation - E.Andruhova, A.Bulgakov, A.Astapenko, S.Gritsevsky, D.Kolesnik, A. Popov, M. Ackermann
Install package and Website - M.Savchenko
Advisory - A.Astapenko, S.Gerasimov, D.Okan, M.Bezmen
Information material - A.Astapenko, A.Klimov, G.Suhih, Alexander (Shark), D.Okan, A.Fedotov
Leading pilots and tests - S.Andruhov, A.Astapenko, D.Okan, M.Savchenko

Clear sky and fly safe !