TOLAPS - A PROGRAM FOR TAKEOFF AND LANDING PROFILE SIMULATION

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ABSTRACT The program name TOLAPS is an acronym for Take-Off and LAnding Profile Simulation. Some of the interesting features of this program is the ability to detect flight performance effects of airport altitude, ambient temperature, air pressure and wind. TOLAPS can also handle effects of TOW and LW.

The program user can also calculate profiles by user defined flaps and thrust settings deviating from recommended standard settings for each aircraft. Wind effects on straight out flying as well as turns can also be demonstrated.

Output from TOLAPS are either screen graphics of profiles (altitude, speed or thrust versus flight distance) or flight track. Profiles can also be made in a tabular form, ready for use in most airport noise calculation programs. In this way, TOLAPS is a valuable tool to evaluate effects of noise abatement procedures.

1 INTRODUCTION

TOLAPS is a PC-program developed for simulation of landing- and takeoff profiles for aircraft under different meteorological conditions. The program can also handle variations in some flight performance related parameters.

One of the basic requirements was that most of the aircraft used in commercial traffic in Norway should be included in the database developed for TOLAPS.

2 THE STORY BEHIND --

The original idea for this program stems from long time plans to include a profile builder into FAA's Integrated Noise Model. As this now is done in INM Version 4.11, our TOLAPS is using the same basic routines for profile simulation. New for TOLAPS is inclusion of possibilities for variation in more parameters than INM's PROFILE BUILDER can do. The wind effect on track generation is specific for TOLAPS only.

3 ALGORITHMS USED

TOLAPS is mainly using the same mathematical tools as INM's PROFILE BUILDER, as they both are based mainly on Society of Automotive Engineers Aerospace Information Report SAE AIR 1845: "Procedure for the Calculation of Airplane Noise in the Vicinity of Airports". Consequently, the basic concept is to generate flight profiles intended for noise calculation. Therefore, profiles generated may differ slightly from real profiles without any practical consequences on aircraft noise calculations.

As the profile builder for INM now is released, a complete parameter database for this kind of profile generation is available. TOLAPS will therefore be prepared to use INM database 11 or any update of this. At the moment, this database includes necessary information for 107 different aircraft.
In addition to this basic parameter database, TOLAPS has an extra information file, giving weight limitations for each aircraft type. Both minimum and maximum takeoff and landing weight is included.

4 PROFILE PRESENTATION

Profile presentation is primarily made in datafiles prepared for aircraft noise calculations by programs as INM, NOISEMAP etc. In addition, graphical screen presentation of all parameters in a flight profile can be made. Not only the altitude versus flight distance, but also air speed or engine thrust versus flight distance. The graphical presentation can be made combined with listing of the entire profile generated, or a full screen graphical profile presentation can be made.

5 TRACK GENERATION

The main idea behind the track generation was to make a tool suitable for consequence evaluation of noise abatement procedures. Therefore we had to include turning segments defined by bank angle or change in heading. A turning segment will reduce the aircraft climb performance, and wind effect will wary during a turn.

Runway heading, aerodrome altitude, static air pressure, wind speed and -direction are all important parameters affecting a profile and track generation.

The track generation is unique for TOLAPS. This is made very simple by calculating the airplane drifting distance for each profile segment.

A default profile generation by TOLAPS, creating a straight out take off or landing profile without any sidewind effects, will create a profile equal to a profile in INM's database.

6 RUNNING TOLAPS

In the following presentation, some practical examples of using TOLAPS to generate take-off profiles will be given. A diskette with the TOLAPS program and all acessory files necessary, is available from The Civil Aviation Administration in Norway.

<u>DEFAULT TAKEOFF PROFILE</u> By starting TOLAPS, an interactive menu will ask for aircraft type to generate a flight profile for. By selecting a B-737-200 from the menu offered, a default takeoff profile will be created and presented on the screen as in Figure 1.

<u>RUNWAY HEADING</u> For example, let us assume a runway direction of 60° (RWY-06). To include this in the program, the cursor must be moved into the table by hitting the [TAB] to access the upper line in the table. By using the right pointing arrow [⇒], the cursor must be moved into position [Heading] in the table. Now we can enter the runway heading of 60°.

