

# FAARFIELD 1.3

## Software Overview

Presented to: IX ALACPA Seminar on Airport Pavements  
Ciudad de Panamá, Panamá

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Federal Aviation  
Administration



# FAARFIELD – What Is It?



- **FAARFIELD** is the new FAA airport pavement thickness design program.
- **FAARFIELD** superseded LEDFAA 1.3 as the standard design procedure in FAA Advisory Circular (AC) 150/5320-6E.
- **Officially released September 30, 2009.**
- **Current version is 1.305 (posted 1/18/11)**

# FAA Legacy Design Procedures vs. FAARFIELD

	AC 150/5320-6D (Chapters 3 - 4)	FAARFIELD
<b>Traffic Model</b>	All traffic converted to equivalent departures of design aircraft	CDF (Cumulative Damage Factor) accounts for mixed traffic
<b>Structural Response Models</b>	<ul style="list-style-type: none"> <li>•Westergaard's solution for rigid pavements</li> <li>•Boussinesq model used to compute ESWL for flexible</li> </ul>	<ul style="list-style-type: none"> <li>•Layered elastic analysis (LEAF) for flexible.</li> <li>•3D finite element for rigid.</li> </ul>
<b>Thickness Design Method</b>	<ul style="list-style-type: none"> <li>•CBR equation with alpha factor (flexible)</li> <li>•Apply percent of thickness to basic design for 5000 coverages (rigid)</li> </ul>	Failure model relates coverages to structural failure to a suitable response: subgrade strain (flexible) or concrete stress (rigid).
<b>Implementation</b>	Design nomographs (spreadsheet implementation also available)	Desktop computer program written in Visual Studio 2005

# FAARFIELD 1.3

## Key Differences from LEDFAA 1.3

- **Rigid Pavements/Overlays**
  - Slab edge stresses are now computed directly using 3D-FEM.
  - Completely revised rigid pavement failure model.
  - Rewrote and improved rigid overlay design procedures.
- **Flexible Pavements/Overlays**
  - Automatic base thickness design.
  - Improved pass-to-coverage ratio computation routine.
  - Supports HMA overlay design on rubblized PCC base.
- **General**
  - Upgrade to MS Visual Basic 2005 programming environment.
  - Aircraft library updated.
  - New function allows user to export design data to XML.
  - Improved formatting for Notes.
  - All user options collected on one “Options” screen.



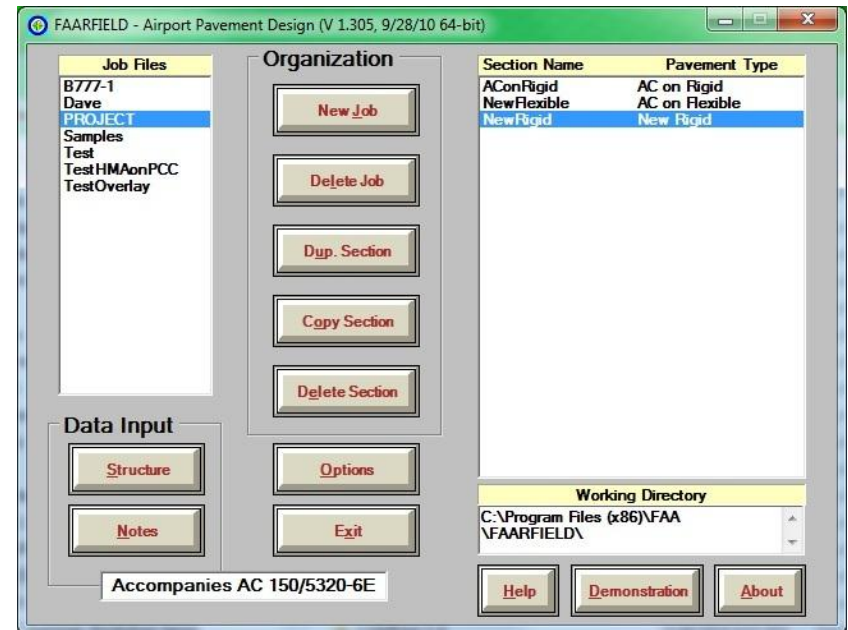
# FAARFIELD 1.3 New Features

- **Pavement thickness is now computed for constant tire contact area.**
  - Changing the airplane gross weight causes the tire pressure to be adjusted to maintain the contact area.
- **External aircraft library in XML format.**
- **Displays CDF values graphically.**
- **Enhanced Airplane Data window now displays gear coordinates.**
- **Support for PCC over rubblized base.**



# FAARFIELD Version 1.305

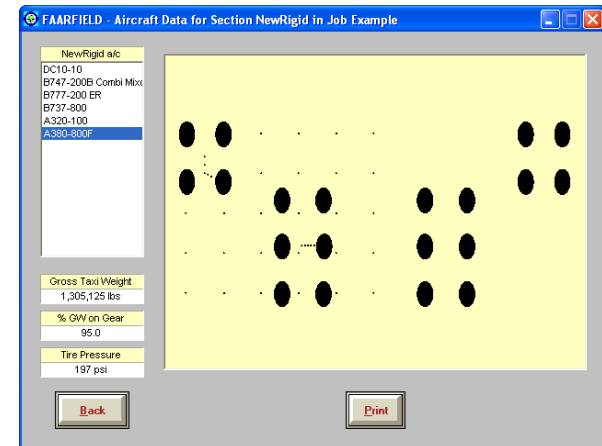
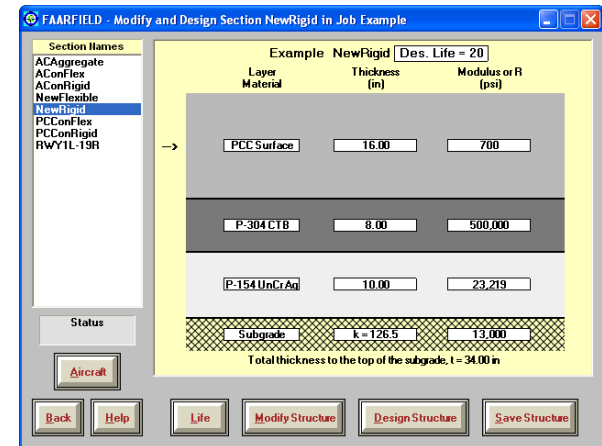
- Upgrade was posted January 2011.
- Compatible with Windows 7.0 and the 32- and 64-bit versions of Windows Vista.
  - Previous versions of FAARFIELD (up to 1.302) were not compatible with 64-bit operating systems.
  - Link to previous version (1.302) is still maintained.
- Design outputs from FAARFIELD were not affected by this version upgrade.



