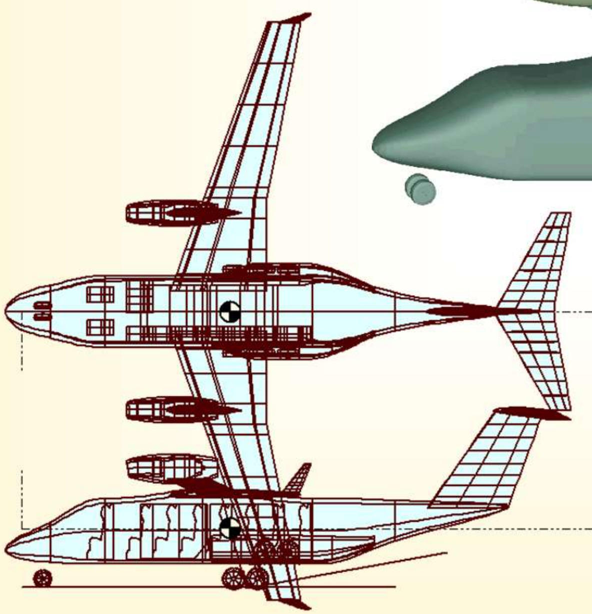
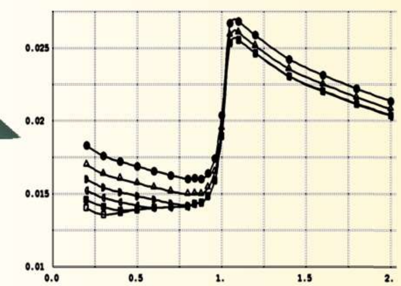
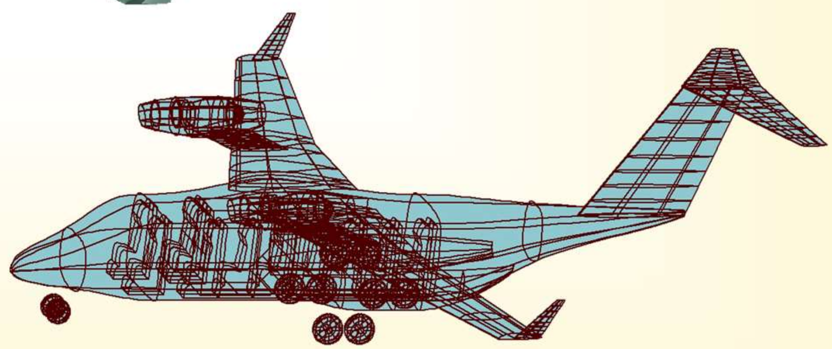
Rev 1-2020

RDS^win

Integrated Windows Software for Aircraft Design, Analysis, & Optimization

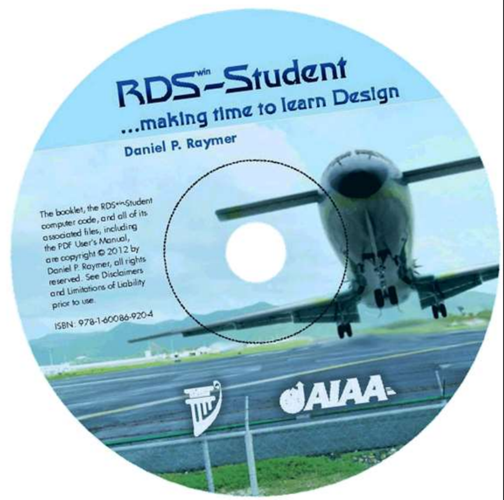


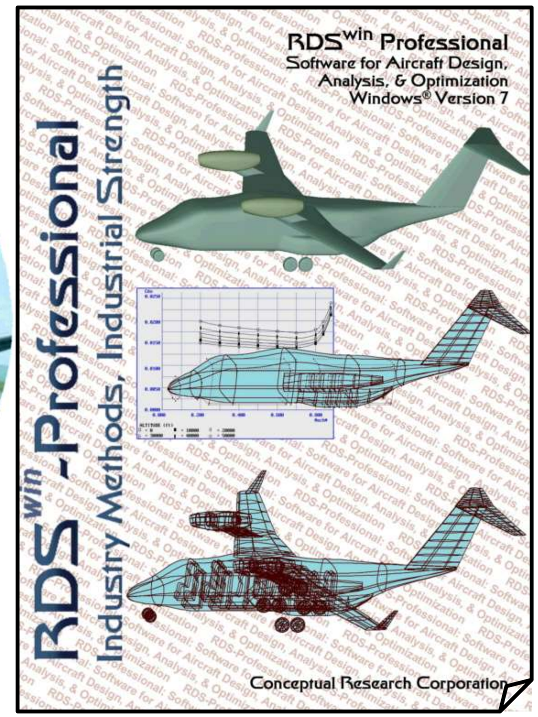




RDS^{win} - Integrated Windows Software for Aircraft Design, Analysis, & Optimization

- **Aircraft design, analysis, & optimization based on real industry methods and decades of personal experience, not a few equations from someone else's book**
- **25+ years of evolutionary development**
- **Integrated CAD, aerodynamics, weights, propulsion (jet & prop), stability & control, sizing, range, performance, & cost analysis.**
- **Switches between MKS and FPS**
- **Student & Professional versions in use world-wide**
- **Professional version adds automated trade studies, MDO/multivariable optimizer, greater accuracy, fully-lofted surface geometry, IGES CAD output, & numerous other "Design Pro" features**





RDS^{win} is 100k+ lines of all-original source code

Microsoft® and Windows® are registered trademarks of Microsoft Corporation.
RDS^{win} is not a product of, nor is it tested or endorsed by Microsoft.

RDS^{win} - Overview

•RDS^{win} allows taking an aircraft design from first conceptual layout through functional analysis, leading to performance, range, weight, and cost results.

•By automating the "grunt work" of vehicle analysis, RDS^{win} makes enough time for the student to truly learn design, and for the design professional to do a wide range of initial trade studies before the first design concept is released to other groups.

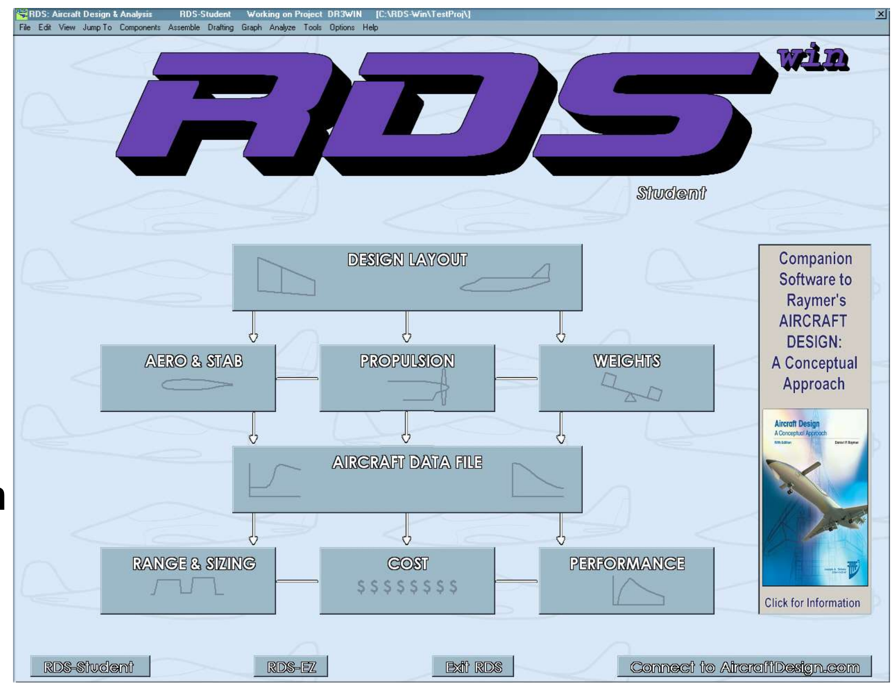
•All-new, all-original computer code (even the CAD module)

•True Windows* Application, with pulldown menus, popup boxes, fonts, graphics, dialog boxes, clipboard read/write, Undo/Redo, and more

•RDS^{win} outputs analysis results and program data to popup boxes, text files, Windows printers, or directly to your spreadsheet, word processor, or internet browser.

•Powerful & flexible, with ~600 pulldown menu commands and ~100 submenus, plus on-screen buttons and hot keys

*(*runs perfectly in 32- or 64-bit Windows)*



AIRCRAFT DESIGN: A Conceptual Approach

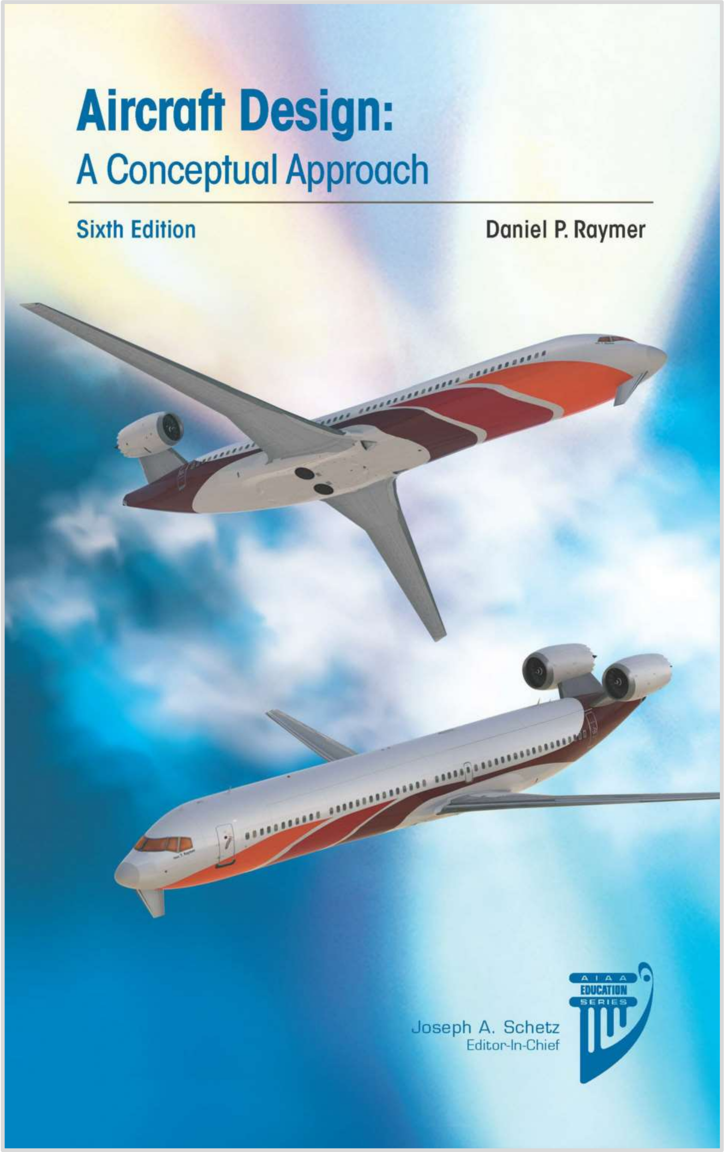
Practical Working Knowledge of Aircraft Design
....As It Is Actually Performed

