SERVICE PACK 1 (SP1) SUPPLEMENT

The **PMDG 777-200LR/F** SP1 release features the largest number of new features and changes that we've ever placed into a single product update.

Aside from the hundreds of smaller changes, tweaks and bug fixes, the update includes three major new features:

- A simulation of the Collins WXR-2100 weather radar system

- A simulation of the FMC datalink system that sends routes, performance data, wind prediction updates and so on to the airplane over ACARS and SATCOM

- A major reworking of our simulation of the 777's fly-by-wire flight control system.

We'd like to describe these large changes and additions in more detail on the following pages.

THE COLLINS WXR-2100 WEATHER RADAR

SP1 includes for the first time in PMDG's history a realistic simulation of an aviation weather radar system - in this case the Collins WXR-2100 unit commonly found on the 777 and other airliners. Most of the major functions are simulated including manual tilt, auto tilt, gain, WX+T turbulence detection mode, and the Predictive Windshear System (PWS).

Active Sky Next requirement:

The WXR-2100 simulation in SP1 requires the most recent version of the Active Sky Next (ASN) or later weather engine by HiFi Simulations. ASN is the first weather addon to output an external 3D precipitation model, which we've used to accurately model the operation of the radar. The weather radar does not currently function with default FSX weather or with any other weather addon. We will evaluate supporting other weather addons on a case-by-case basis if they can provide similar 3D precipitation data output.

ASN can be purchased here:

http://www.hifitechinc.com/products/activeskynext

Many simmers are under the assumption that radar shows the locations of clouds and could not understand our insistence for many years that realistic radar wasn't possible in FSX, mainly due to the presence of other

products on the market that showed the position of clouds or used cloud positions to make guesses about precipitation levels. This ASN-based radar system is not showing cloud positions and this is immediately apparent in the sim.

Basic radar concepts and theory:

Though it's become a word in its own right in the seven decades since its inception, radar is actually an acronym standing for **RA**dio **D**etection **A**nd **R**anging. Radars pulse waves in the radio band of the electromagnetic spectrum out into space where they reflect off objects and return back to a dish that collects and focuses them. By measuring the precise timing and signal strength differences between the pulses and their returns, the radar is able to calculate and display information about what's in front of the aircraft. In the case of a weather radar, the objects it is looking for are precipitation returns – essentially rain, snow, or ice (hail).

There are physical limitations inherent in how radar works that you need to be aware of when using the radar in the 777.

Radar beams are emitted from the nose in a 3-dimensional cone shape. The cone is very narrow close to the aircraft and spreads out with increasing distance. Because of this, the radar is showing a larger vertical cross section of the sky depending on the distance the returns are located at. This has important implications for determining precisely where precipitation is vertically in relation to the aircraft. If a return is far away, the actual precipitation could be within a large block of potential altitudes and you will need to make use of the tilt control and/or wait for the range to decrease to determine exactly where the return is vertically.

The physical locations of the radar controls are described in detail in the FCOM2 on pages 11.10.21 to 11.10.22. (pages 857 to 858 in the PDF file)

Tilt:

Antenna tilt is one of the key parameters you have control over with the radar system. Tilt controls the vertical angle that the radar beam pulses are sent out at by physically pivoting the transmitter and dish in the vertical plane.

The WXR-2100 is equipped with an auto tilt function that is engaged by default. For most users, this will be sufficient, but in real life some pilots like to set their tilt manually. In general here are some guidelines for manual tilt settings:

Before takeoff and lower part of the climb: +2 to +5 degrees.

The idea here is to see heavy precipitation that you may be climbing into since you're gaining altitude so rapidly. You want to keep the tilt high enough to avoid ground clutter (in real life, clutter is not yet modeled in the sim version).

Mid to high altitude climb: -2 to +2 degrees.

Here you're more concerned with storms that are in the in general straight line path of the aircraft as it climbs at a slower vertical speed up higher.

Cruise: -5 to 0 degrees.

In cruise, you will most often be looking at precipitation that's either at or below your current altitude. A storm is still very dangerous even if there's not precipitation from it at your current altitude due to powerful updrafts and turbulence in the core. Pilots will often scan with a downward tilt at cruise in order see down into the precipitation area of a storm, which makes it visible for avoidance.

Descent: 0 to +10

In the descent phases, the nose is pointing at the ground so you're going to need to have the radar tilted even more than it was during the climb to avoid ground clutter and see the main precipitation core of a storm, which may be thousands of feet above you.

Gain:

"Gain" is a term that essentially means amplification of the radar's return signals. As the gain is turned up, lighter areas of precipitation (green color) will show on the radar display. Think of it like a radio's squelch control – you're setting a "noise floor" where nothing below the setting gets through. Since light precipitation isn't generally dangerous to an airplane, the standard practice is to set the gain so that only the more severe yellow and red areas show. The default 0 setting generally accomplishes this and should be sufficient for most use.

WX vs. WX+T modes:

The WX mode shows only precipitation returns. WX+T overlays magenta areas of suspected severe turbulence over the precipitation returns by using the Doppler capability of the radar to see areas where the precipitation is moving quickly (suggesting strong updrafts, downdrafts or windshear) You will generally only see these magenta areas near the

core of heavy thunderstorms. Many pilots use WX+T mode exclusively because there's no downside to having it on vs. the standard WX mode.