FAARFIELD 1.305 Screen Shot

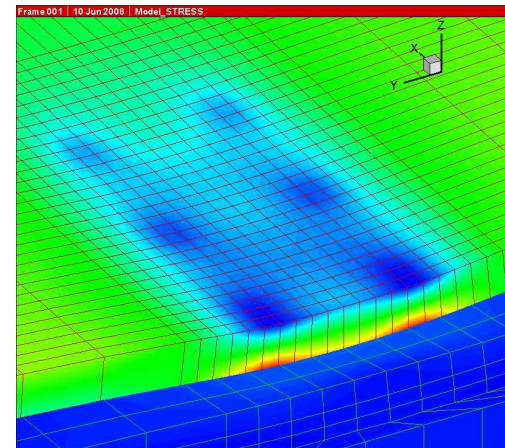
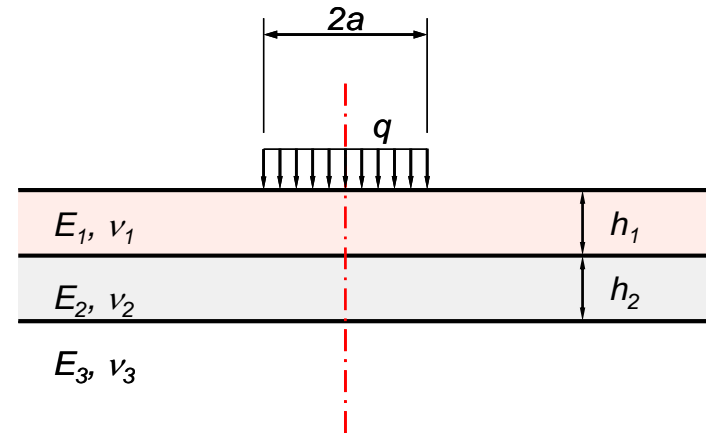
# FAARFIELD – Technical Background

- Computer program for desktop PCs.
- Program preserves the “look and feel” of LEDFAA 1.3.
- Major changes are internal.
- Main program drives three subprograms:
  - LEAF (layered elastic analysis)
  - NIKE3D (3D finite element analysis)
  - INGRID (3D mesh generation)
- **NIKE3D and INGRID information:**
  - Modified for FAARFIELD by the FAA
  - Distributed in compiled form under a software sharing agreement with Lawrence Livermore National Laboratory (LLNL)



# Structural Models in FAARFIELD

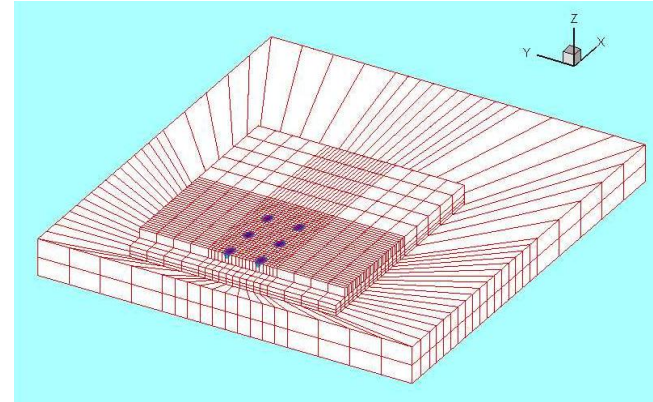
- **Both layered elastic (LEAF) and 3D-FEM (NIKE3D) are used in FAARFIELD.**
- **Flexible pavement design**
  - LEAF is used for all structural computations.
  - For flexible, no advantage to using 3D-FEM.
- **Rigid pavement design**
  - LEAF is used to generate a preliminary thickness.
  - Final iterations are done using a 3D finite element model (3D-FEM).



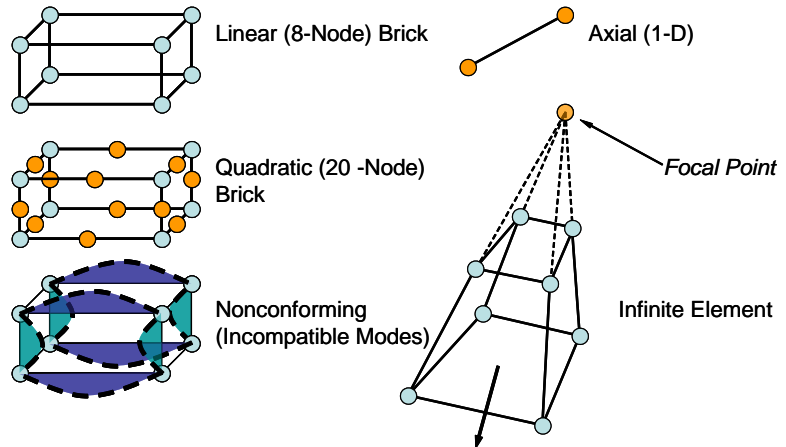


# What is 3D Finite Element?

- **3D Finite Element is:**
  - A method of structural analysis.
  - Applicable to a wide range of physical structures, boundary and loading conditions.
- **3D Finite Element is not:**
  - A design method or procedure.
  - An exact mathematical solution.
  - Always preferable to other analysis models.



## Types of 3D Elements:



# Why 3D Finite Element?

- **For rigid pavements, we desire a method that gives a direct edge stress solution for a layered structural system.**
- **Layered elastic analysis programs such as LEAF always assume continuous, uniform layers with no interruptions (e.g., no joints).**
  - LEAF cannot model jointed rigid pavements accurately.
  - LEDFAA 1.3 compensates for this with the “equivalent edge stress” approach, but this is theoretically unsatisfactory and is not extendable to new aircraft types.
- **3D-FEM provides a practical solution.**
  - Suitable for modeling complex landing gear configurations explicitly.
  - Recent advances in computing power allow implementation in routine design programs.

# Summary of Advantages and Disadvantages of 3D-FEM

- **Advantages**

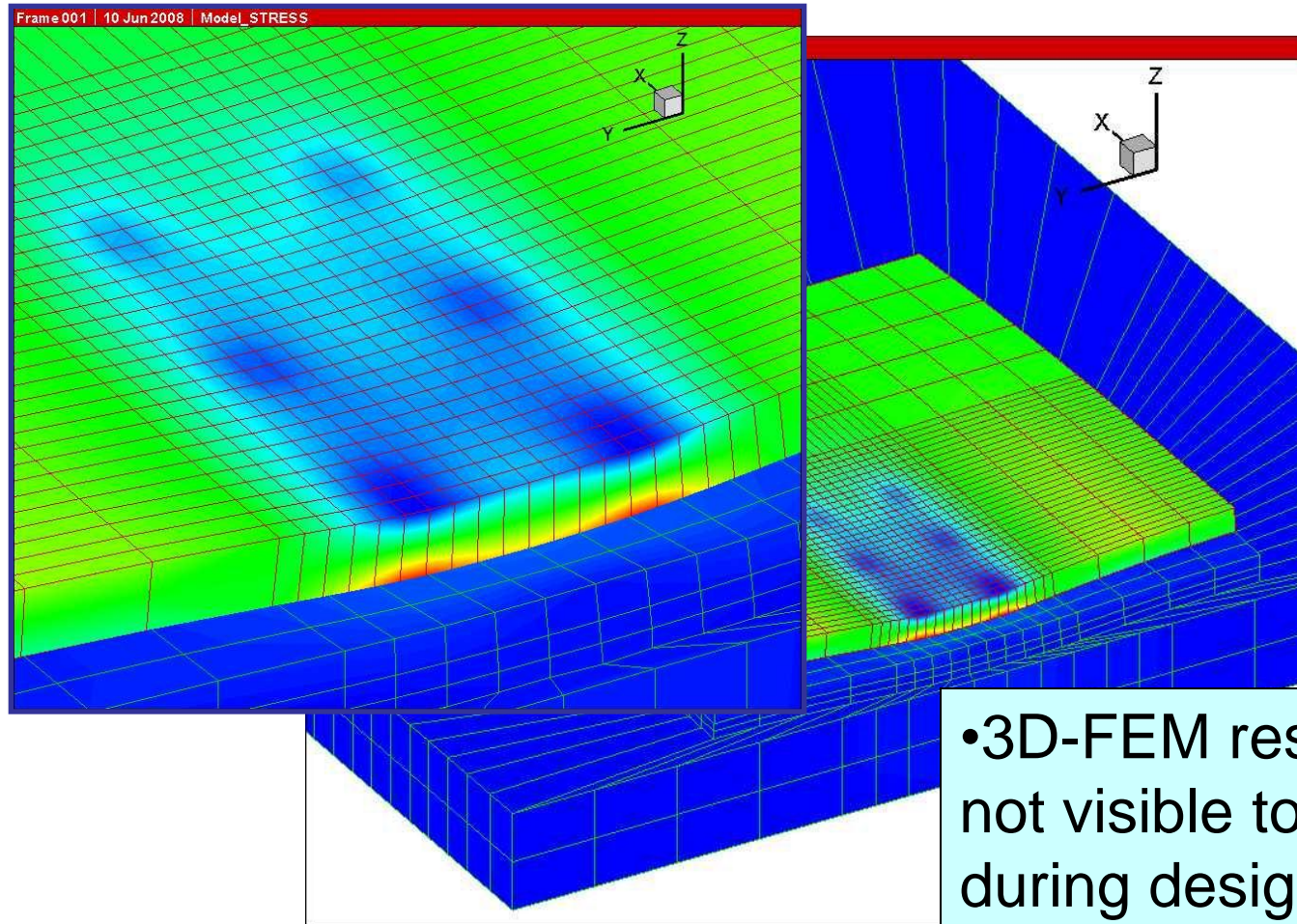
- Properly models rigid pavement features including slab edges and joints.
- Provides the complete stress and displacement fields for the analyzed domain.
- Handles complex load configurations easily.
- No inherent limitation on number of structural layers or material types.
- Not limited to linear elastic analysis.