Overview of the Whole Design Process
- **Design Layout**
- **Systems Integration**
- **Aircraft Analysis, Sizing, Performance, & Cost**
- **Optimization & Trade Studies**
- **Complete design examples**

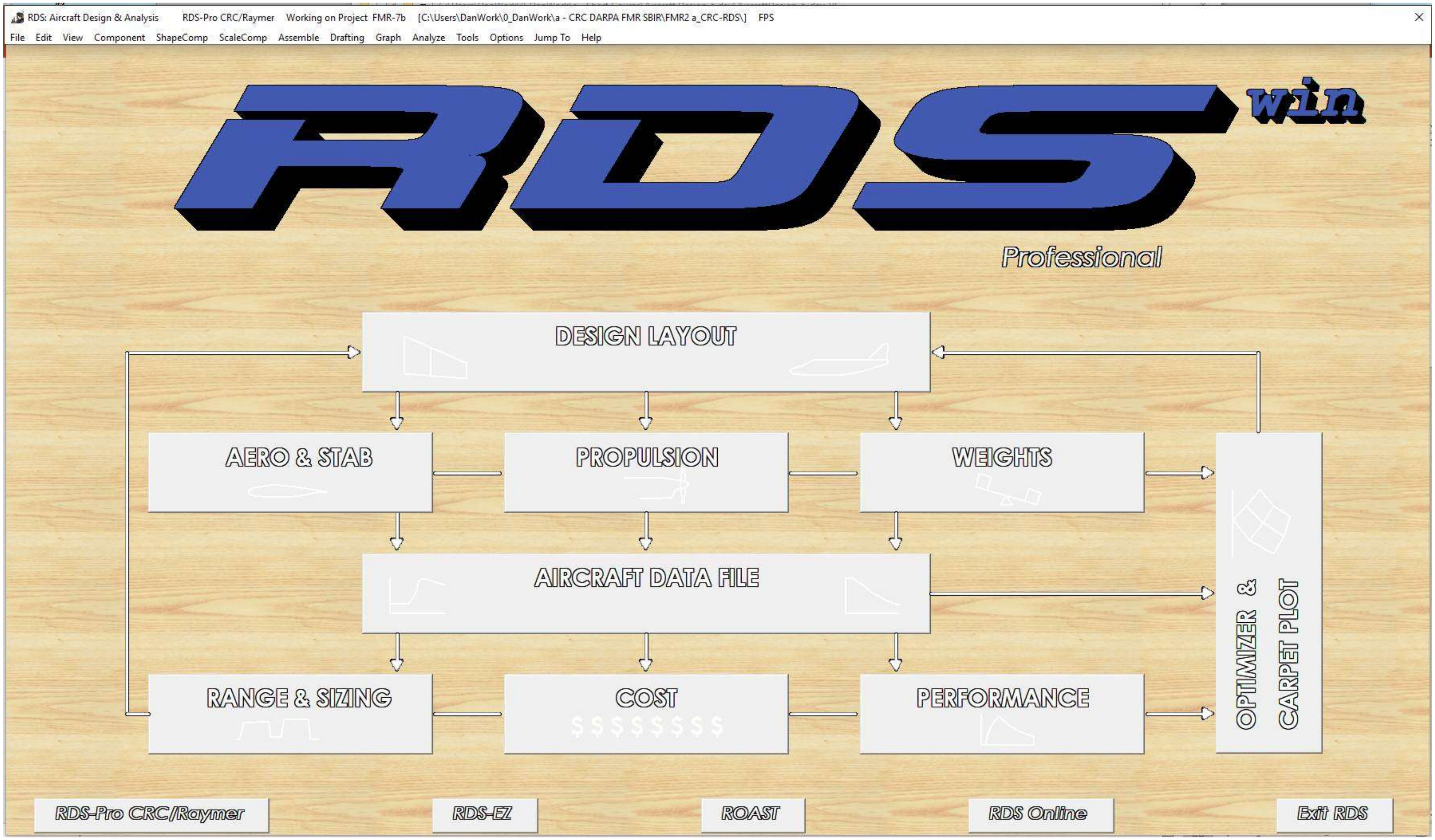
Award-winning Best Seller

60,000+ copies sold

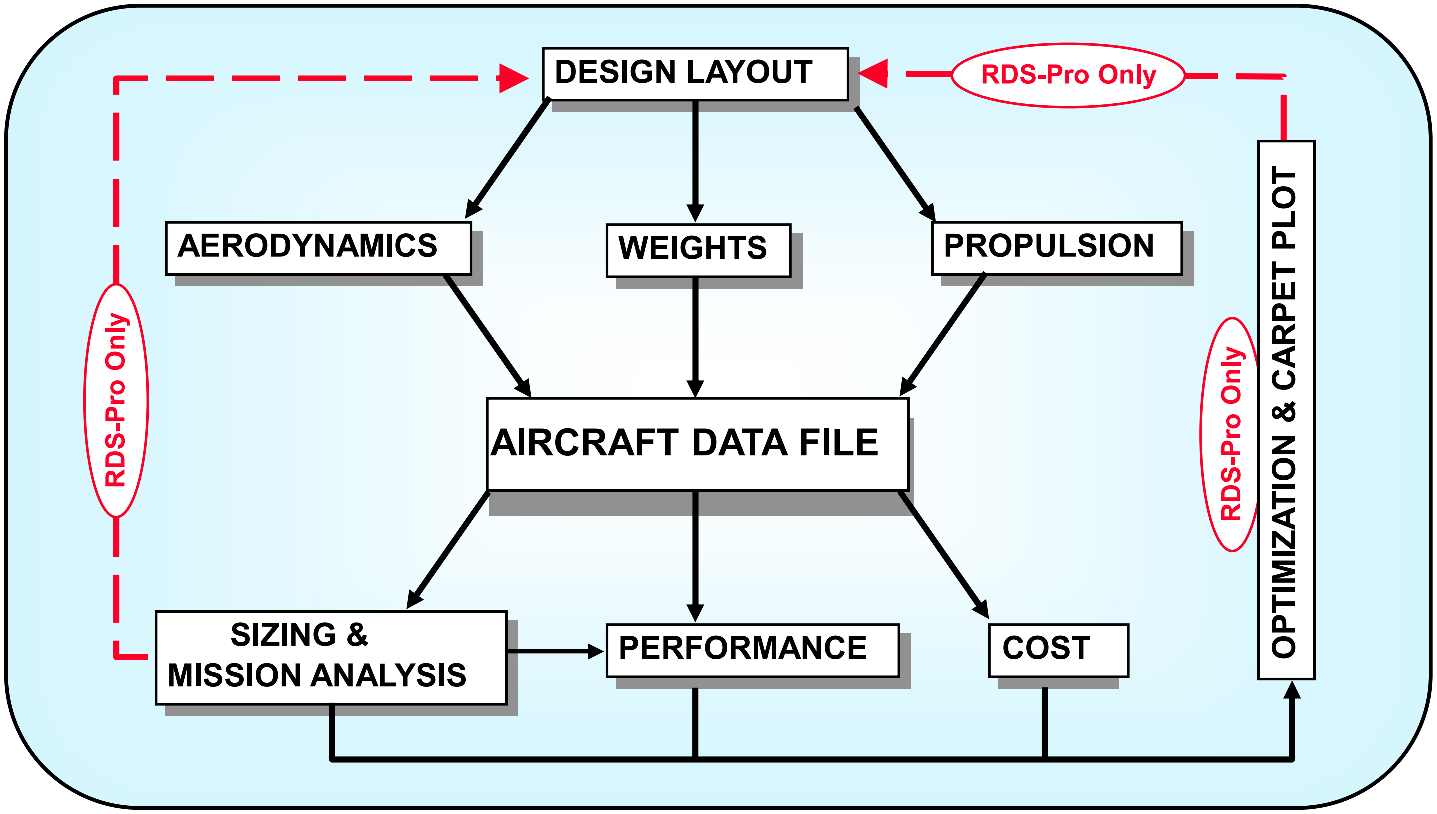
available at http://www.aircraftdesign.com



Main Screen with Pulldown Menu & Module Buttons



RDS^{win} Modules & Program Flow



•The main program page of RDS^{win} looks like this, and you can click on the boxes to go to those modules

•Or navigate using the pulldown JumpTo menu, or use the pulldown File-Open, or start RDS by clicking on an RDS file, or......

RDS^{win}: A KEY PHILOSOPHY !

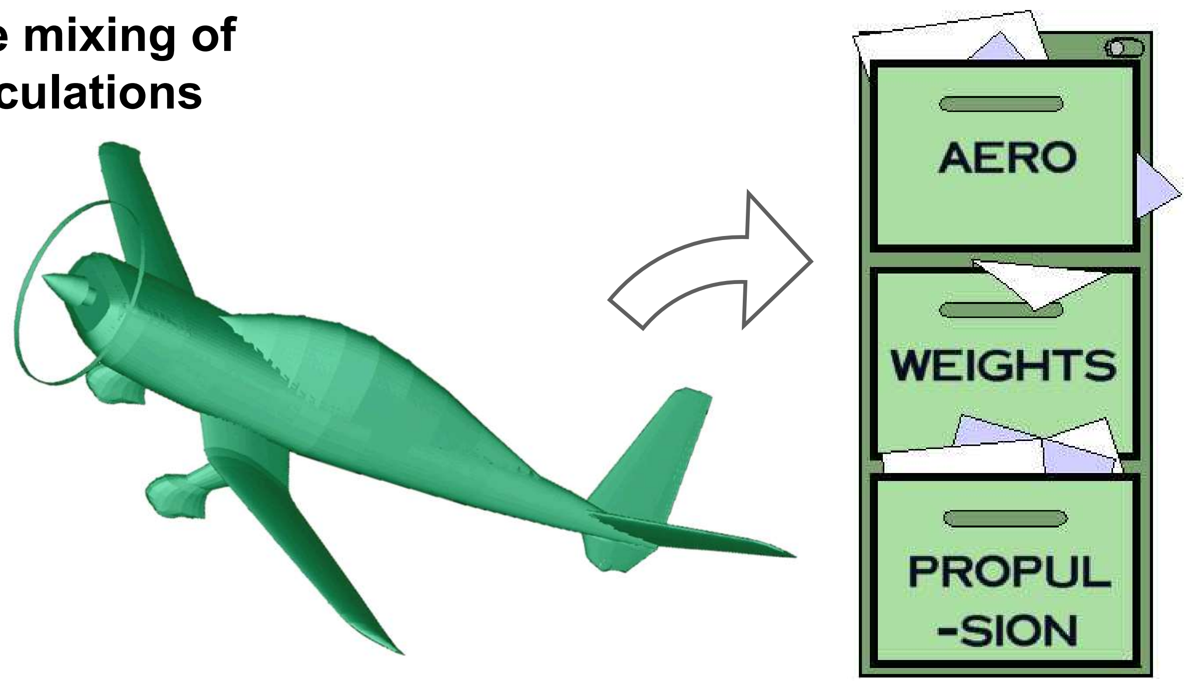
The User is in Charge - Answers do NOT flow down automatically !