Predictive Windshear System (PWS):

The PWS uses the Doppler radar information from particulate matter (dust, water vapor, etc.) in the air just in front of the airplane when in the terminal area in an attempt to detect windshear activity. If such activity is detected, a symbol appears on the ND showing the approximate magnitude and direction of the windshear and the EGPWS calls out "WINDSHEAR! WINDSHEAR!" Full TOGA power should be immediately selected and the airplane flown through the event with careful attention paid to airspeed and pitch. ASN is capable of simulating windshear and microburst events and you should be prepared if one happens.

Limitations:

Active Sky Next range settings:
The radar will technically work out to a maximum range of 250 nm depending on how high you have the ASN Minimum cloud draw distance and Maximum cloud draw distance sliders set (note that this does not imply that our radar is actually showing clouds – the clouds have to be there for the precipitation to be there).

Please be aware that setting these sliders above their default values can drastically affect FSX performance on even the highest end computers. There's unfortunately nothing we can do about this. It isn't coming from the radar itself but rather from the sim's graphics engine processing and rendering cloud sprites out to such extreme distances. In real life, the weather radar is rarely useful for making course deviation decisions beyond around 100 nm and we feel this is a reasonable level to leave the maximum range set at.

Future features:
The weather radar is currently considered an "in-progress" feature and certain functions are not yet simulated. We intend to keep developing it over time and more features will be added.

Among these planned are:

- Simulation of radar shadows and the path attenuation compensation (PAC) feature that alerts pilots to the possible presence of shadows.

- More realistic depiction of longer range radar returns. (beam spread/loss of resolution)

- Simulation of ground clutter in the WX and WX+T modes and simulation of returns from the ground MAP mode.

THE 777 AND TURBULENCE IN FSX

With the inclusion of the weather radar, many SP1 users will probably seek out heavy weather to fly through. It is important to understand the limitations of FSX's modelling of turbulence and the likely side effects you'll experience if you choose to do this. (It's worth pointing out that real life pilots go out of their way to avoid flying through such weather!)

What FSX turbulence does:

Below is a graph recorded over a few minutes of standard turbulence in FSX. On the Y axis is G-load and on the X axis is time.
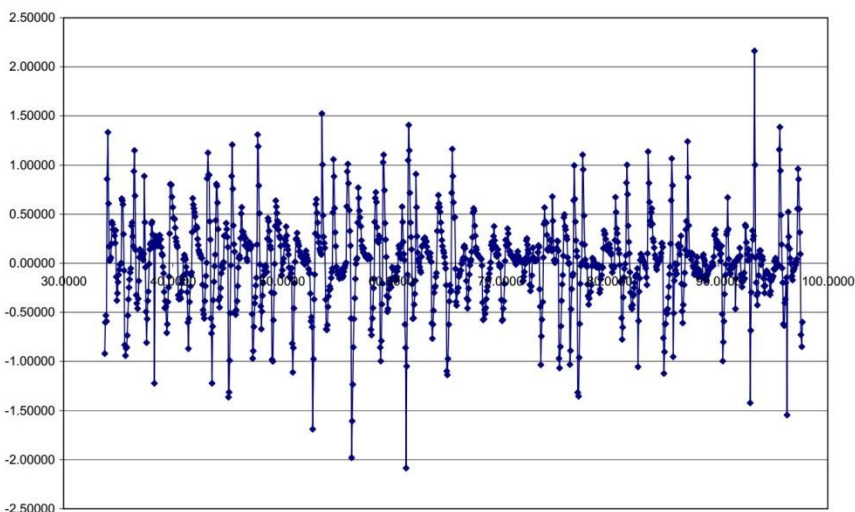
FSX is constantly hitting the airplane with G-loads in excess of 2.0 Gs in both the positive and negative directions. What's more, the magnitude of these "hits" actually remains the same regardless of the level of turbulence happening – the only thing that changes is how frequently they occur. 2.0+ Gs is extremely excessive and would constitute incredibly severe turbulence or windshear in real life. No real life autopilot system could possibly compensate for this. The PMDG 777's autopilot is programmed in the same way the real life one is and naturally, it has issues with these kinds of instantaneous forces jarring it out of its "comfort zone" so to say.

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The biggest side effect you are likely to see is an inability for the flight director to precisely maintain speed with pitch while such turbulence is occurring. The reason is highly technical and involves esoteric concepts such as the relative contribution of PID controller gains, but the real life autopilot would react in exactly the same way if put into a situation like this.