- **Disadvantages**

- May require long computation times.
- Pre-processing and post-processing requirements.
- Solution may be mesh-dependent.
  - In theory, the solution can always be improved by refining the 3D mesh.
  - Improvement comes at the expense of time.

# 3D-FEM Stress Response

## Stress $\sigma_{yy}$ Contours Displayed Using NikePlot

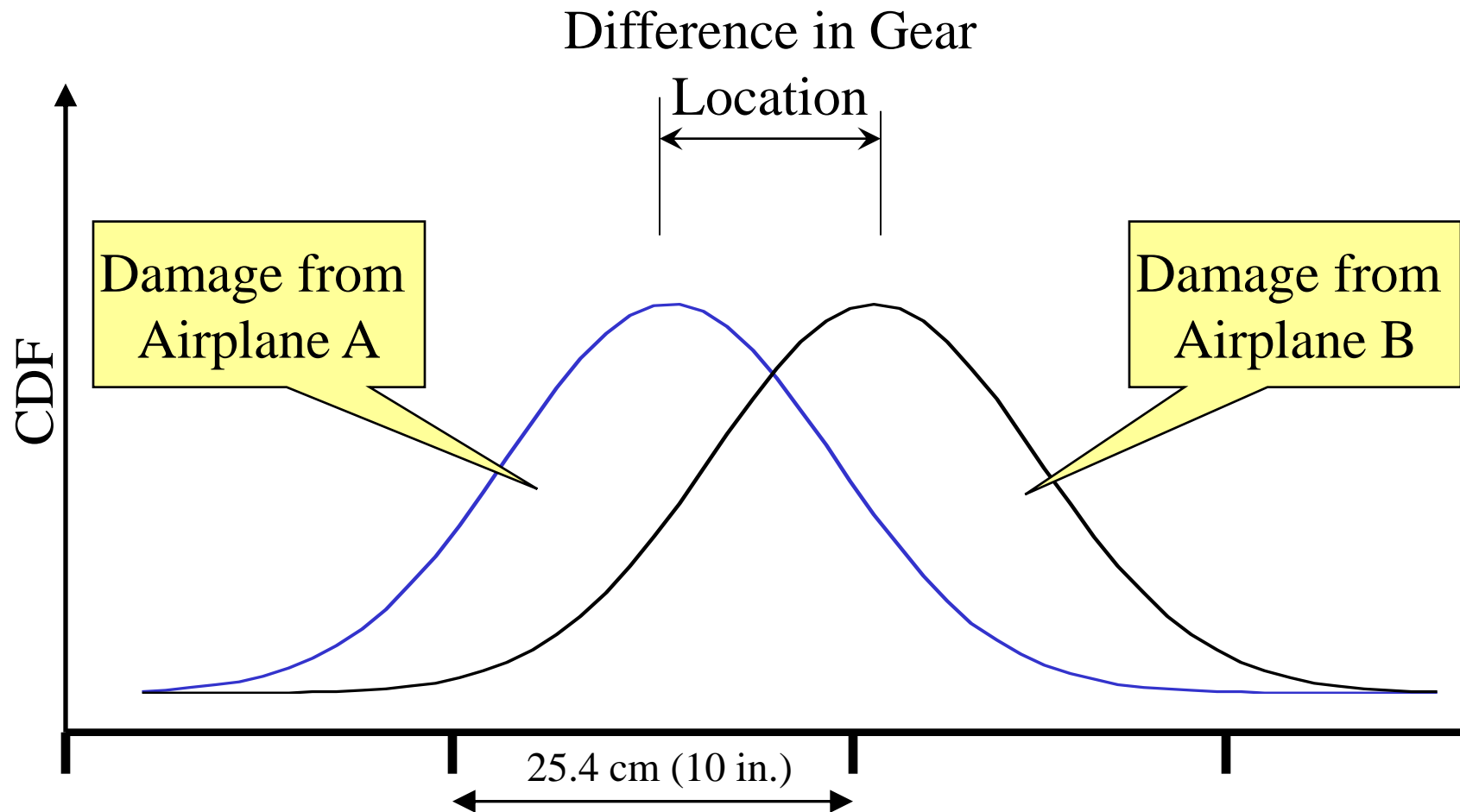


- 3D-FEM responses are not visible to the user during design.