•AIRCRAFT DATA FILE acts like a filing cabinet which you fill with aero, weights, and propulsion information on your design. This information then gets used for sizing, range, performance, trade studies, and optimization

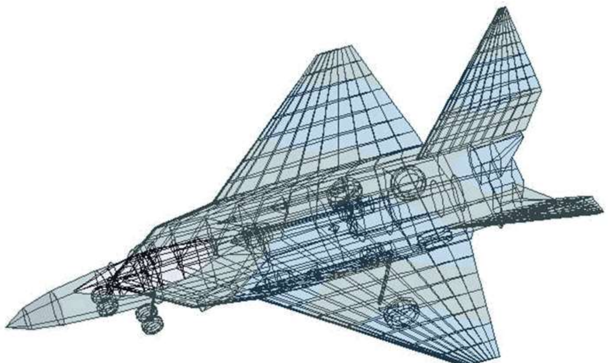
•This permits & almost *forces* the user to review the analysis results before using it for anything important

•This also allows the mixing of data sources for calculations

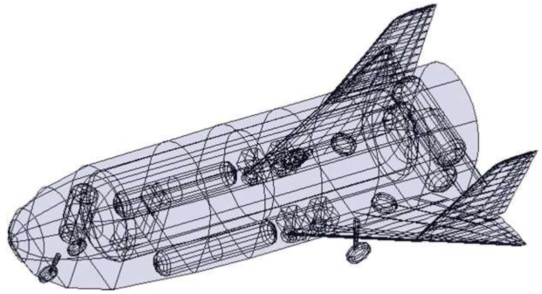
- ***RDS analysis***
- ***Wind tunnel***
- ***CFD & FEM***
- ***Other analysis***
- ***Test data***



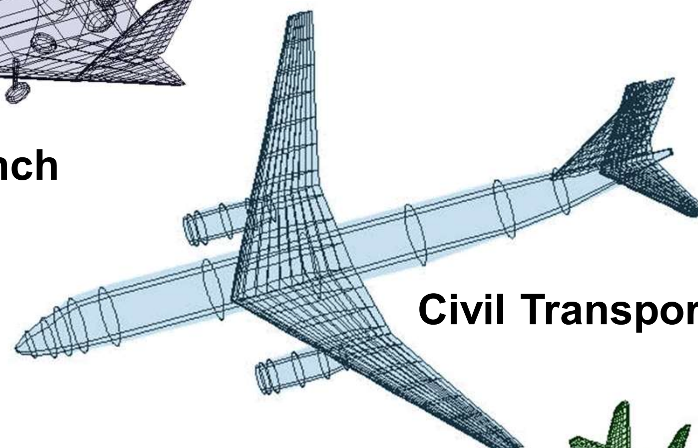
RDS Can Be Used For All Sorts of Aircraft and Spacecraft