REFERENCE PROFILE To use this profile and track as a reference to compare for later modifications, hit the function key [F9]. This reference profile now assume no wind, 15°C, 1013 hPa static air pressure, AAL at sea level, and takeoff weight according to INM's defined stage length 1.

TURN TO 150° FROM 400 ft AAL To edit a takeoff profile it is recommended to have a full screen profile table. This is accessed by selecting the [View] menu, followed by [Table]. This can be obtained by hitting the following sequence: [F5],[⇓], [ENTER].

In the table, the third segment (line) is climbing from AAL to 1000 ft above. To start a turn within this segment, it must be subdivided. To do so, set the bank angle to 30° in profile segment 3 (Ini Clmb), by moving the cursor to line three in the table, and into column named [Bank]. Write 30, followed by [Return]. 30° bank angle is a typical max value for most aircraft in traffic, and therefore also a recommended max value for use also in TOLAPS.

Now the third primary segment of the default takeoff profile for this aircraft is divided into 16 minor subsegments, starting from liftoff. Each subsegment has a change in heading of 5.2°. All subsegments under 400 ft must be straightened out. Except for the very first subsegment, this is done by setting the bank angle in each subsegment to 0°. In the first subsegment, a very small bank angle must be inserted (0.001°). If not, the subsegmenting of the basic Initial Climb segment will be omitted.

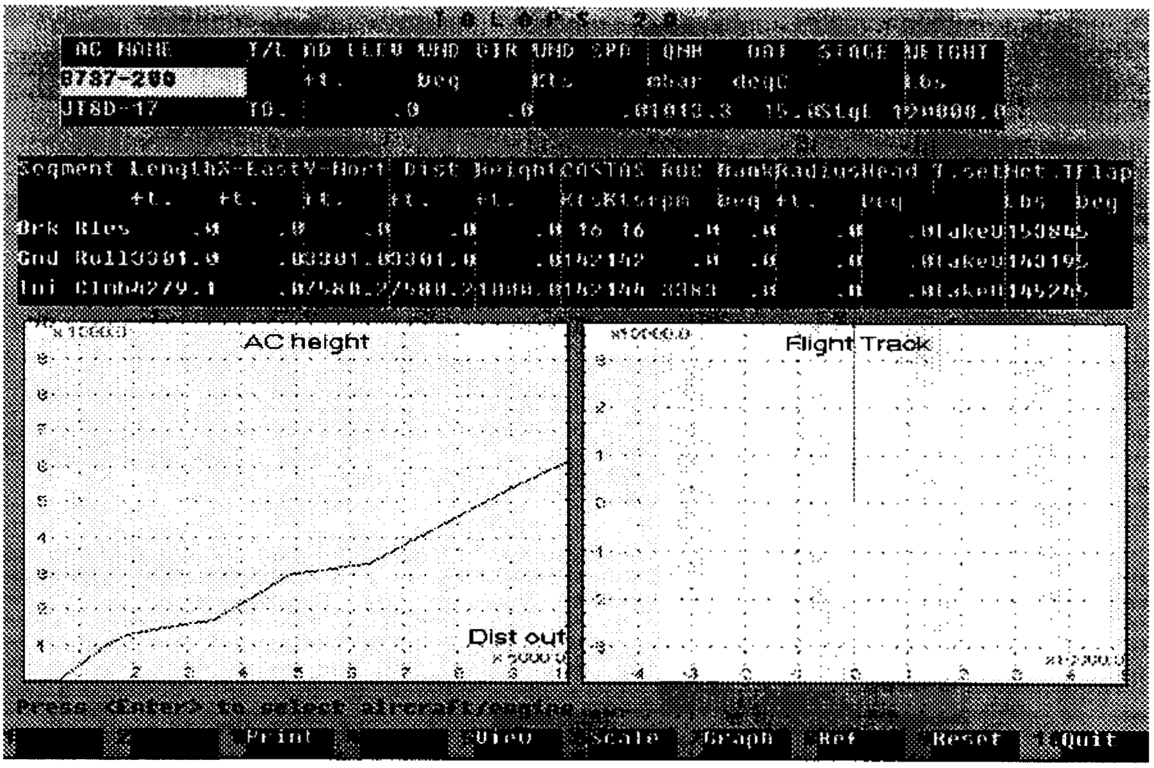
Now the first 6 subsegments has no bank angle, and the turn out from runway heading starts at 437 ft. A normal turn will never go into 30° bank angle as abrupt as this. Therefore it is recommended to take no more than 10° change in bank angle for each subsegment. That will introduce a 30° bank angle over 3 subsegments.