# Cumulative Damage Factor (CDF)

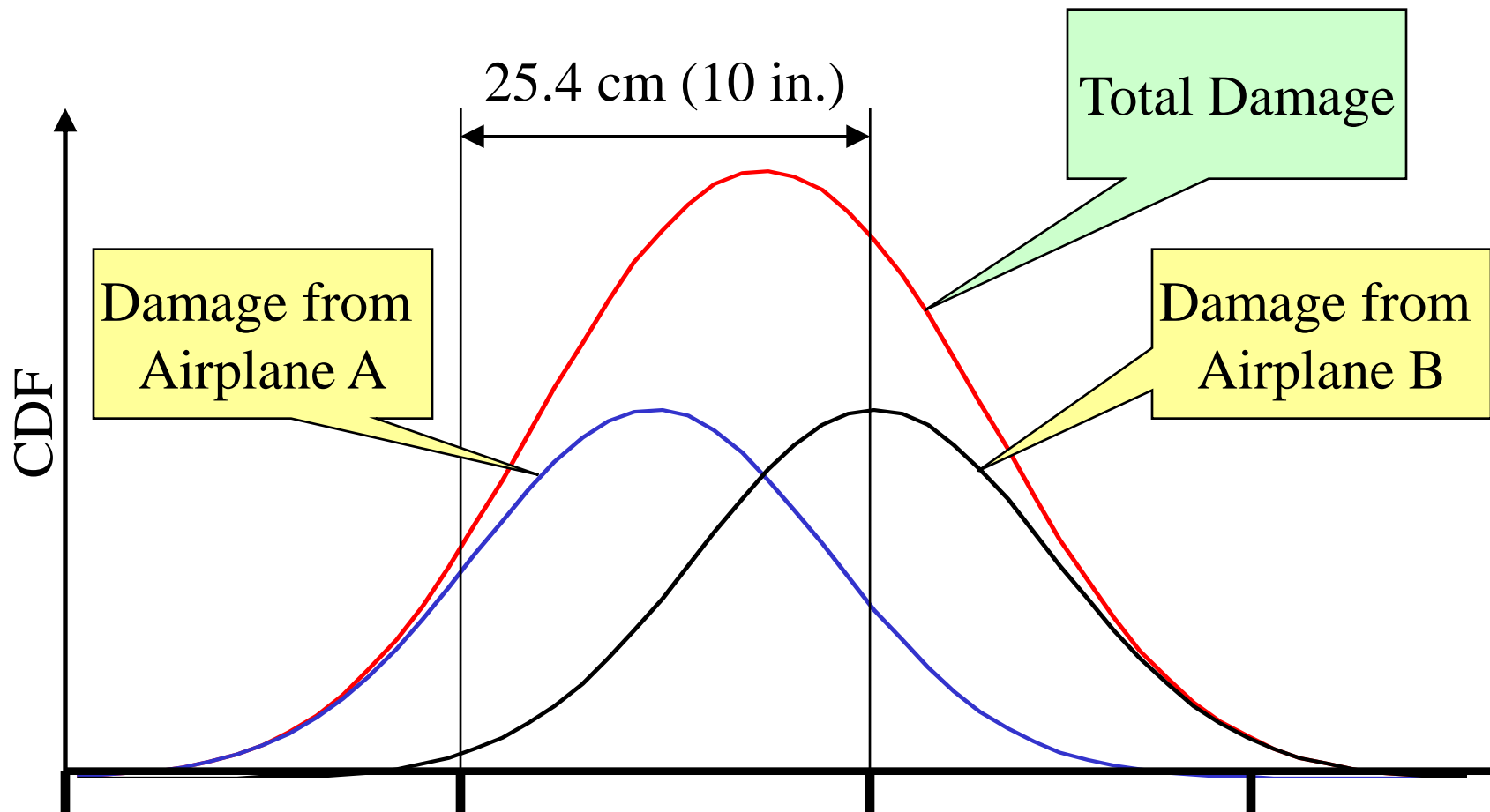
- Sums the damage contributed from each aircraft - not from equivalent aircraft.
- **CDF =  $\Sigma (n_i / N_i)$ , where:**
  - $n_i$  = actual passes of individual aircraft  $i$
  - $N_i$  = allowable passes of individual aircraft  $i$
- **When CDF = 1, design life is exhausted.**
- **In FAARFIELD (and LEDFAA 1.3):**
  - The gear location and wander are considered separately for each aircraft in the total mix.
  - CDF is calculated for each 25.4 cm (10 inch) wide strip over a total 20.83 m (820 inch) width.
  - Miner's rule to sum damage for each strip.
- **Must input the fleet mix, NOT equivalent departures of design aircraft.**