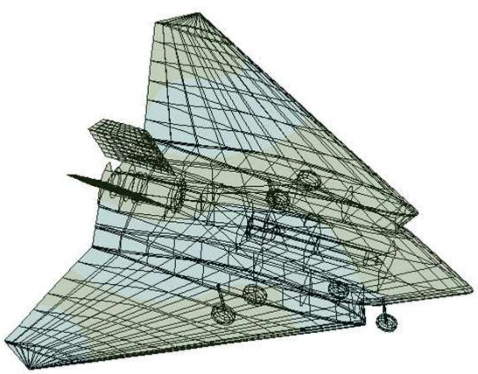
Advanced Fighter



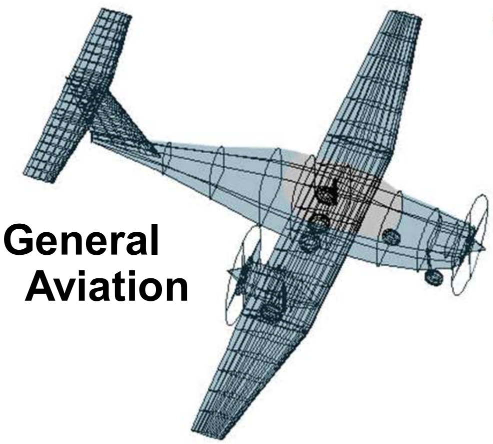
Reusable Launch Vehicle



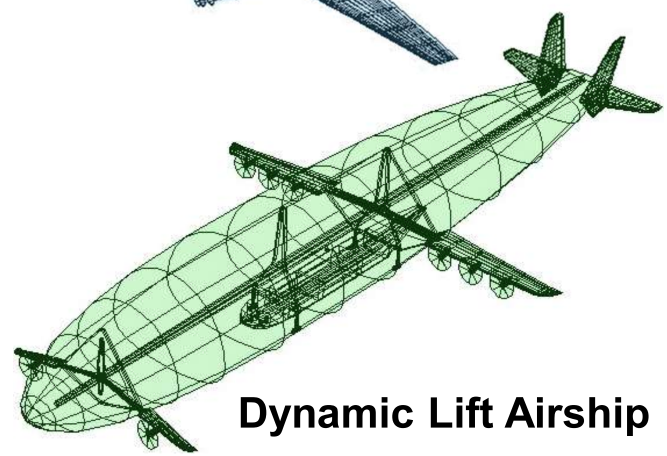
Civil Transport



Tactical UAV

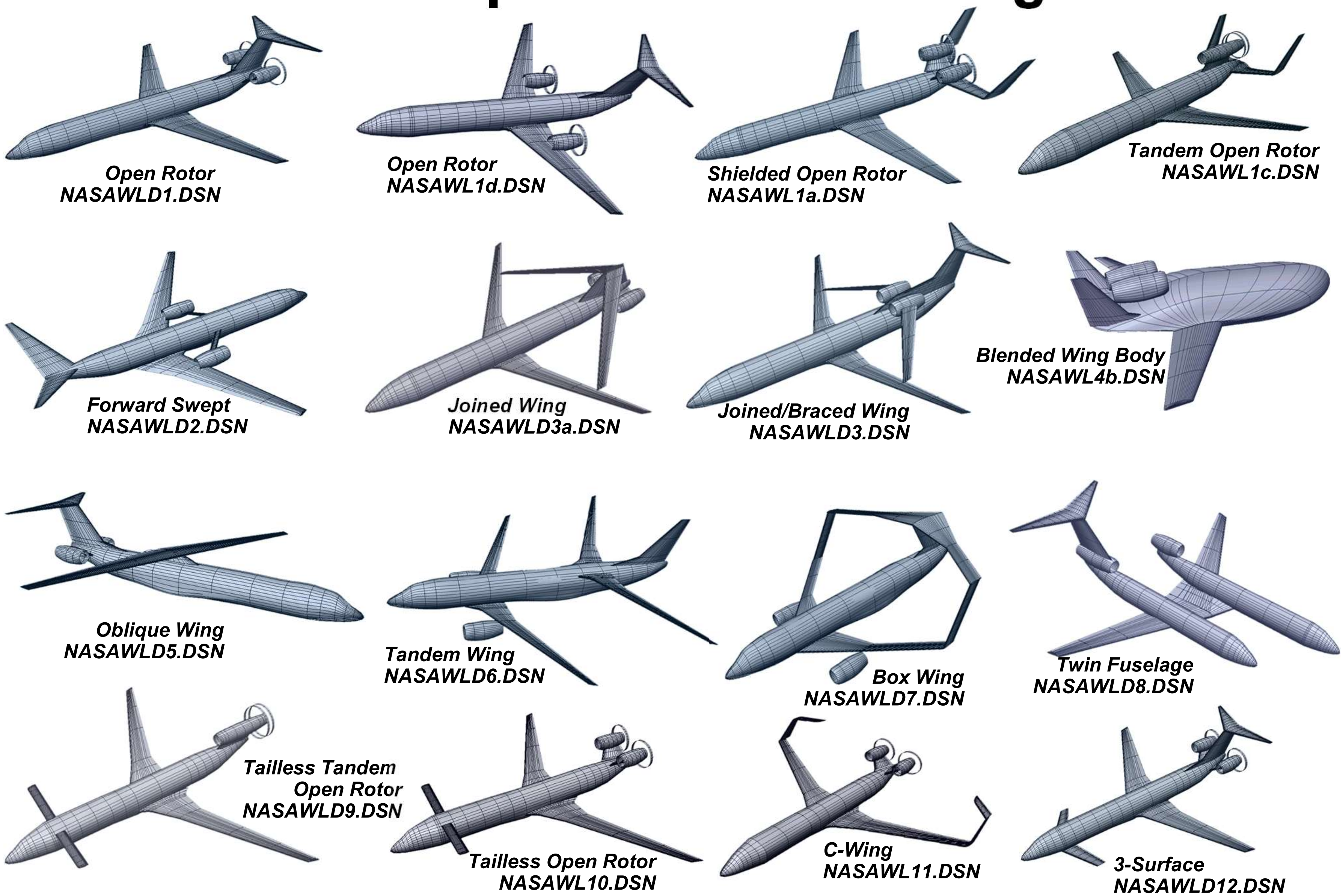


General Aviation



Dynamic Lift Airship

Ideal for Concept Alternative Design Studies

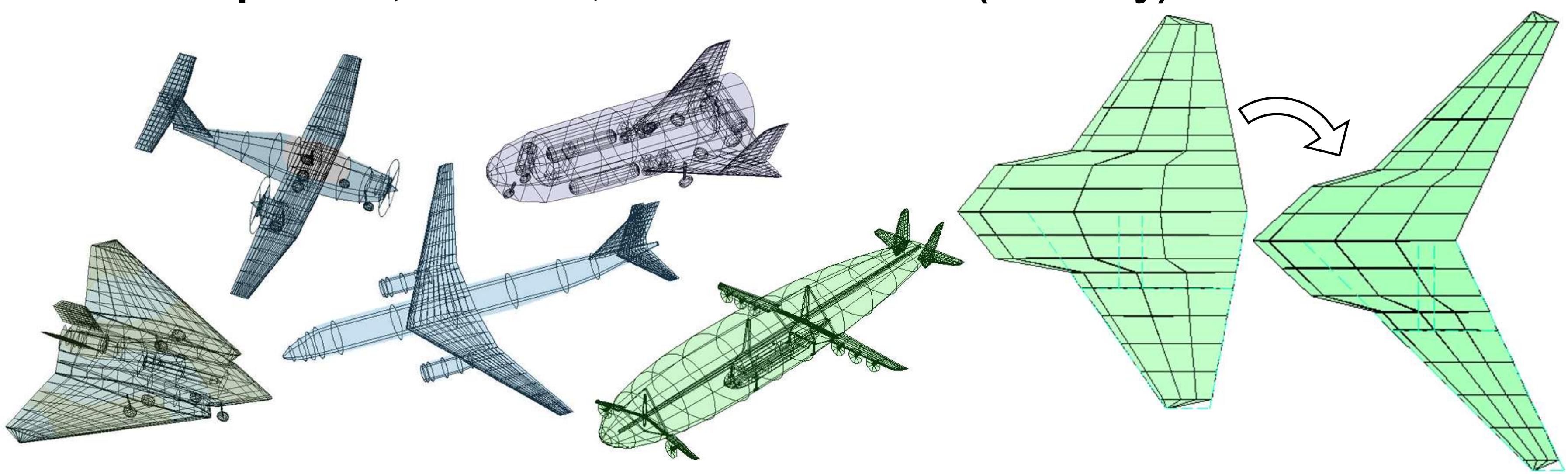


RDS Design Layout Module (DLM)

>35,000 lines of all-new interactive CAD code

Numerous airplane-specific features and capabilities:

- **Quickly Create New Fuselage, Wing/Tail, Wheel, Gear ShockStrut, Streamlined Strut, External Store, Engine, Seat, and others**
- **Position, Scale, Stretch, Copy, Instance, & Mirror Components**
- **Reshape Wings & Derived Components by Revising Ref. Wing Data**
- **Output Formatted Geometric Data Table (TAB)**
- **Output DXF, VSAERO, & RhinoCAD files (Pro only)**



RDS^{win} has its own CAD Module - Why?

•**Commercial CAD systems were developed for detail part and production design, not the fluid environment of Concept Design**

•**Drawbacks of commercial CAD systems:**

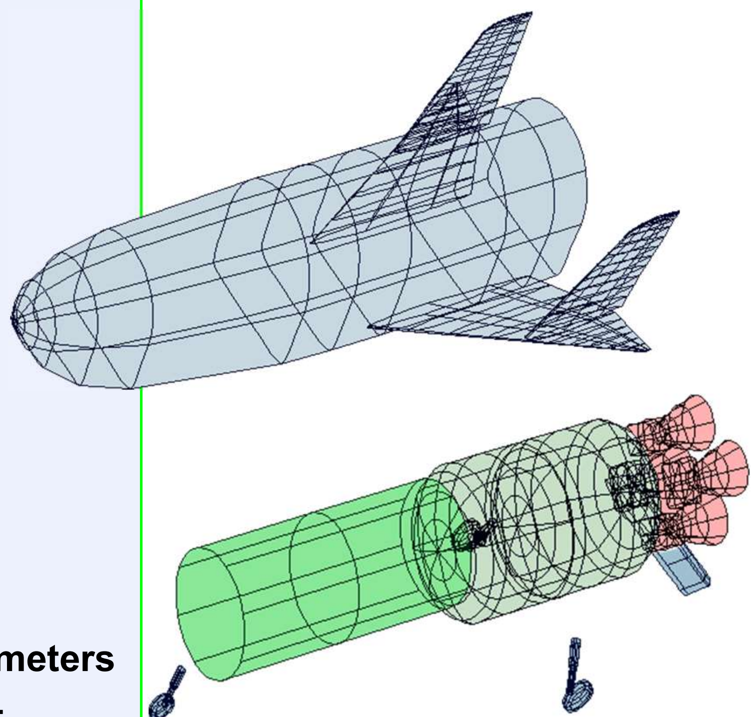
- **Too much time to develop an initial aircraft configuration**
- **Too much work to modify the configuration layout for each trade study and concept iteration**
- **Too much focus on perfect local geometry, not enough on the overall concept being developed**
- **Too generic – what's an airplane?**

•**Discussions with vendors of existing CAD systems were not rewarding – nobody wanted to make the enhancements required to produce a tool optimized for aircraft conceptual design (*"you can already do all those things…"* – sure, but it takes too long!)**

Aircraft Defined as Collection of Components

- Components are parts of the airplane defined in the usual vocabulary (wing, tail, fuselage, tire, engine, duct, spar, etc...)
- Components are generally individual closed shapes
- Components include geometric and non-geometric information

Component name
Local axis system (X, Y, Z, Roll, Pitch, Yaw)
Symmetry & mirror options
Type of geometry (point, quartic, or quartic surface)
Component pre-rotation & Viewing Code
Actual stored points (X, Y, Z) as stacked sections
Component Type Code SAWE RP8A+
Last change date
Component notes (user-input)
Installed weight, uninstalled (or empty tank) weight
Component Xcg,Ycg,Zcg
25 data items peculiar to type - reference wing parameters
- length, width, height



- "Non-real" components are possible (cg symbol, tail-down angle, etc...)

RDS-DLM: Unique Tools For The Unique Tasks...

- Create Component
- Get Comp from File
- Select Comp for Edit
- Shape Component
- Scale Component
- Copy Component
- Make Comp Instance
- Delete Component
- Misc Comp Options
- Comp Parameters

...a small sampling

Create Comp:

- Fuselage
- Wing/Tail
- Wheel
- Gear Leg ShockStrut
- Streamlined Strut
- External Store
- Engine
- Seat
- Box
- Cylinder
- Sphere
- Body Of Revolution
- New Empty Comp

Comp Scaling:

- X
- Y
- Z
- YZ
- XYZ
- X/YZ (hold volume)

Wing Revision:

- Reference Area
- Aspect Ratio
- Taper Ratio
- Sweep
- Dihedral
- Airfoil t/c
- Twist & Incidence
- Replace Airfoil
- Enter LE & TE lines

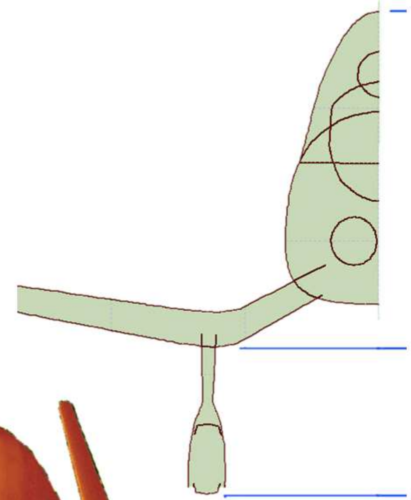
RDS^{win} Design Viewing

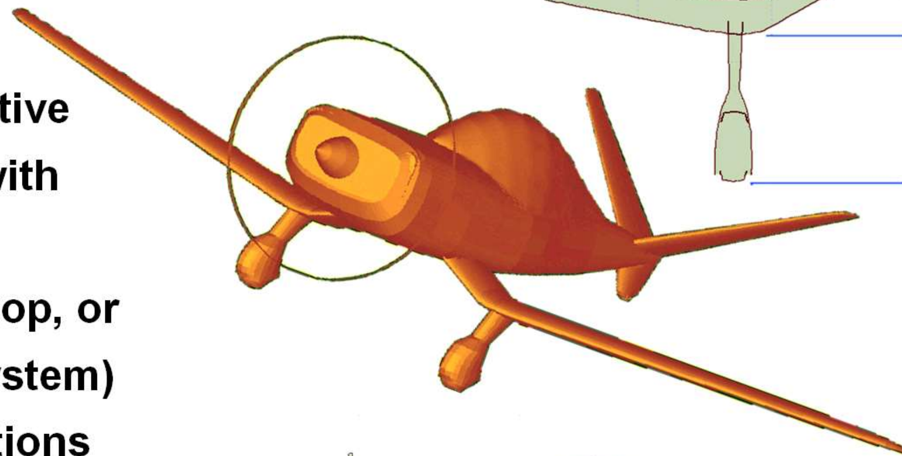
•RDS^{win} DLM "knows" what an airplane is, and makes it easy to get typical aircraft design views

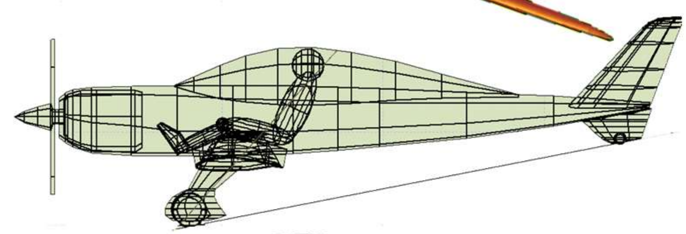
- Side, Top, Rear, and Front
- Isometric, Orthographic, Perspective
- Shaded, hidden-line renderings with or without wireframe lines
- Component relative views (side, top, or rear in component's axis system)
- Three-Views with various orientations
- Entire aircraft cross-section cut at component cross-section location or at a defined cut-plane
- Stacked cross section, waterline, and buttock-plane cuts

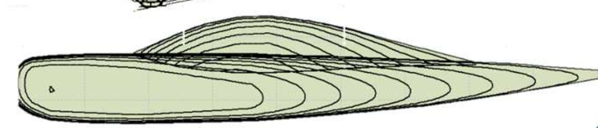
•All viewing options are available in the pulldown menu (<1 second)