Now the heading of the final subsegment in the Initial Climb part of the profile is 106°. The takeoff procedure requested a final heading of 150°. The two next segments of the profile, named Initial Acceleration and Thrust Reduction, must also be subdivided. This is done in the same manner as previously described, by entering a bank angle of 30° into each basic segment. During the Initial Acceleration segment, the aircraft heading ends up at 149°. By checking the heading through the subsegmented Thrust Reduction segment, a final heading of 150° can be obtained. Remember a slow roll back to level wings!

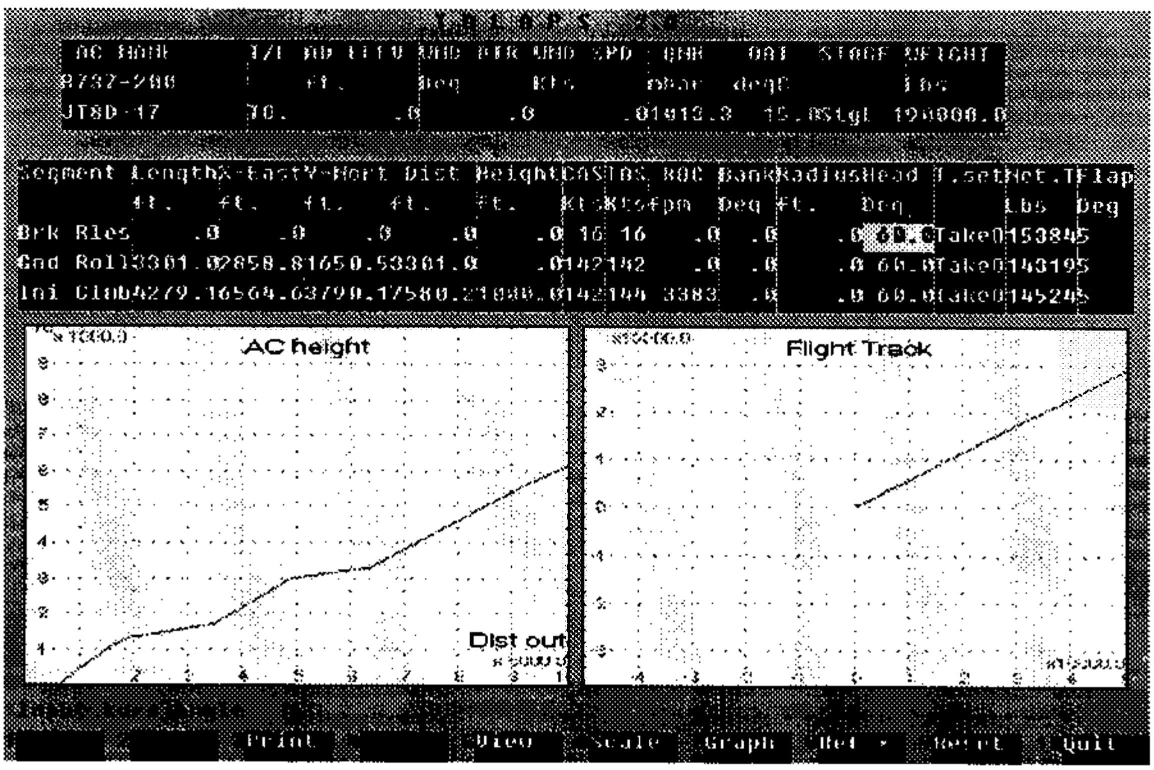
COMPARE TO REFERENCE By selecting [VIEW] menu and both table and graphical presentation, it is easy to compare reference conditions to a takeoff procedure including a turn. To return to graphical presentation, hit [F5] and [⇑]. Now you have both altitude profile and flight track presentation on the screen, and comparison between default profile and new generated procedure can be made.

WIND CORRECTIONS Both the reference track and profile, as well as the newly generated, assumes no wind. Let us assume that the generated profile will be exposed to a 30 kts wind from east. This is inserted in the basis field, the very upper part of the table of the TOLAPS picture on the screen.