# Cumulative Damage Factor (CDF)

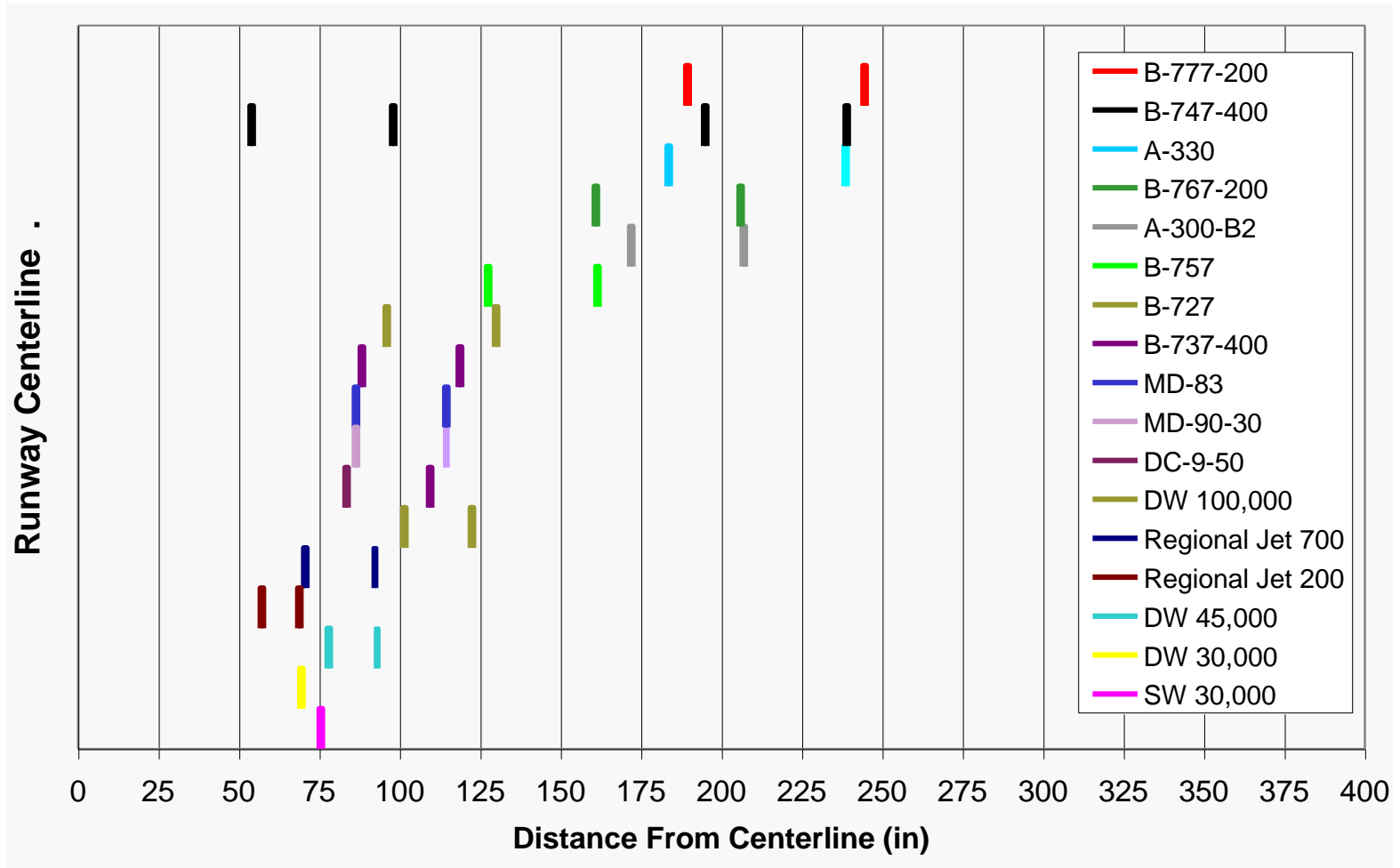




# Cumulative Damage Factor (CDF)

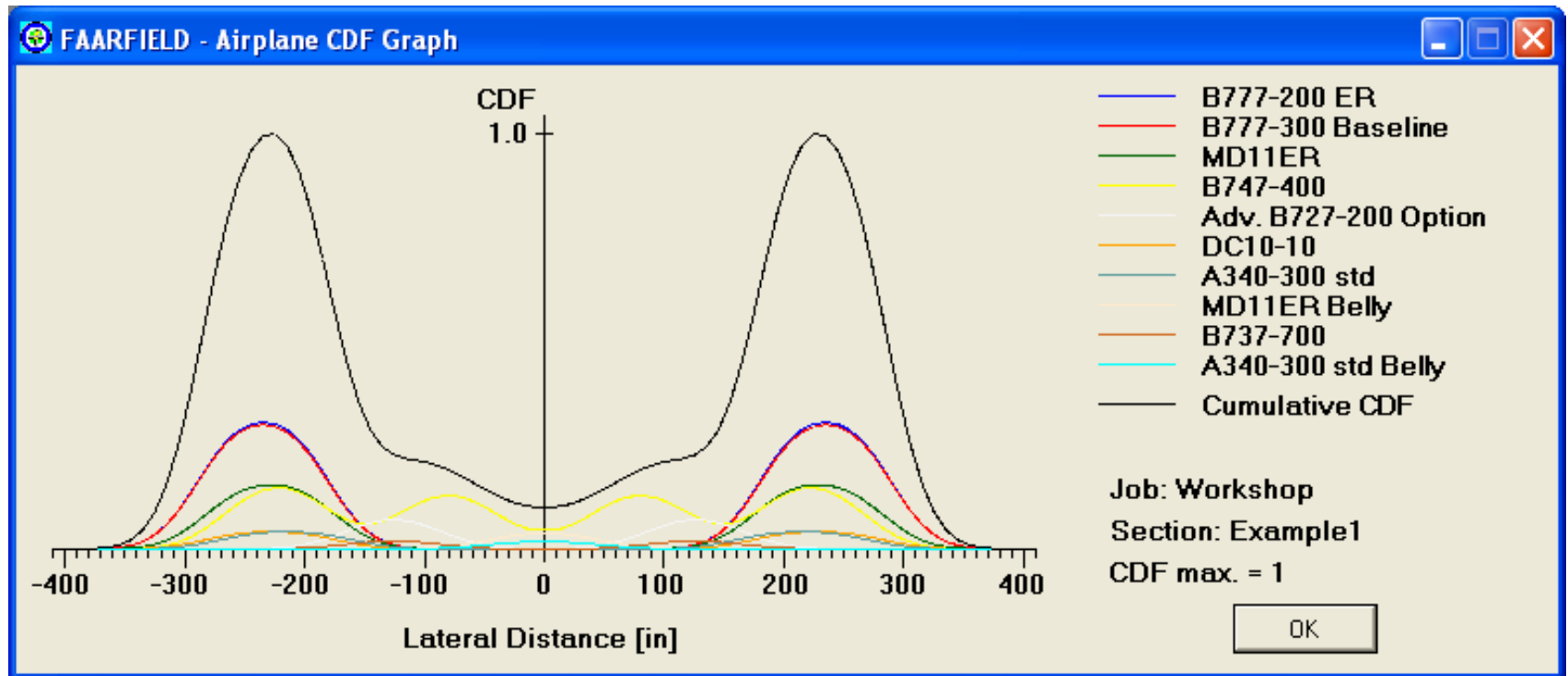


# Large Airplane Traffic Mix Gear Locations

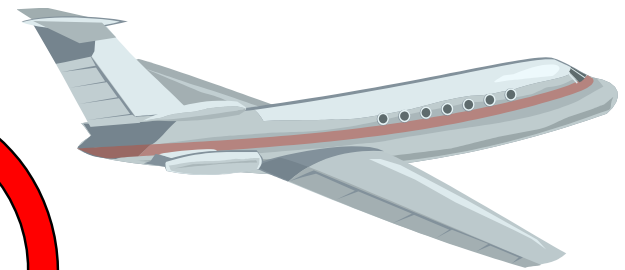
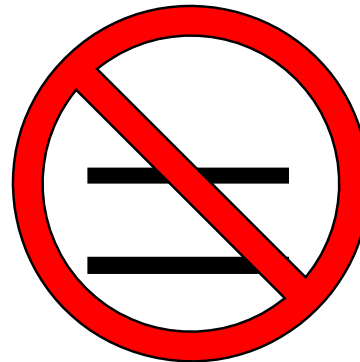
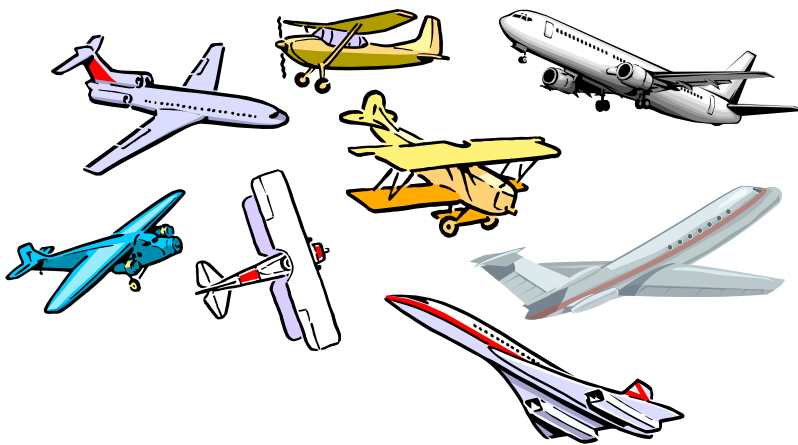




# FAARFIELD – CDF Graphical Display



# Remember - in FAARFIELD



**Use the entire traffic mix!**

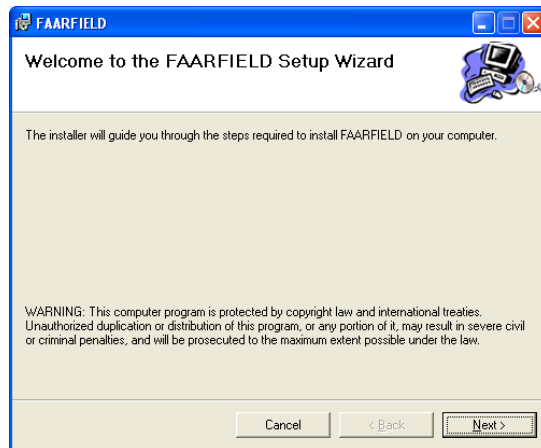
# Installing and Running FAARFIELD

- **Download files from FAA Airport Technology R&D Branch Downloads page:**  
<http://www.airporttech.tc.faa.gov/naptf/download/index1.asp>  
or unpack the FAARFIELD 1.305 installation files from the thumb drive you received at registration.
- **Run setup.exe**
- **Follow the instructions in the setup wizard.**