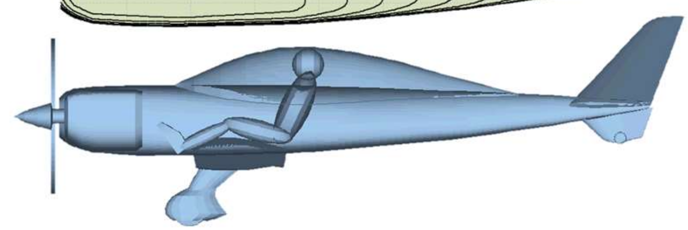
•Single stroke hot-keys available for common views (and press H for Help popup)







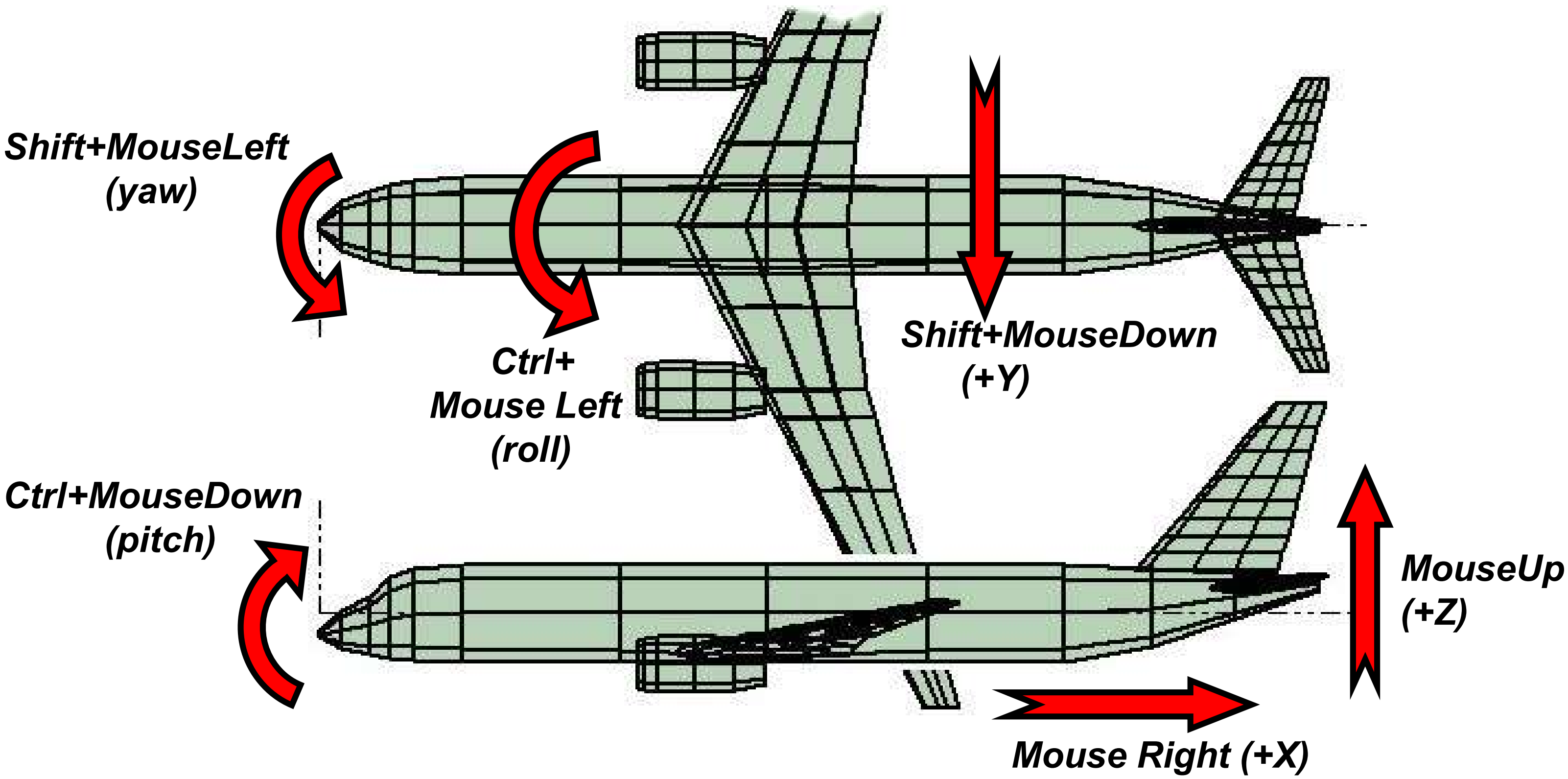




DLM FlyView and FlyAssemble

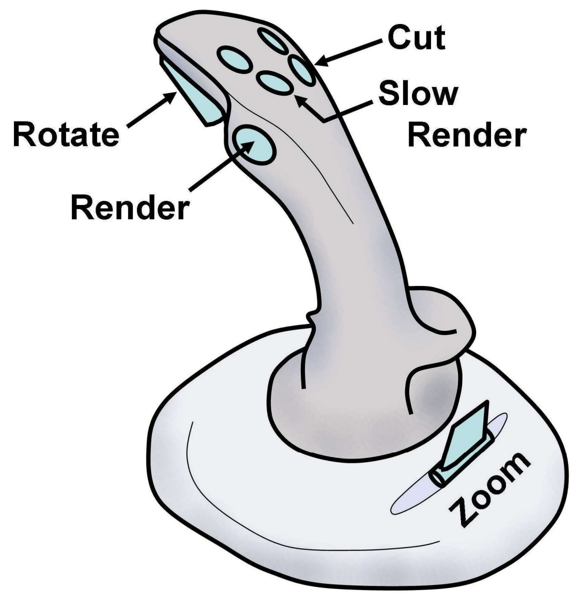
•RDS^{win} lets you “Fly” the airplane to change views and to move or rotate components, using the mouse as a “control stick” like a pilot flies an airplane.

•Views and component moves can also be done from pulldown menu or with arrow keys, and common views are available as hot keys



Joystick FlyView and FlyAssemble

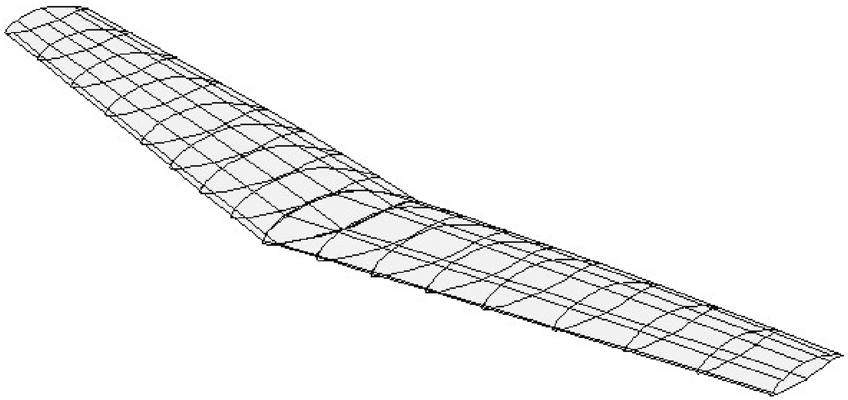
- Use your flight simulator control stick to “Fly” the airplane to change views, or to move and rotate selected components
- Single hand operation using a multifunction controller (3-axis + paddle)
- Stick motion controls translation and perspective distance (twist)
- Trigger is held for 3-axis rotations
- Paddle controls zoom (normally used for throttle)
- Buttons do instant render and cross-section cuts

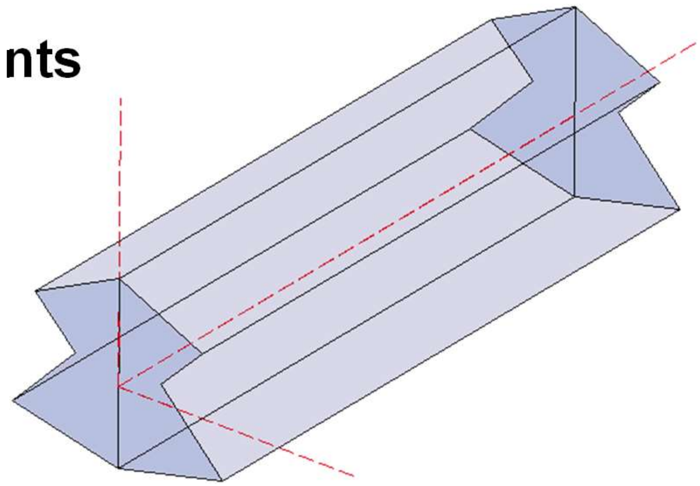


Sorry, RDS^{win} is not a flight simulator and you cannot actually fly your airplane. But, the joystick controller is very handy for design and viewing!

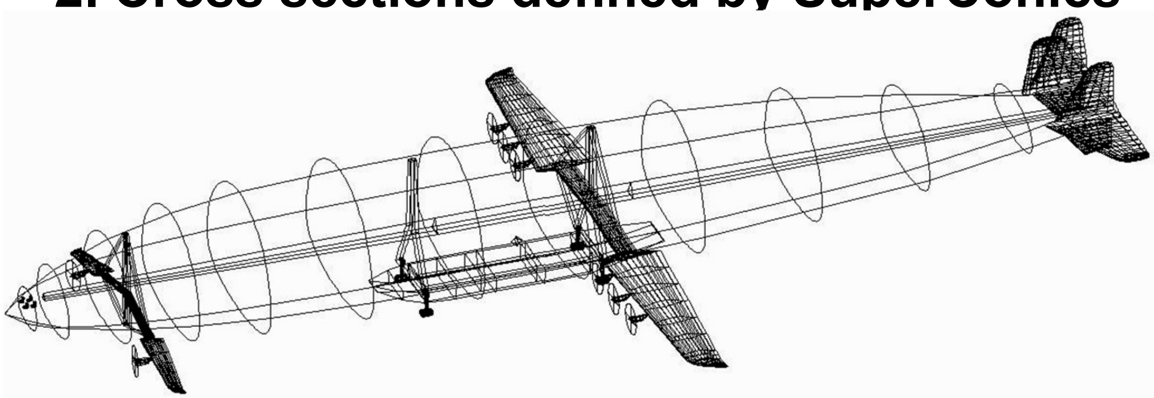
Three Geometry Representations

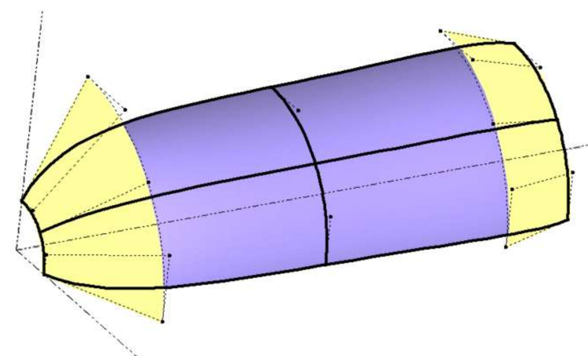
1. Cross sections defined by Surface Points