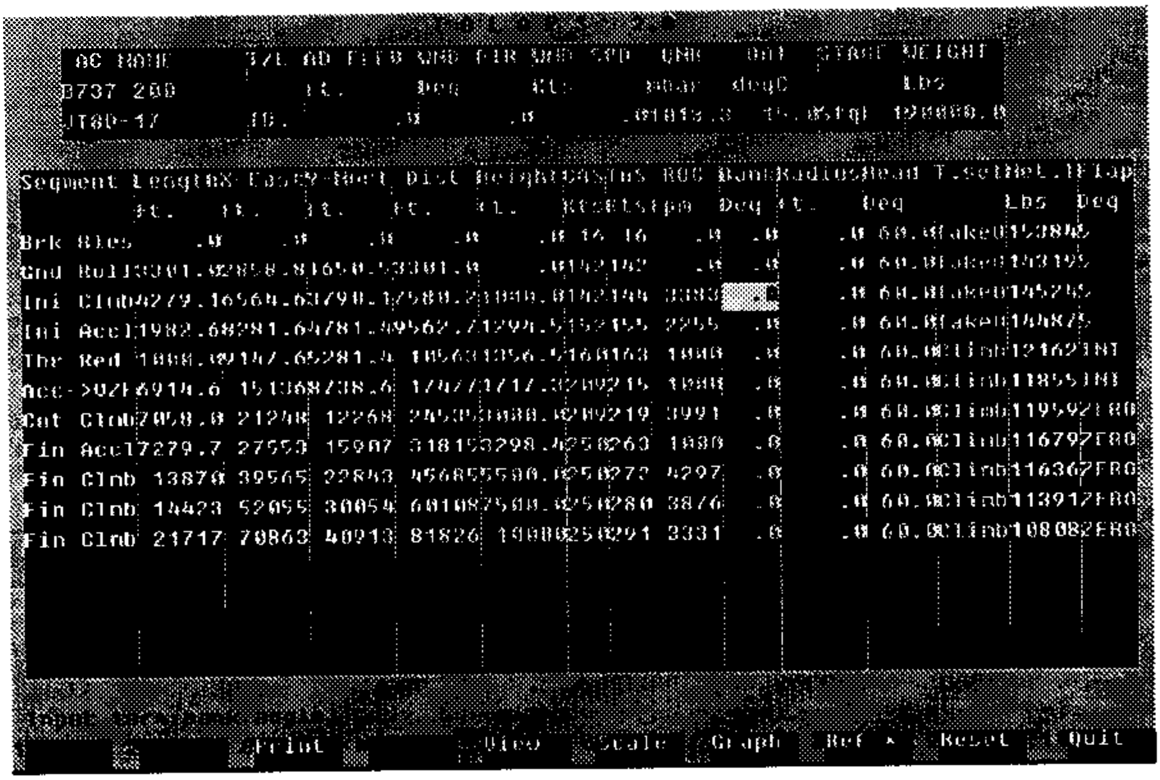
To access this, move the cursor into the wind area by using the arrows [⇒] and [⇓]. Insert [WIND DIR] 90° and [WND SPD] 30 kts. As you will observe from the graphical presentation, a steeper climbout will occur when the headwind component is at max. The track generation will also be affected by this wind input, but the aircraft heading will still be 150°.