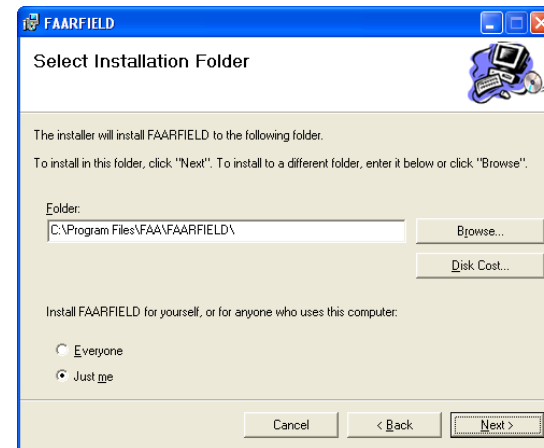


# FAARFIELD Installation Procedure

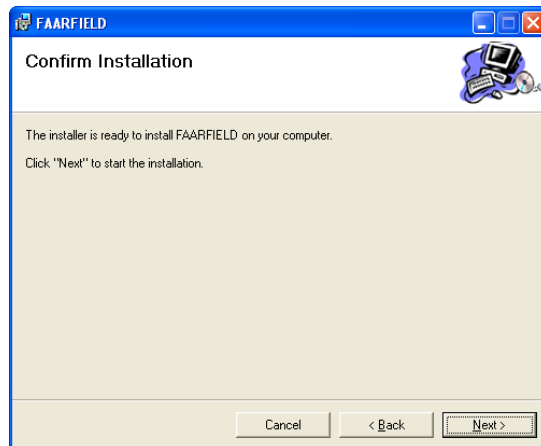
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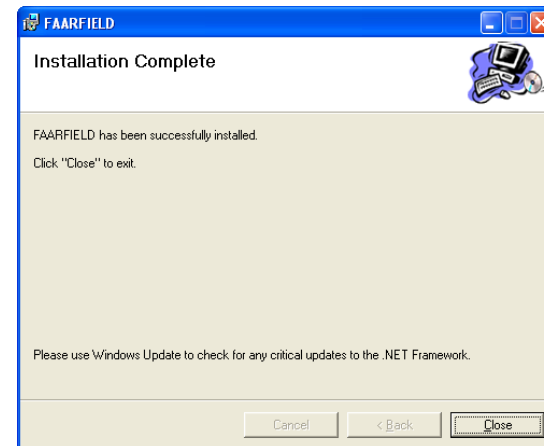
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3



4



# FAARFIELD System/Software Requirements

## Minimum

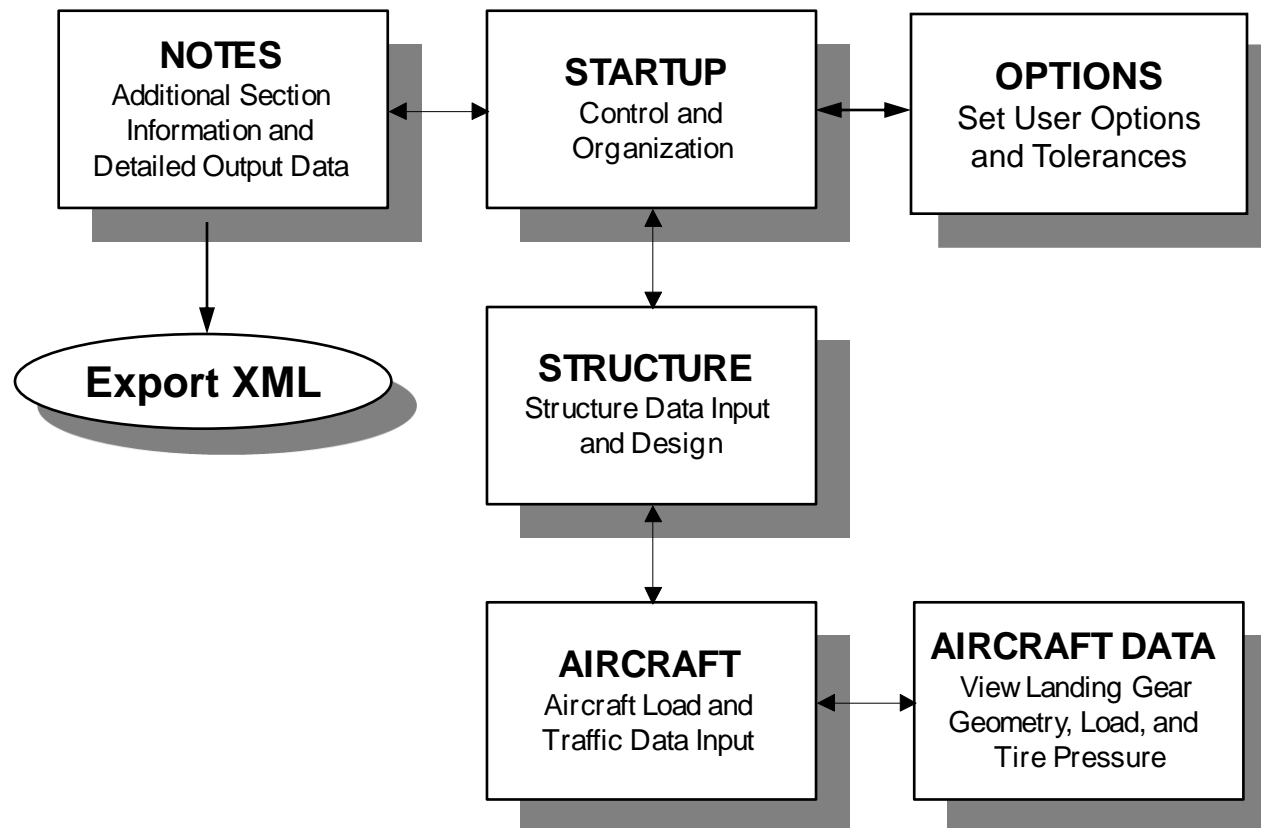
- Windows 2000
- 600 MHz Pentium III processor
- 256 MB memory
- 200 MB of available space on hard drive.
- Users of older operating systems may require a one-time installation of the .NET Framework (free download from Microsoft).

## Recommended

- Windows 7, Vista, XP or higher.\*
- 2 GHz Pentium IV processor
- 512 MB memory
- Users of older operating systems may require a one-time installation of the .NET Framework (free download from Microsoft).