2. Cross sections defined by SuperConics

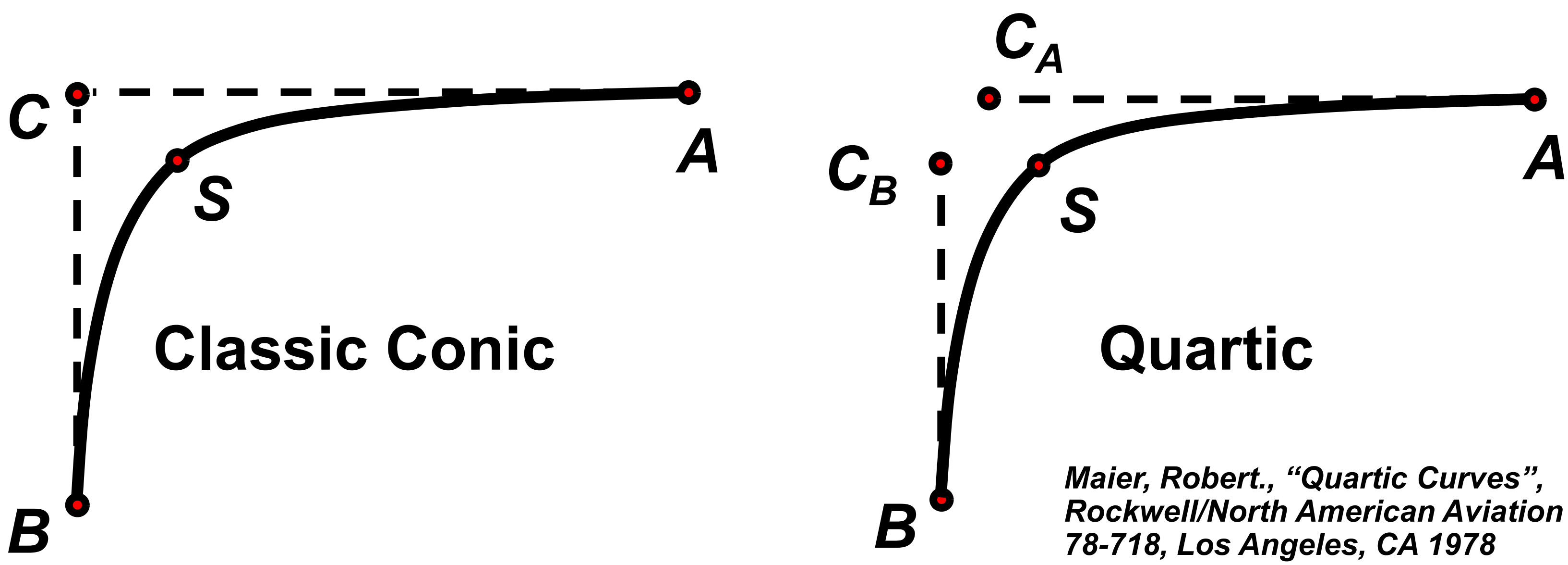




3. Surfaces defined by SuperConics (RDS^{win}-Pro only)

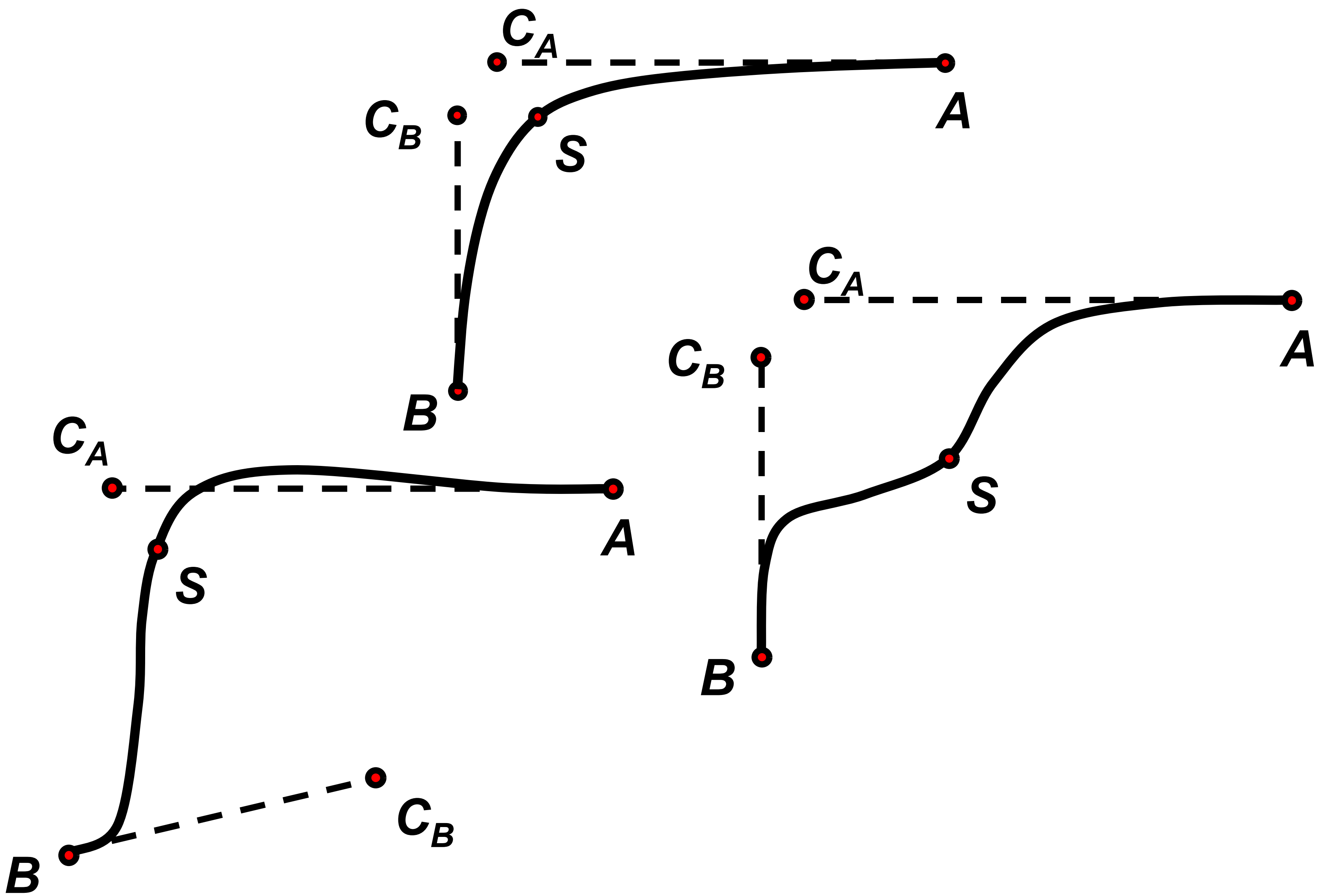
SuperConic Parametric Curve (NURB family)

- Modified 4th degree Bezier polynomial such that middle point is *on* the curve, not floating in space
- Visually looks like classic conic lofting but with extra powers
- Quartic defined by five control points:
  - Two endpoints A & B
  - Two tangent control points C_A & C_B (conic has single C point)
  - Shoulder point S on the curve, somewhere in its middle



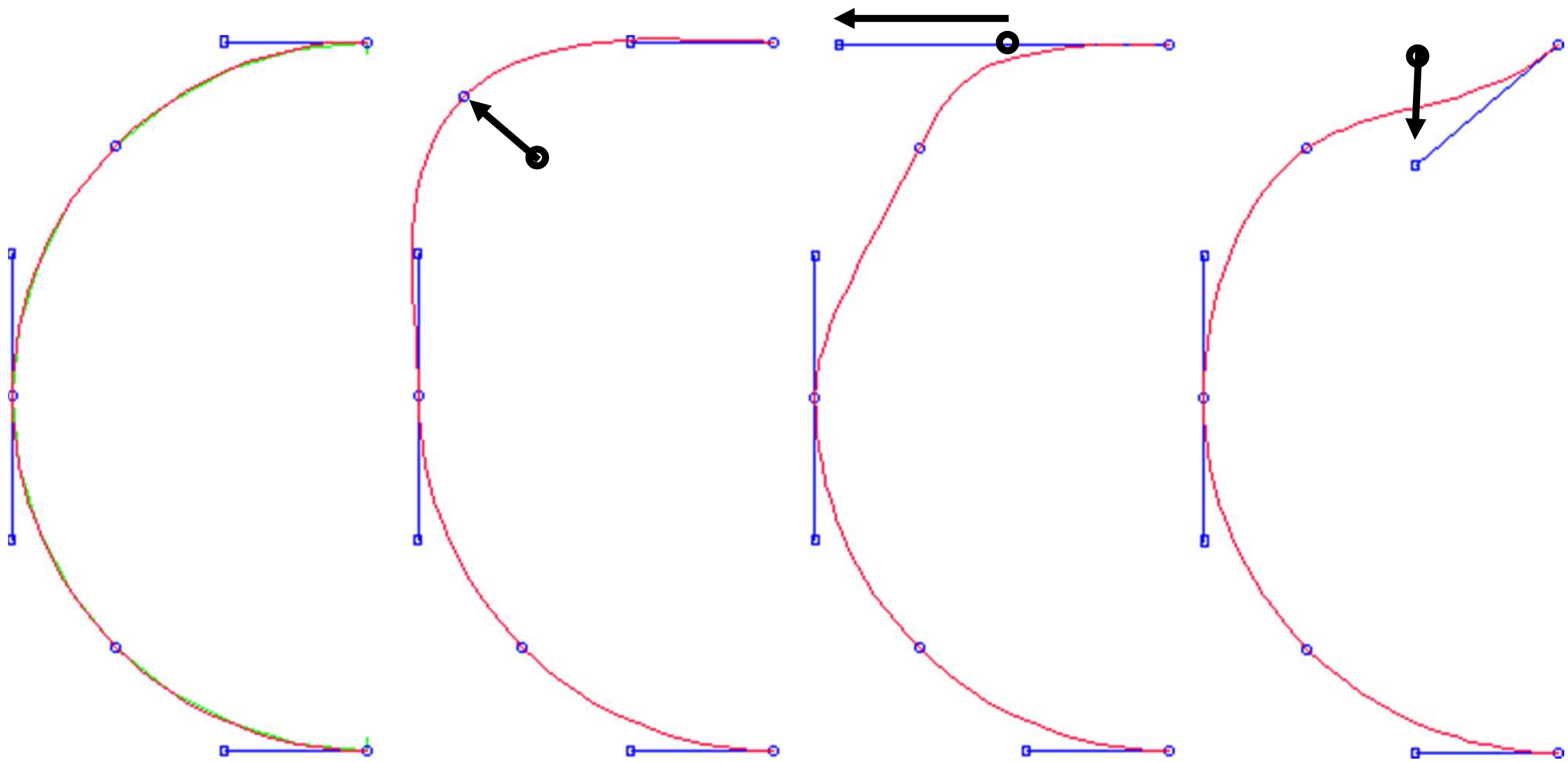
Maier, Robert., "Quartic Curves", Rockwell/North American Aviation TFD-78-718, Los Angeles, CA 1978