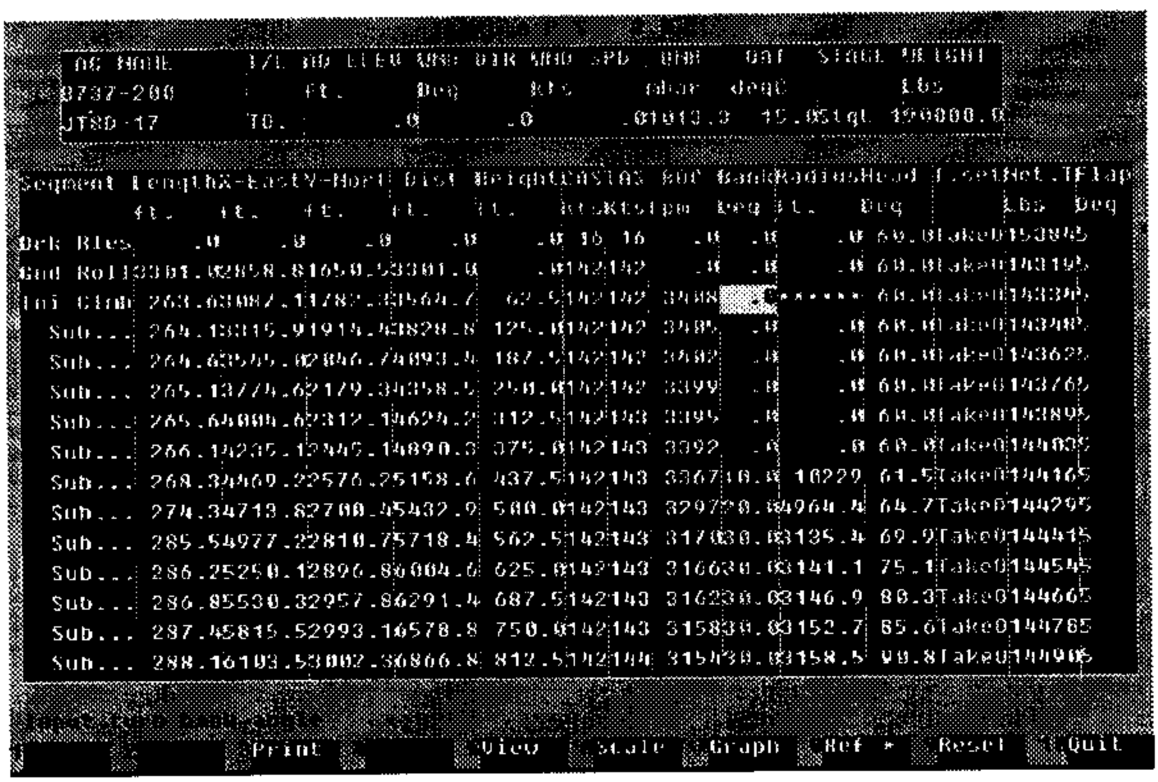
Figur 1: Opening screen picture for TOLAPS



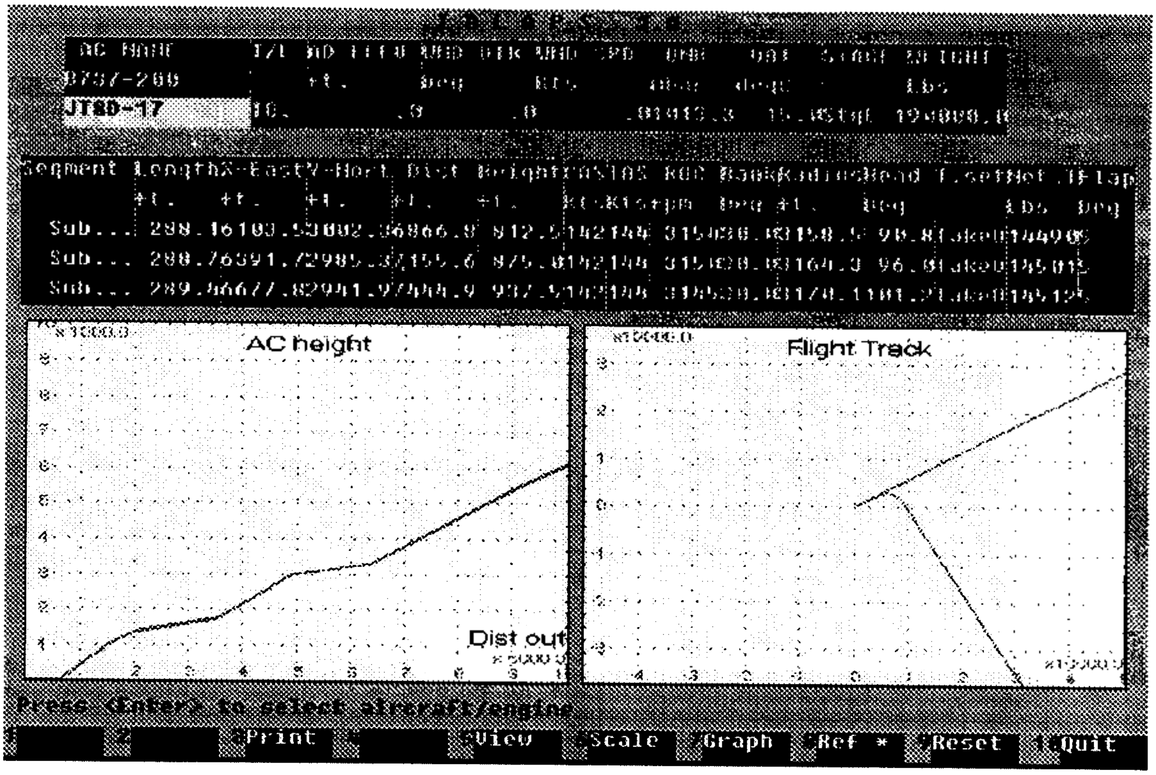
Figur 2: Runway heading inserted, and reference profile set.