**\*Note: FAARFIELD 1.305 supports 64-bit operating systems. Users of Windows 7.0 and Vista 64-bit versions must install FAARFIELD version 1.305.**

# Running FAARFIELD: Program Windows and Linkage



# FAARFIELD Input Requirements

**FAARFIELD - Modify and Design Section NewRigid in Job Example**

Section Names: ACAggregate, AConFlex, AConRigid, NewFlexible, **NewRigid**, PCConFlex, PCConRigid, RWY1L-19R

Example NewRigid Des. Life = 20

Layer Material	Thickness (in)	Modulus or R (psi)
PCC Surface	16.00	700
P-304 CTB	8.00	500,000
P-154 UnCr Ag	10.00	23,219
Subgrade	k = 120.0	12,152

Total thickness to the top of the subgrade, t = 34.00 in

Status: Aircraft

Buttons: Back, Help, Life, Modify Structure, Design Structure, Save Structure

**FAARFIELD - Create or Modify Aircraft for Section NewRigid in Job Example**

Aircraft Group: Generic, Airbus, Boeing, Other Commercial, General Aviation, Military, External Library

Library Aircraft: SWL-50, Sngl Whl-3, Sngl Whl-5, Sngl Whl-10, Sngl Whl-12.5, Sngl Whl-15, Sngl Whl-20, Sngl Whl-30, Sngl Whl-45, Sngl Whl-60, Sngl Whl-75, Dual Whl-10, Dual Whl-20, Dual Whl-30, Dual Whl-45, Dual Whl-50, Dual Whl-60, Dual Whl-75, Dual Whl-100

Aircraft Name (5)	Gross Taxi Weight (lbs)	Annual Departures	% Annual Growth	Total Departures
DC10-10	458,000	2,263	0.00	45.2
B747-200B C...	873,000	832	0.00	16.6
B777-200 ER	634,500	425	0.00	8.5
B737-800	174,700	8,000	0.00	160.0
A320-100	150,796	4,380	0.00	87.6

Buttons: Add, Remove, Save List, Clear List, Save to Float, Add Float, Float Aircraft, Back, Help, View Gear

## Structure Window

- For each structural layer:
  - Material type (FAA specification)
  - Layer Thickness
  - Modulus or R-value (if applicable)
- There are built-in restrictions on the layer types, including relative position and layer properties.
- For subgrade, can enter CBR or k and FAARFIELD will convert to E.

## Aircraft Window

- Select airplane from library.
- For each airplane in the mix:
  - Aircraft Name
  - Gross Taxi Weight
  - Annual departures and percent annual growth if applicable
- Enter data for all airplanes in the mix.

# FAARFIELD External Files

## •New Flexible Pavements •Flexible Overlays on Flexible Pavements

- *LeafSG.out* – Subgrade layer responses for flexible pavement.
- *LeafAC.out* – HMA surface layer responses for a flexible pavement.

## •Common Files

- **Storage files:**
  - \*.JOB.xml – job files (XML format) contain data required by FAARFIELD for all the sections in one job.
  - \*.DES.xml – design information files generated by “Save XML” command.
  - \*.nts – notes files (contain user entered information)
- **Help file:** *faarfield.chm*.
- **External airplane file:** *FAAAirplaneLibrary.xml*

## •New Rigid Pavements, •Rigid Overlays on Rigid Pavement •Flex Overlays on Rigid Pavement

- *NikePCC.out* – Stresses at the bottom of PCC layer.
- *Nike3d.txt* – 3D finite element summary output file.
- *n3dhsp* – 3D finite element detailed output file.

## •Legacy Files

- *Leaf loa* and *Leaf.str* – Load and structure definition files compatible with programs LEDNEW and Juleaww.exe



# FAARFIELD Job Files (JOB.xml)

- **Job files in FAARFIELD 1.3 are in XML format. This is a different format than previous job files in LEDFAA.**
- **FAARFIELD looks for old job files in the working directory and automatically converts them to the new XML format.**
  - After reading, the old job files are moved to a subdirectory of the working directory called *old\_job\_files*.
  - All subsequent changes are written to the JOB.xml files only. The old job files are not changed.

# FAARFIELD External Airplane Library

- **FAARFIELD includes 190 airplanes in the internal library.**
- **FAARFIELD allows users to define additional airplanes in the external library.**
- **Add or modify external library airplanes by editing the file: FAAairplaneLibrary.xml**
- **XML (Extensible Markup Language) format.**
- **Edit the file using Microsoft Word or other XML editor.**