SuperConic Shaping

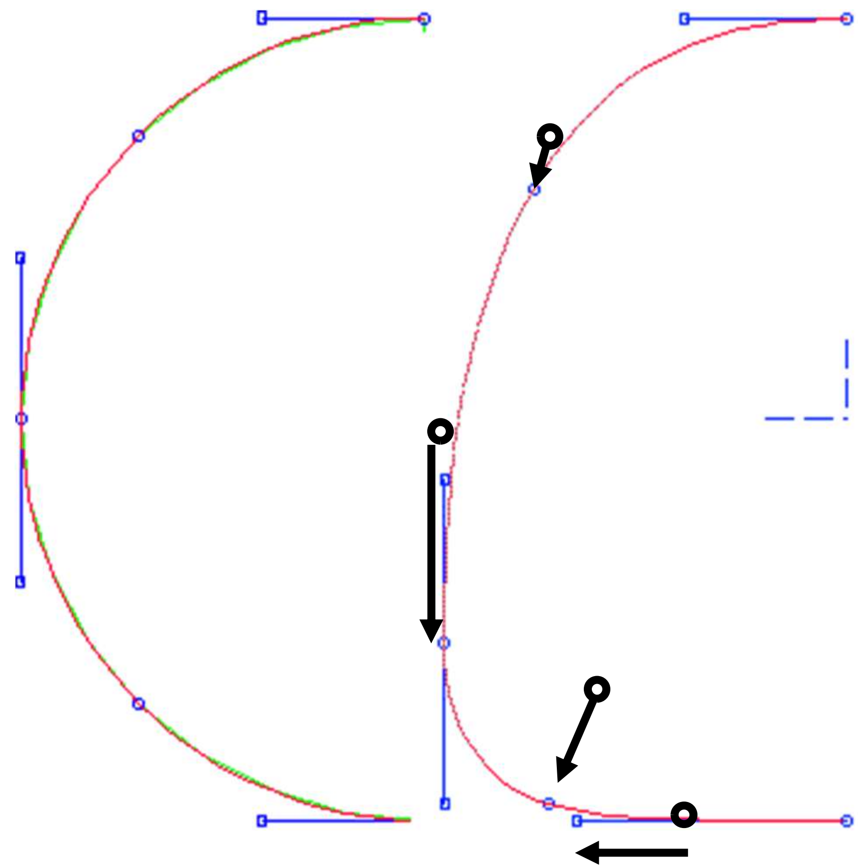


On-Screen SuperConic Shaping

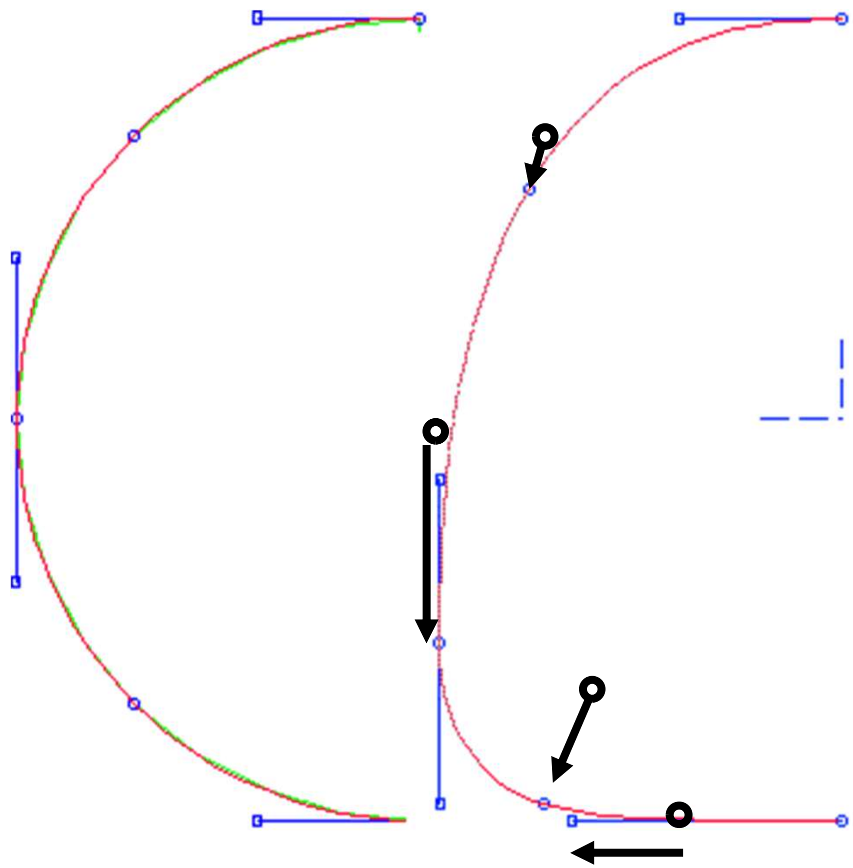
(each from moving one point)



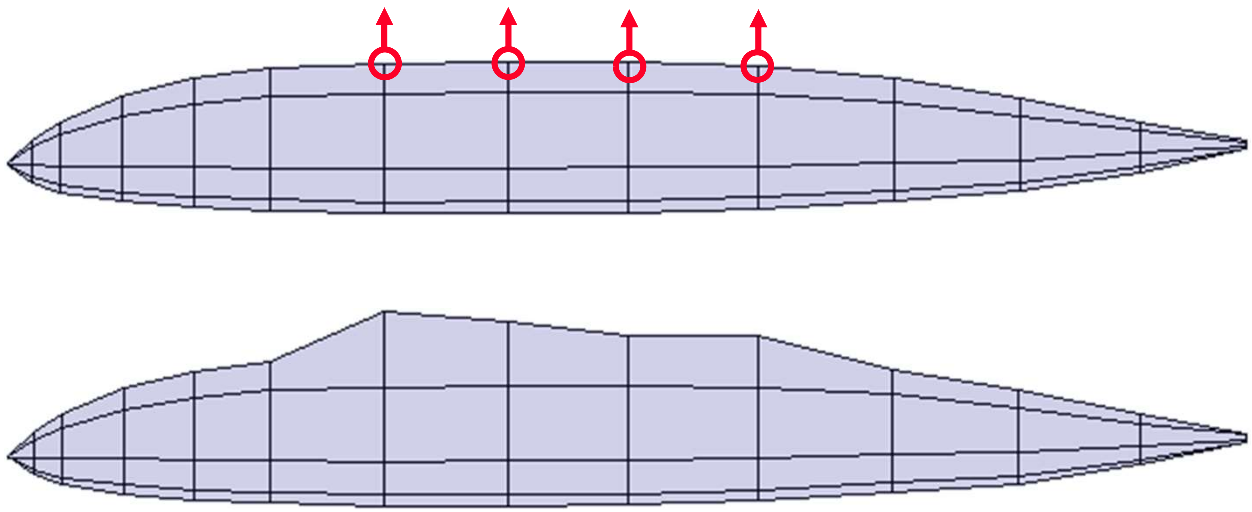
On-Screen SuperConic Shaping
(4 quick changes)



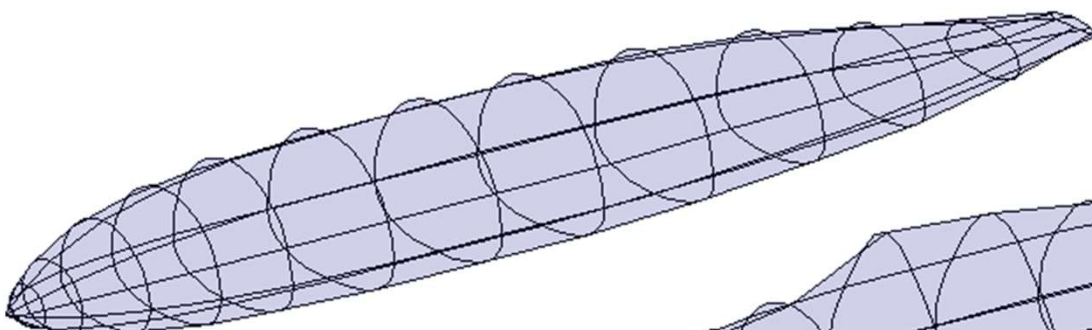
On-Screen SuperConic Shaping
(4 quick changes)



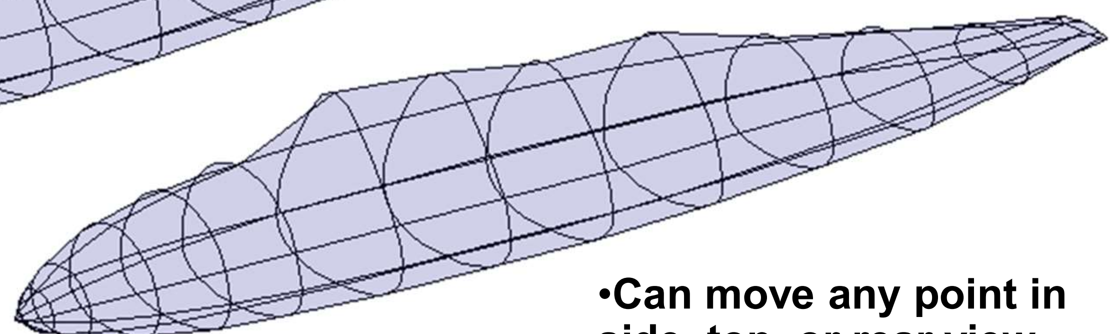
SuperConic Reshaping in Side & Top Views