Turbulence filtering:

Despite the above description, we have attempted to average out FSX's frenetic G-load hits and make the airplane react better to them. Below is another graph, this time with the Y axis showing instantaneous tailwind component resulting from the turbulence and the X axis again showing time over the course of a few minutes.
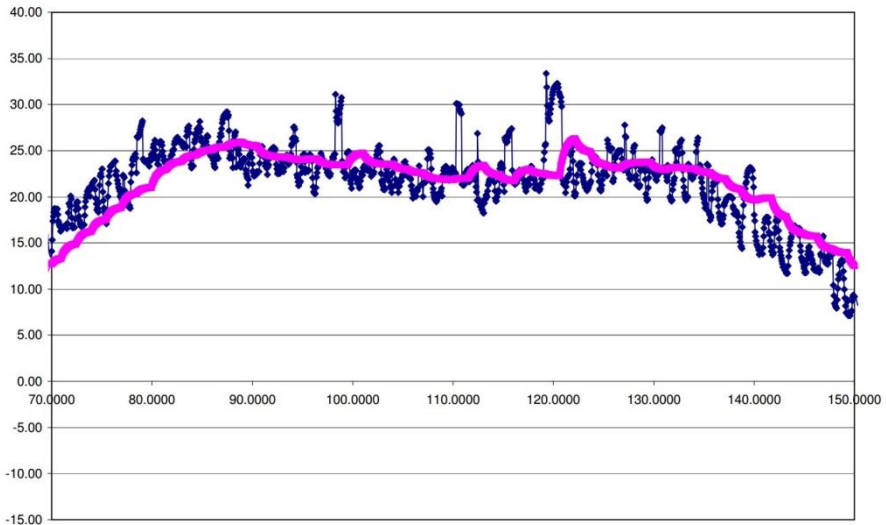
The magenta line is the result of a sophisticated mathematical filtering algorithm we developed to try to deal with the FSX turbulence. This line is what the flight director and autothrottle are actually "seeing" and reacting to instead of the wild raw fluctuations. This makes things better, but it's not (and can't be) perfect. Always remember that you are the pilot, not the computers. If you don't like what the flight director or the autopilot are doing, take over manually and make it do what you want it to.

AP/AT TURB MODE TRIGGER option:

The above filtering algorithm is activated when an average tailwind component threshold is measured. We have included a new option

accessible at MENU > PMDG SETUP > OPTIONS > SIMULATION on page 2/7 that allows you to set the exact threshold for the activation of this filtering mode in knots. We've set it to what we feel is a happy medium with the 1.0 knot default, but if you aren't happy with its performance you can play with this setting and tweak it to your liking. Valid values are 0.5 to 5.0 knots.

Other ways of mitigating turbulence effects:

FSX turbulence settings

In the FSX weather options there is a setting called "Disable turbulence and thermal effects on aircraft." This (despite its name) doesn't actually disable those things, but has helped users in the past with control issues in turbulence and seems to help tamper down the wild effects described earlier.

In the FSX.cfg file there is a line under the [Weather] section that reads TurbulenceScale=1.000000

This setting can be decreased and does seem to lower the severity of the turbulence "hits" FSX applies to the airplane.

Weather addon settings

Virtually all the commercial weather addons on the market have a setting or slider for turbulence level or strength. If you're having difficulties, try lowering this option – it's likely defaulted to FSX's 100% setting and may be excessive.

FMC SAVED FLIGHT PLAN CHANGES AND COMPANY DATALINK ADDITIONS

SP1 introduces changes in the way flight plans are saved and loaded and adds the simulation of many of the functions of the FMC company datalink. This builds on the wind import feature in the original release and includes functionality for routes, performance data, alternate lists, alternate weather, and position reports.

Route Request:

Flight plan file management

In SP1 we have added additional functionality to the way that flight plan files are stored and retrieved.

Flight plan files for all PMDG products are saved in the PMDG .rte format and are located in the FSX\PMDG\FLIGHTPLANS folder. In the original

release of the **PMDG 777-200LR/F**, flight plan files were located either in this folder or in a subdirectory (FSX\PMDG\FLIGHTPLANS\777) that is created automatically.

In SP1, the system is able to load or save flight plans from any folder in the PMDG\FLIGHTPLANS folder. This includes subfolders already created by other PMDG products (such as the **PMDG 737NGX**) or folders created by the user. You can create any number of additional folders to arrange your flight plan files in any way that is convenient, for example, by airline routes, short or long range, destinations, local or international, and so on.

Loading flight plan files

Loading an FMC route is accomplished through the FMC CDU's RTE page, using either the CO ROUTE (LSK 3R) or the ROUTE REQUEST (LSK 3L) prompt.

CO ROUTE is used to directly load a route for which you already know the file name. Enter the name into the scratchpad without the extension and press LSK 3R. Initially, the PMDG\FLIGHTPLANS\777 folder is searched and if the file is not found, the root level PMDG\FLIGHTPLANS is searched.

ROUTE REQUEST will allow you select a flight plan file located in PMDG\FLIGHTPLANS or any subfolder within it. Once the file is selected the route will be loaded by simulating the FMC datalink procedure used to load routes on the real life aircraft.

The ORIGIN (LSK 1L), DESTINATION (LSK 1R) and FLT NO (LSK 2R) fields of the RTE page are used to define the request. If you press the ROUTE REQUEST with these 3 fields empty you will be able to select any flight plan file manually. If you have already filled in the origin field, both the origin and destination fields, or the flight number field the FMC will filter the available routes it displays based on the criteria you've entered.