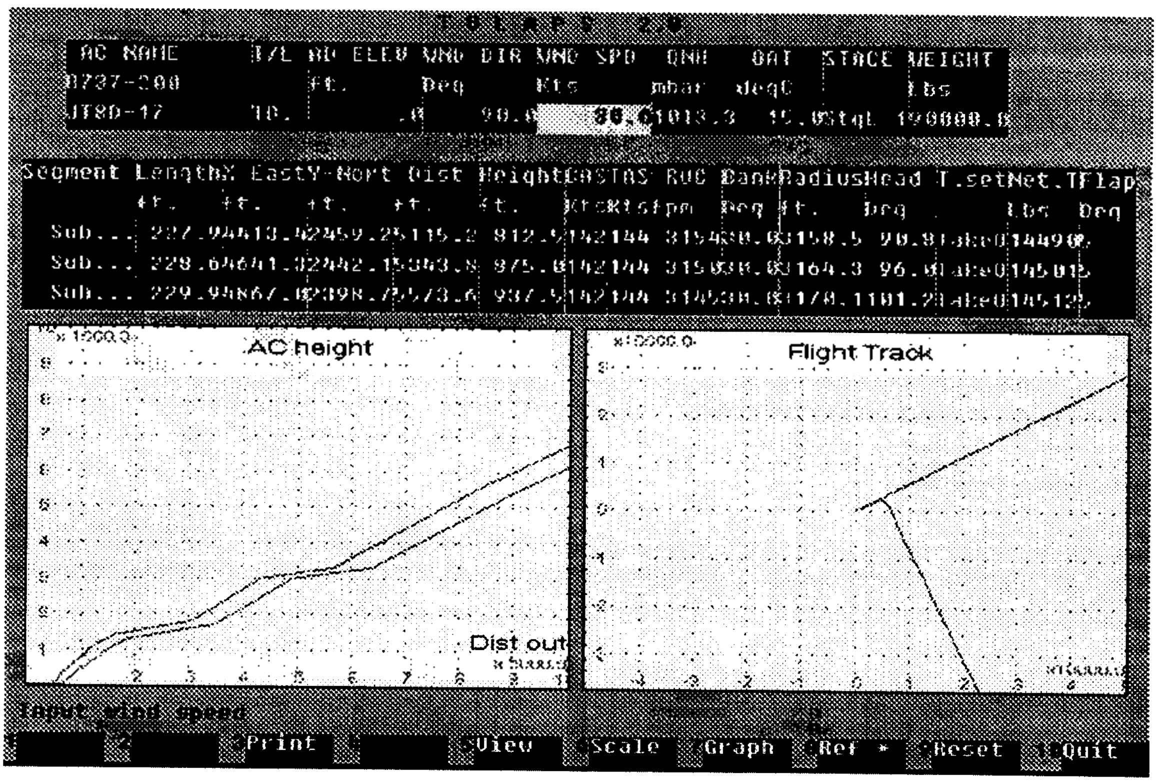
Figur 3: Takeoff profile table in full screen presentation.



Figur 4: Takeoff turn with 30° bank initiated at 437 ft altitude.



Figur 5: Reference profile and track presentation compared with user defined takeoff procedure.



Figur 6: Effect of 30 kt wind from 90° on generated takeoff procedure.