# Example Airplane Info in XML File

```
- <AirplaneInfo>
  <Name>B777-300ER Example</Name>
  <GrossWt>777000</GrossWt>
  <MGpcent>0.475</MGpcent>
  <CP>221</CP>
  <Gear>N</Gear>
  <IGear>3</IGear>
  <TT>55.00</TT>
  <TS>404.50</TS>
  <TG>0.00</TG>
  <B>57.60</B>
  <NTires>6</NTires>
- <Wheel_Coordinates>
  <TX>-27.50</TX>
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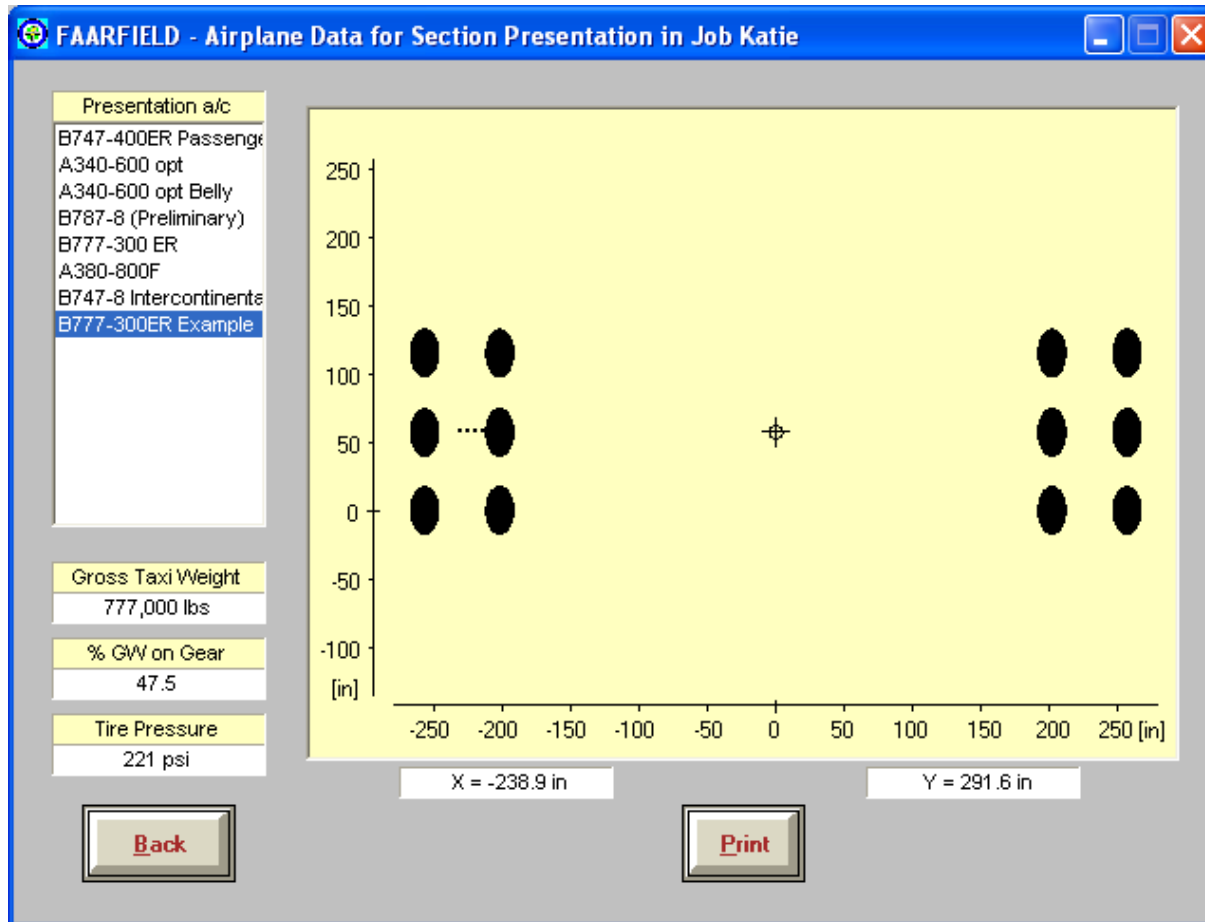
- **GrossWt** = weight of airplane, lbs.
- **MGpcent** = % of GrossWt on 1 main gear
- **CP** = tire contact pressure, psi
- **Gear** = gear designation letter code
- **IGear** = gear ID no. (see file ExtFile.doc)
- **TT, TS, TG, B** = gear parameters (see file LEDGear.doc)
- **NTires** = no. of tires in 1 gear
  - TX, TY: Enter 1 pair of coordinates for each tire (1 through NTires), in.
- **NEVPTS** = no. of evaluation points for LEAF
  - EVPTX, EVPTY: Enter 1 pair of x,y coordinates for each evaluation point (1 through NEVPTS), in.
- **Note:** You have to enter the data in U.S. units (inches, psi).

# Codes for Common Gear Types

Gear Type	Example	Letter Code	ID No.
S	DC3	B	2
D	B737	D	3
2D	B767	F	3
2D/2D2	B747	J	4
3D	B777	N	3

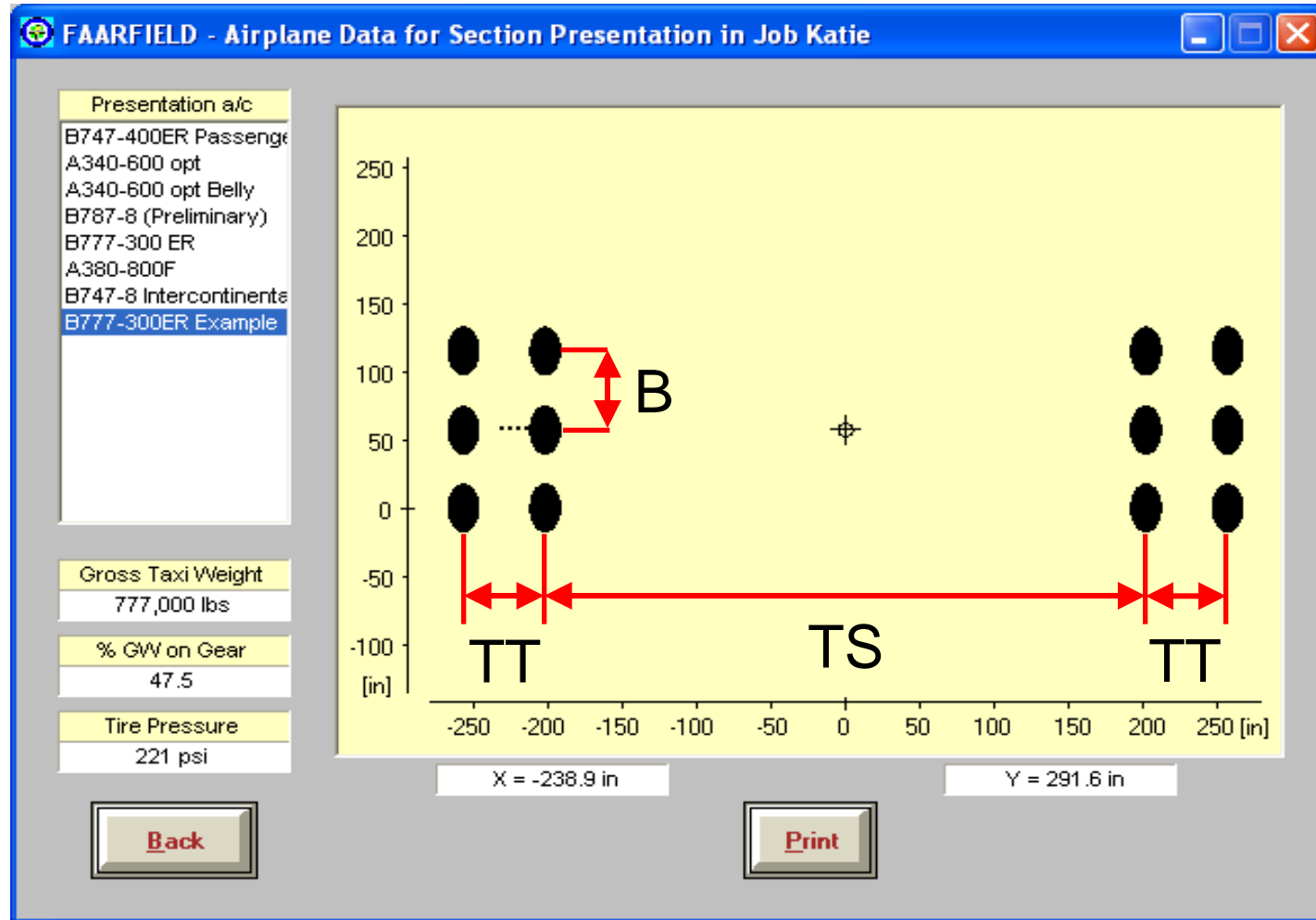
- Note: Currently only common gear types conforming to one of the letter codes can be entered in the external library. Future versions will allow complex gear geometries (e.g., A380). This feature is in development.

# Example of Gear from External File










## •Example Airplane Info in XML File

```
<AirplaneInfo>
  <Name>B777-300ER Example</Name>
  <GrossWt>777000</GrossWt>
  <MGpcent>0.475</MGpcent>
  <CP>221</CP>
  <Gear>N</Gear>
  <IGear>3</IGear>
  <TT>55.00</TT>
  <TS>404.50</TS>
  <TG>0.00</TG>
  <B>57.60</B>
  <NTires>6</NTires>
- <Wheel_Coordinates>
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</AirplaneInfo>
```



# FAARFIELD External Airplane Library Related Materials and Resources

- XML Standard: <http://www.w3.org/XML/>
- FAA Airport Technology R&D web page:
  - [www.airporttechnology.tc.faa.gov](http://www.airporttechnology.tc.faa.gov)
  - Click on Downloads, then Pavement, then Software.
  - Link to “Format for External Data File” (under BAKFAA) – contains additional documentation.

Name ▲	Size
 ExtFile.doc	61 KB
 InitAC.doc	96 KB
 LEDFAAacLibrary.Ext	3 KB
 LEDGear.doc	61 KB
 Max Response.doc	39 KB
 MilDes.doc	154 KB
 External Aircraft File Format.zip	208 KB



Job Files

ACC  
Brisbane  
CC6  
Conduit  
Dave  
Phil  
PROJECT  
Samples  
SAN\_TWC  
Subgrade

Organization

New Job  
Delete Job  
Dup. Section  
Copy Section  
Delete Section  
Options  
Exit

Section Name

ACAggregate  
AConFlex  
AConRigid  
NewFlexible  
NewRigid  
PCConFlex  
PCConRigid

Pavement Type

New Flexible  
AC on Flexible  
AC on Rigid  
New Flexible  
New Rigid  
PCC on Flexible  
Unbonded on Rigid

Data Input

Structure  
Notes

Working Directory

C:\Program Files\FAA\FAARFIELD\

Help

Demonstration

About

Accompanies AC 150/5320-6E

Thank You. Questions?

*Gracias. ¿Preguntas?*