Initiating a ROUTE REQUEST at LSK 3R will bring up a new page titled "REQUEST CO ROUTE" that lists all the subdirectories that include flight plans meeting the selection criteria and also indicate how many flight plan files were found in each subdirectory. The PMDG\FLIGHTPLANS folder is listed as "GENERIC". Selecting one of the subfolders will bring up a new page listing all the relevant flight plans in it. Once you select one of the flight plans the name will be highlighted and a REQUEST> prompt will appear in 6R. Pressing LSK 6R will return to the RTE page and initiate the uplink procedure for the selected route.

```
    REQUEST CO ROUTE 1/2          777 ROUTES        3/5
<777 (21)                      <LGTSLGRP008
<GENERIC (6)                   <LGTSLTBA001
<747 (1)                       <LGTSTNCM001
<FOLDER3 (2)                   <MMMXKSAN001
<LONG RANGE (1)                <MMMXKSAN002
------------------------       -----------------------
<RETURN                        <RETURN       REQUEST>
```

While in the REQUEST CO ROUTE page or in the subfolder files listing pages, you can further filter the displayed routes by typing on the scratchpad. Any characters typed on the scratchpad will filter the displayed routes to those with a file name starting with the entered characters.

If there is only one flight plan file matching the RTE page selection criteria (origin + destination or flight number) the REQUEST CO ROUTE page is not displayed and the uplink procedure is initiated immediately, directly from the RTE page. This opens up a lot of interesting methods of organizing your flight plans – you could made a folder with routes organized by flight number, simply enter that number into the FMC and press ROUTE REQUEST and the datalink simulation will load the correct route automatically.

Saving flight plan files

You can save the current flight plan from the ROUTE SAVE prompt on the FMC RTE page. Pressing LSK 5L will bring up a page named "SAVE ROUTE", where you can set the name and the location of the flight plan file.

```
          SAVE ROUTE
  FOLDER        FILE NAME
  777           LGTSLGRP009
<777          NEW DEP/ARR>
<GENERIC      USE CO ROUTE>
<OTHER         USE FLT NO>
              SET CUSTOM>
------------------------
<RETURN           CONFIRM
```

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The top line fields (1L and 1R) show the folder and file name that will be used to save the flight plan.

On the left side of this page you can select the desired folder:

<777: The file will be saved in the PMDG\FLIGHTPLANS\777 folder

<GENERIC: The file will be saved in the root PMDG\FLIGHTPLANS folder

<OTHER: Brings up a new page on which you can select any of the other folders that may exist under the PMDG\FLIGHTPLANS directory.

On the right side of the page you can select the desired file name:

NEW DEP/ARR>: The file name will be constructed from the ICAO codes of the origin and destination airports followed by a 3-digit index, selected so that there is no conflict with any other existing flight plan file for the same origin-destination pair.

USE CO ROUTE>: The file name will be determined by the CO ROUTE field of the RTE page. In case the flight plan was originally loaded from a file (by CO ROUTE or ROUTE REQUEST) this will be the name of the existing file. Selecting this option will result in overwriting the original flight plan file.

USE FLT NO>: The file name will be determined by the FLT NO field of the RTE page. Flight plan files saved using a flight number can be retrieved by filling the required flight number in the RTE page FLT NO field before selecting ROUTE REQUEST.

SET CUSTOM>: A custom user entered file name will be used. Type the desired file name in the scratchpad (with no extension) and press 5R.

Selecting a folder and/or file name option will update the fields in 1L & 1R. Pressing the EXE key will save the flight plan file.

FMC company datalink functionality and options

In SP1 we have simulated the FMC company datalink. This functionality is described in detail in the provided documentation in the FCOM2 on pages 11.34.1-11.34.12 (pages 925-936 of the PDF). This includes RTE, FLT NO, PERF INIT, WIND DATA, DES FORECAST, ALTN, ALTN WX and ALTN LIST uplinks and RTE REPORT and POS REPORT downlinks. The optional TAKE OFF datalink functionality is not presently modeled in the PMDG 777 product line.

There are several options regarding the FMC datalink configuration that can set from MENU > PMDG SETUP > AIRCRAFT > EQUIPMENT on pages 12 & 13.
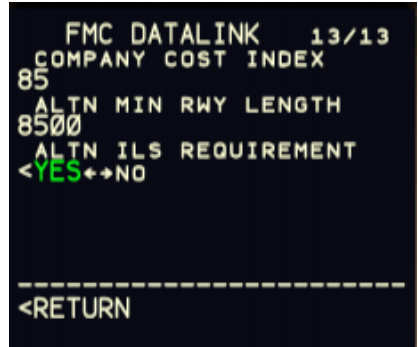
AUTO PREFLIGHT UPLINKS: With this option selected, initiating a ROUTE REQUEST from the RTE page during preflight will automatically trigger in sequence PERF INIT, WIND DATA and DES FORECAST requests. The data for each request will become available once data of the previous request in the sequence is loaded and accepted.

AUTO ALTN LIST UPLINK: With this option selected the alternate airports list data (ALTN page 2/2) is automatically updated periodically during the flight.

AUTO DES FRCST UPLINK: With this option selected, each time a WIND DATA request is performed, a DES FORECAST data uplink request is automatically triggered following it.

AUTO POS RPRT DOWNLINK: With this option selected, position reports are automatically downlinked during the cruise phase of the flight each time a waypoint is sequenced. With this option selected, position reports are automatically downlinked during the cruise phase of the flight each time a waypoint is sequenced. This option is simulated by the presence of the REPORTING and REPORT SENT prompts - there is no sending of an actual report to anywhere.

COMPANY COST INDEX: This option sets the preferred company cost index that is used in PERF INIT uplink requests.

ALTN MIN RWY LENGTH: This option is used (in conjunction with the next option) to define company preferred airports to be used as alternate destinations in ALTN (ALTN page 1/2) and ALTN LIST (ALTN page 2/2)

requests. Any airport that does not have at least one runway longer than the defined length will not be considered as a valid alternate airport by the FMC.

ALTN ILS REQUIREMENT: This is used (in conjunction with the previous option) to define company preferred airports to used as alternate destinations in ALTN (ALTN page 1/2) and ALTN LIST (ALTN page 2/2) requests. With this option selected, only airports that have at least one runway equipped with ILS are considered as alternate destinations.

Weather Forecast Data

For all weather related uplink requests, (WIND DATA, DES FORECAST, ALTN WX) weather data is retrieved either directly from FSX or from third party weather addon applications.

When there is no weather addon application running, data is retrieved from FSX directly. If the FSX weather is set from the FSX Weather menu to real-world weather (either static or update every 15 minutes) you must make sure that you have enabled the following FSX option:

Settings > Display > Weather > Download winds aloft data with real-world weather.
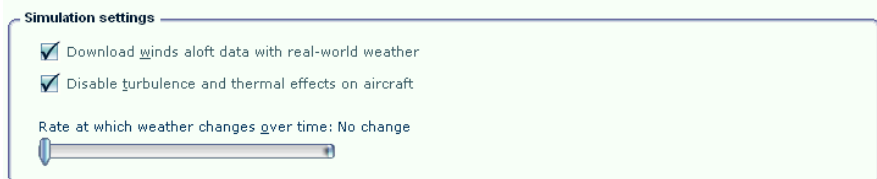
If any of the FSX Weather Themes are used instead of the real-world weather option, you must be aware that although you will receive forecasts that will correspond to the weather that you will encounter along the route, themes apply the same weather globally and will usually contain wind data only for a couple of low altitude flight levels.

If you are running a 3rd party weather add-on application, there will be some actions you must take in order to retrieve the correct weather data from the add-on application using the datalink simulation.

The PMDG 777 looks in the [FSX]\PMDG\WX folder for a file named XXXXYYYY.wx, where XXXX and YYYY are the active route's origin and destination airport ICAO codes. This file should contain wind and temperature data for the waypoints along the route in a specific format.

Depending on the weather addon application, this file will be created automatically or by manual action. The MENU > PMDG SETUP > OPTIONS > SIMULATION page 7 provides two options at LSK 3L and LSK 4L that can help to automate the process and reduce the required user actions.

The following 3 steps are required:

1. Create a flight plan file

Create a flight plan file in FSX format (.pln). This file may be created by any means. (flight planner applications, waypoint-by waypoint entry in FSX, a file downloaded from the internet etc.)

You can skip this step if you set the FSX PLN FILE FOR WX option (3L) to either CREATE FILE (WX.PLN) or CREATE AND LOAD TO FSX. In this case the PMDG 777 will automatically export the active FMC route into an FSX format .pln file. This file is named WX.pln and is saved in the default FSX flight plans directory (My Documents\Flight Simulator X files). This file is created and subsequently updated each time the user selects a CDU page that contains a weather data related REQUEST prompt (RTE DATA, DES FORECAST, ALTN pages).

Note that if you want to be able to access weather data for the 4 alternate destination airports (displayed in the ALTN CDU page) these alternate airports must be included in the created .pln file as waypoints and be placed anywhere between the origin and destination airports. In case the option for automatic FSX .pln file is selected, you may also set the INCLUDE ALTNS IN PLN option on to automatically include the alternates in the exported flight plan file.

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2. Load the flight plan file into the add-on application

Once the .pln flight plan file is created, either manually or automatically, it must be loaded into the weather add-on application so that weather forecasts are produced for each waypoint of the flight plan.

You can automate this process if you are using Active Sky Next. Set the FSX PLN FILE FOR WXR option at LSK 3L to CREATE AND LOAD TO FSX and at the same time set the Active Sky Next "Auto load simulator flight plan" option in Settings > General Options. (screenshot on the next page) In this case the PMDG 777 will automatically create the .pln file and then load it into FSX triggering an automatic loading of the FSX flight plan into Active Sky Next. This may work with other add-on weather applications if they provide a similar option for automatically loading the simulator flight plan.
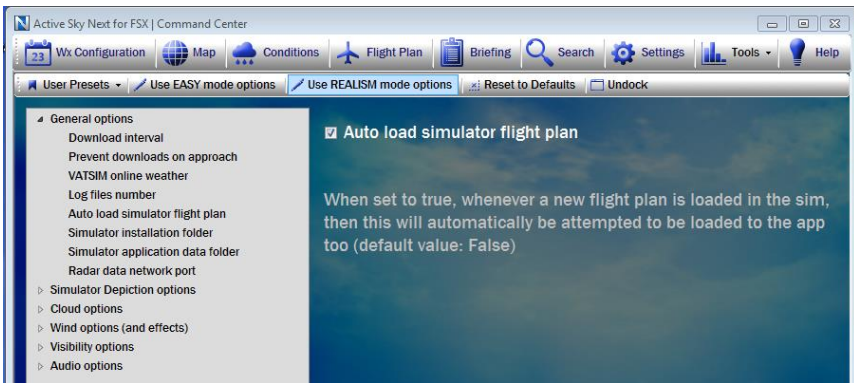
3. Create the WX file in PMDG\WX folder

Most of the add-on applications (currently confirmed for Active Sky 2012, Active Sky Next, PFPX, Opus FSX, and FS Global Real Weather) will automatically create the WX file in the required format and place it in the [FSX]\PMDG\WX folder. In this case you are now ready to make the REQUEST from the relevant CDU page and the data will be retrieved.

If the add-on application you use does not yet support automatic creation of the required WX file, you must extract the wind data manually and create the file yourself. For details see the PMDG-WIND-DATA-REQUEST-readme.txt file in the FSX\PMDG\WX folder.

Important Note:

If you have an add-on application running but the required WX file is not created because you have not followed properly followed the steps described above, the 777 PMDG will try to retrieve weather data directly from FSX. Since the add-on applications generally only set the FSX weather for an area of 60-100 NM around the current aircraft position and clear the weather in the rest of the world, you will get wind data only for a few waypoints ahead, some of the alternate destinations (depending on distance) and, unless the destination airport is in range, no data at all for the DESCENT FORECAST (you'll get an INVALID FORECAST UPLINK message on the CDU).

Tip:

When you request waypoint winds or descent forecast data for the first time (the relevant CDU pages contain no data), wind data will be retrieved for a predefined set of 4 altitudes depending on the cruise level. Subsequent requests will update the wind data for these altitudes.

If you want to get data for a different set of altitudes you can delete the altitude rows that you are not interested in and enter new desired altitudes without making any wind data entry. On request, wind data for these altitudes will be retrieved.

777 FLY-BY-WIRE (FBW) SYSTEM CHANGES

With the release of the SP1 update, our simulation of the 777 fly-by-wire system has changed significantly from how it operated in the original release version of the product. The deep inner workings and logic of this part of the aircraft are a closely guarded secret and unfortunately some wrong information about its operation was funneled to us during the original development of the product by what appeared to be a highly credible source. This information led us to believe that the system operated in a manner that it doesn't in reality.

Pitch speed stability and FBW theory:

The immediate major effect you will notice in SP1 is that you now have to trim for all airspeed changes while handflying, just as you would in any of Boeing's mechanically-linked aircraft like the 737 or 747. The difference is that on the 777, the use of the yoke trim switches in-flight actually commands the FBW system to select a new "trim reference airspeed" within the primary flight computers. They do not command the stabilizer directly unless on the ground or in the degraded secondary or direct modes. The rate of change is approximately 10 knots of trim reference

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speed per 1 second of trim switch application. For example, if you accelerate from 250 knots to 300 knots in manual flight, you will need to input approximately 5 seconds of nose-down trim for the reference speed to move from 250 knots to 300 knots, a 50 knot change. This is now modeled correctly and there are no situations under manual flight where the aircraft will autotrim or otherwise change the trim reference speed on its own.

The precise pitch speed stability behavior of the FBW system was extensively tested and tuned during SP1 development via observation in level D full-flight 777 simulators and on the real aircraft. With hands off the controls in an out of trim state, the real airplane exhibits a tendency to pitch in the direction that will return it to the trim reference speed. It was common in our real life tests when increasing or decreasing airspeed with thrust held constant to see the airplane go into what's known as a "phugoid" oscillation pattern when out of trim. It pitches up until slower than the trim reference speed, then pitches down until faster than it and repeats this cycle, with the oscillations becoming smaller and smaller until the aircraft settles back at the trim reference airspeed. We have modeled this type of out of trim phugoid behavior to the best of our abilities within the confines of FSX in SP1.

Remember that in the real airplane this is all a simulation of sorts occurring within the primary flight computers. It's under computerized FBW control at all times but simulates a normal mechanically linked airplane. The 777 FBW pitch algorithm at its core is what's known as a C* (pronounced "see star") control law that actually is virtually identical to what Airbus aircraft use in their own FBW systems. Boeing, however, added additional functionality on top of this base level C* law to cause it to simulate a conventional airplane with control forces and phugoid tendencies that requiring trimming to alleviate (the 777 control law is called C*U – "see star you" with U representing the speed stability function). All of this is now properly simulated in SP1. You truly have a "simulation of a simulation inside a simulation" now with the way this system of the airplane is modeled within FSX.

Bank compensation:

A prime culprit in the impression that the original version was autotrimming all the time was a misunderstanding on our part of how the bank compensation feature of the 777 FBW actually works. Previously, the system was holding the last flight path angle of the airplane when it was put into a bank, regardless of its trim state. The real aircraft only compensates for the component of pitch change in turns stemming from the natural aerodynamic tendency for the airplane's nose to drop due to

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the turn itself, not the entire pitch axis tendency including out of trim forces from being above or below the trim reference speed. This has been tested and verified on the real aircraft and the simulated airplane will now feel out of trim and need trim application while banking in an out of trim state in SP1.

Control force simulation:

SP1 simulates the build-up of force or pressure on the control column as airspeed deviates from the trim reference speed. You will notice reduced elevator authority in the direction that opposes the trim force as a stand-in for the physical force that exists in the real airplane. This was the best compromise we could make for something that is inherently difficult to simulate without a sophisticated force feedback hardware system. As you trim in SP1 you should feel the elevator effectiveness move back to normal authority.

There are several other situations that will also result in control force loading:

- During rotation at takeoff as the pitch approaches the tailstrike limit.

- Flare compensation mode below 25 feet radio altitude. The FBW commands the nose down slightly during flare to prompt the pilot to pull back on the yoke. This is done because the C* control law doesn't normally take ground effect into account.

- When the aircraft exceeds 30 degrees of bank (this is felt in the roll axis).

- When the aircraft is near the flight envelope limits (stall, overspeed, or g-limits based on flap and gear configuration)

  The real airplane maintains full elevator and aileron authority at all times but it takes an increasing amount of force by the pilot's arms on the controls to attain it as the loading increases.

Configuration change compensation:

The 777 FBW system compensates for the adverse pitch effects of aircraft configuration changes including:

- Flap extension and retraction.

- Landing gear extension and retraction.

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- Speedbrake/spoiler use.

- Thrust changes where there is no airspeed change (for instance beginning a climb)

As with the bank compensation feature, these functions exist on top of the speed stability layer and these compensations will no longer result in the cancelation or "autotrimming" of the entire pitch tendency of the airplane if done when in an out of trim state as they did previously.

Stall and overspeed protection

It is no longer possible to trim the airplane into an overspeed or stall condition. The real airplane will only go into the stall or overspeed range with considerable force on the control column, not with trim application.

"Blip" trim:

The real life 777 has an undocumented feature pilots call "blip trim" that allows for very precise setting of the trim reference speed to the current airspeed. If the current airspeed and the current trim reference speed are separated by 5 knots or less, a short momentary application of the trim switch in either direction will automatically set the trim reference speed to the exact current airspeed. This feature is extremely useful for fine tuning once the aircraft is close to being in trim and we have simulated it in SP1.

FBW assists for the FSX environment:

SHOW FBW TRIM REF SPEED option

To assist **PMDG 777** pilots in understanding and operating the FBW trim system in the desktop simulator environment where physical control forces aren't present, we have implemented a new global simulation option called "SHOW FBW TRIM REF SPEED" found in the FMC options under MENU > PMDG SETUP > OPTIONS > SIMULATION on page 1. This option adds a cyan **-FBW** marker to the PFD speed tape that shows the precise location of the current FBW trim reference speed. If the speed is offscale, the actual numeric speed shows next to the marker, similar to how an offscale landing reference speed is shown in green. The trim reference speed will be shown any time the option is turned on and the aircraft is in-flight while being handflown above 100 feet radio altitude. The trim reference speed does not show during autopilot use, since the AFDS takes full control of trimming.

Joystick FBW null zone options

Two new global options have been added for tuning the null zone for engagement of the FBW flight path hold mode of the system after release of the controls, both in the pitch and roll axes. These options are intended to simulate the aspect of the real life system whereby the controls must be deflected with a certain amount of force to push the FBW system out of its hands-off path following and speed stability modes and into fully manual control. During testing it was noted that there was a large variance in how much deflection was needed depending on the specific joystick in use and that often the system would remain in manual control mode even with the joystick released. If you experience the airplane acting as if the speed stability out of trim function never engages to cause the aircraft to pitch to return to reference speed, play around with these settings – your joystick likely needs different values than the defaults.

The options are located at MENU > PMDG SETUP > OPTIONS > SIMULATION on page 2/7 and are labeled CTL COLUMN NULL ZONE and CTL WHEEL NULL ZONE (for pitch and roll respectively).

A note on low weight takeoff trim settings

The 777 (particularly the 200LR) is prone to very nose down takeoff trim settings at low gross weights due to the highly aft (30+%) CG. This is most commonly encountered on short flights with light fuel loads.

FSX's flight dynamics engine unfortunately has an issue with this type of configuration that will cause the airplane to still feel like it's out of trim in the nose down direction immediately after takeoff even with the takeoff trim set on the numbers. When the FBW system engages at 100 feet, there can be a noticeable pitch up motion – this is simply the system compensating and correcting for the FSX issue and not any sort of "autotrim" happening. If you find this effect annoying, you can add an extra unit or two of trim to the calculated one at low weights / aft CGs. Even in the real world, anywhere within the green band is acceptable for takeoff, so this isn't completely out of the realm of realistic anyway.

PMDG 777-300ER SUPPLEMENT

Released in July of 2014, the **PMDG 777-300ER** product extension adds the stretched extended range 777-300ER aircraft to the base **PMDG 777-200LR/F** package. There are some key additions and differences you should be aware of when flying this variant of the airplane.

Ground Maneuvering Cameras:

Due to the extreme length of the 777-300ER fuselage, a system of three ground maneuvering cameras were designed into the airplane to give the pilots a visual reference of the landing gear position while taxiing for adequately judging turns. The system can be engaged by pressing the CAM button on the EICAS control panel as shown below:

This system was extremely difficult to model in FSX and due to limitations in the simulator we've had to limit the camera views to a 2D popup panel that appears in the lower left corner of the screen. This method generates a very large performance hit due to the fact that the FSX world is being rendered four separate times while it's on. Unless you have a very high end PC, it may be more advisable to just use spot view to taxi.

The system also requires the use of a separate partial external model, which exists in the FSX\SimObjects\Airplanes\PMDG 777-GMC folder. Do not modify this folder – the placement of the proper textures into it is automated by PMDG Operations Center when you install a livery and no user interaction with the folder is required.

We noticed a tendency among viewers of pre-release beta screenshots of the camera popup to think that we'd incorrectly or poorly drawn the "frame" that separates the three camera views. This is actually a digitally drawn graphic that exists on the display in the real airplane – it is not a

physical frame. It does in fact look very simple and flat in real life, exactly as we've drawn it in FSX.

Tailstrike avoidance:

The 777-300ER fuselage is significantly longer than the 777-200LR or 777F are and is at a greater risk for tailstrikes on takeoff and landing. Older 777-300ER models have a tailskid installed to protect the fuselage while newer versions of the aircraft are omitting the tailskid and relying purely on the FBW system's tailstrike protection mode that increases control loading to prevent the tail from hitting the ground. The latter option reduces weight and increases maximum payload. Both options are simulated in the **PMDG 777-300ER.** You will notice a distinct difference in the feel of the 300ER vs. the 200LR/F during takeoff and landing because of the system's more aggressive control loading.

GE90-115B engines:

Boeing offers the 777-300ER with only one engine, the General Electric GE90-115B. This is the single most powerful jet engine currently in existence and has the maximum thrust rating for the GE90 series. The GE90-115BL1 variant with the takeoff bump option has been modeled here.

Lower climb and cruise performance:

Despite its huge engines, the 300ER can be a bit more sluggish in the climb and it generally cruises at lower altitudes than the 200LR/F due to its higher gross weight. It's not uncommon to see a heavy 300ER max out at FL330 or 340.

APU to pack takeoffs:

The 777-300ER comes standard with an option that allows the APU to feed bleed air to the air-conditioning packs during takeoff so that the engines can develop their full rated thrust without any bleed air being siphoned off. This is important in places like Dubai where the outside air temperature is extremely hot and 777-300ERs are constantly leaving at or near max takeoff weight. Turning the packs off even for a minute or two for takeoff would result in an uncomfortably warm cabin for the passengers, so the APU to Pack takeoff option is used to keep the packs working during the takeoff sequence.

Main landing gear differences:

The 777-300ER's main landing gear trucks are different than those on the 200LR/F in that they are cantilevered. This was done so that the airplane

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can pivot on the rear wheel pair of each axle, which increases the clearance between the tail and the ground. This allows for a higher deck angle at rotation and a shorter takeoff and landing distance than an airplane of this length would normally require.

This feature of the main landing gear was painstakingly modeled and animated on the **PMDG 777-300ER** external model – go to spot view during a takeoff or landing and watch it!

Things the wide beta team wanted you to know:

- The 300ER is a heavier bird and is not as overpowered as the 200LR/F is. At heavier loads, it requires more thrust to break away and maintain taxi speeds. V speeds are going to be a little higher, climbs are going to be slower, and initial cruise altitudes are going to be in the low 30's. All part of hauling more aircraft into the air!

- The extra length requires more oversteer during taxi. For a 90 degree turn, wait until the centerline of the taxiway passes the window pillar by your shoulder (or the FO's) before you start turning. Pay close attention to taxi speed and avoid entering turns at more than 10 knots, or you're going to get NOSE TIRE BALANCE messages on the EICAS and a horrible clatter from the nose wheel on rotation and landing! Good runway alignment and taxiing into the gate requires practice too.

- The extra length also makes the native FSX head movement issue somewhat worse. If you have a spare hat switch on your joystick, map it to the fore/aft and left/right head position keys to make correcting the position easy. After a short while it becomes a non-issue.

- The deck angle at which a tailstrike will occur on rotation is lower than it is on the 200LR/F. While there are built-in FBW protections to mitigate the risk, a disciplined rotation technique is ever more important to avoid a necessary return to base.

- The 300ER doesn't have the same range as the 200LR. Make sure you are planning a route that the aircraft can actually handle at the weight you are carrying. A tradeoff in payload vs fuel load is required to get it to stretch its legs fully.