- Moved Upper Centerline Points by Mouse Inputs



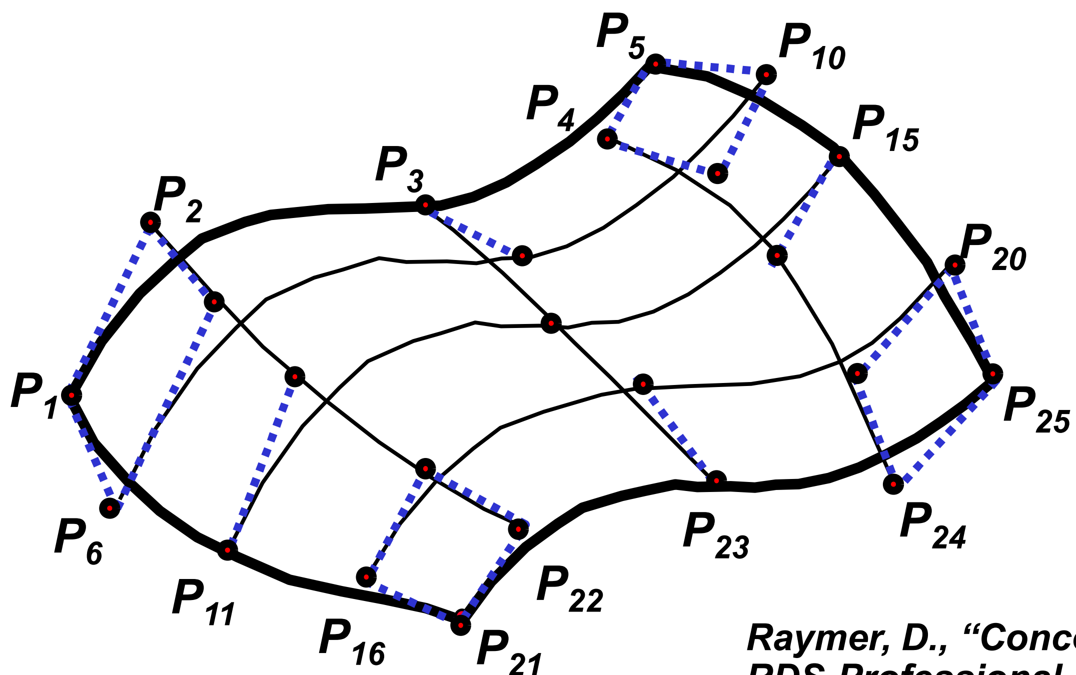
- Slope Control Points Automatically Moved Too



- Can move any point in side, top, or rear view

SuperConic Surface Components

- Modified 4th degree Bezier polynomials extended to surface patches using second parametric variable
- As 5 points make a SuperConic Line, so 5 SuperConic Lines make a SuperConic Surface ("patch")

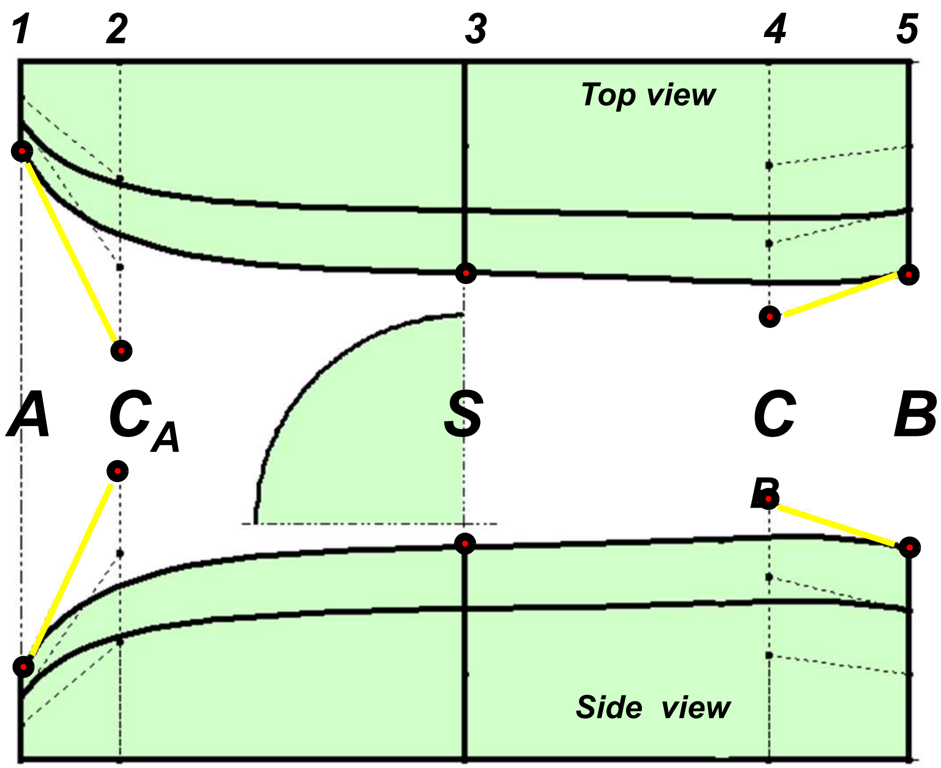


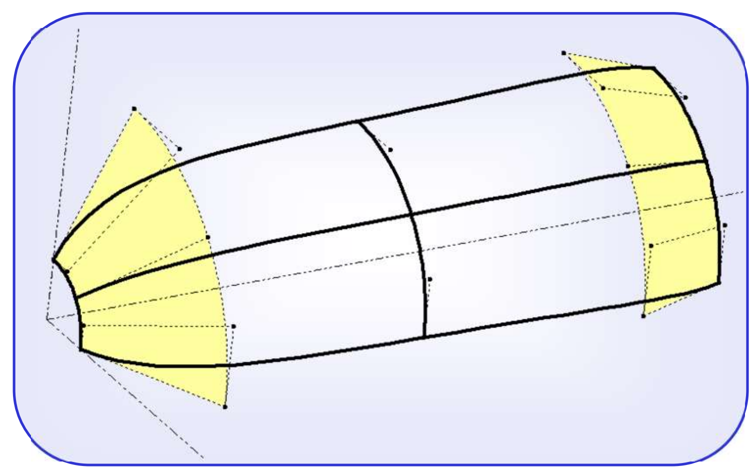
only in RDS^{win}-Pro

Raymer, D., "Conceptual Design Modeling in the RDS-Professional Aircraft Design Software," AIAA Paper 2011-161, AIAA Aerospace Sciences Meeting, Orlando, FL, 2011

Single SuperConic Surface Patch

- SuperConic Cross Sections define longitudinal shape
- Sections 1 & 5 are patch beginning and end (A & B)
- Section 3 is patch middle line (S for "shoulder")
- Sections 2 & 4 are "collars" (C_A & C_B) that control slopes coming from the patch ends

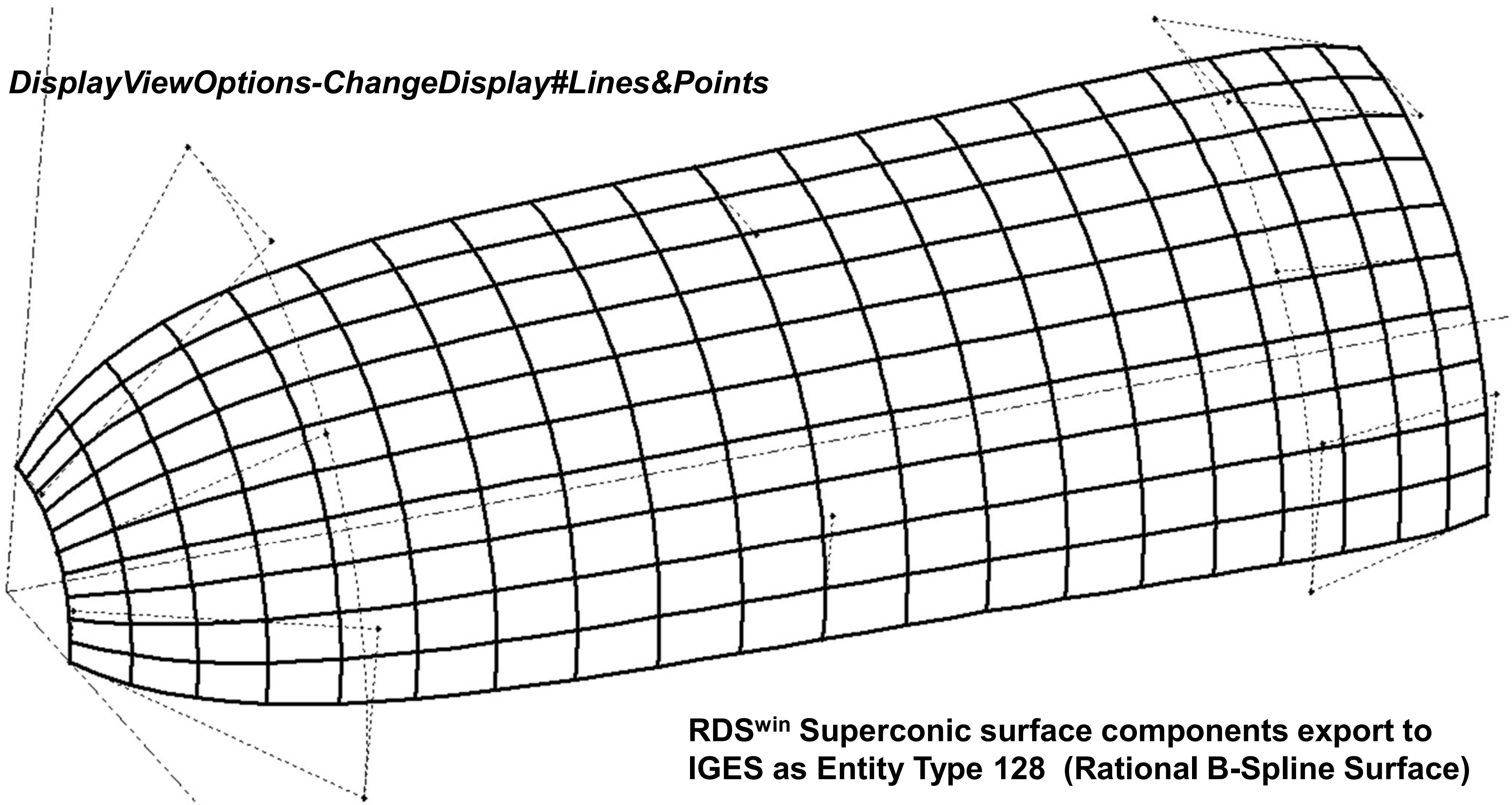




SuperConic Surface Patch Is Fully Defined

- Those 5 sections fully define that patch mathematically
- Here showing 21 cross sections and 11 lines per patch

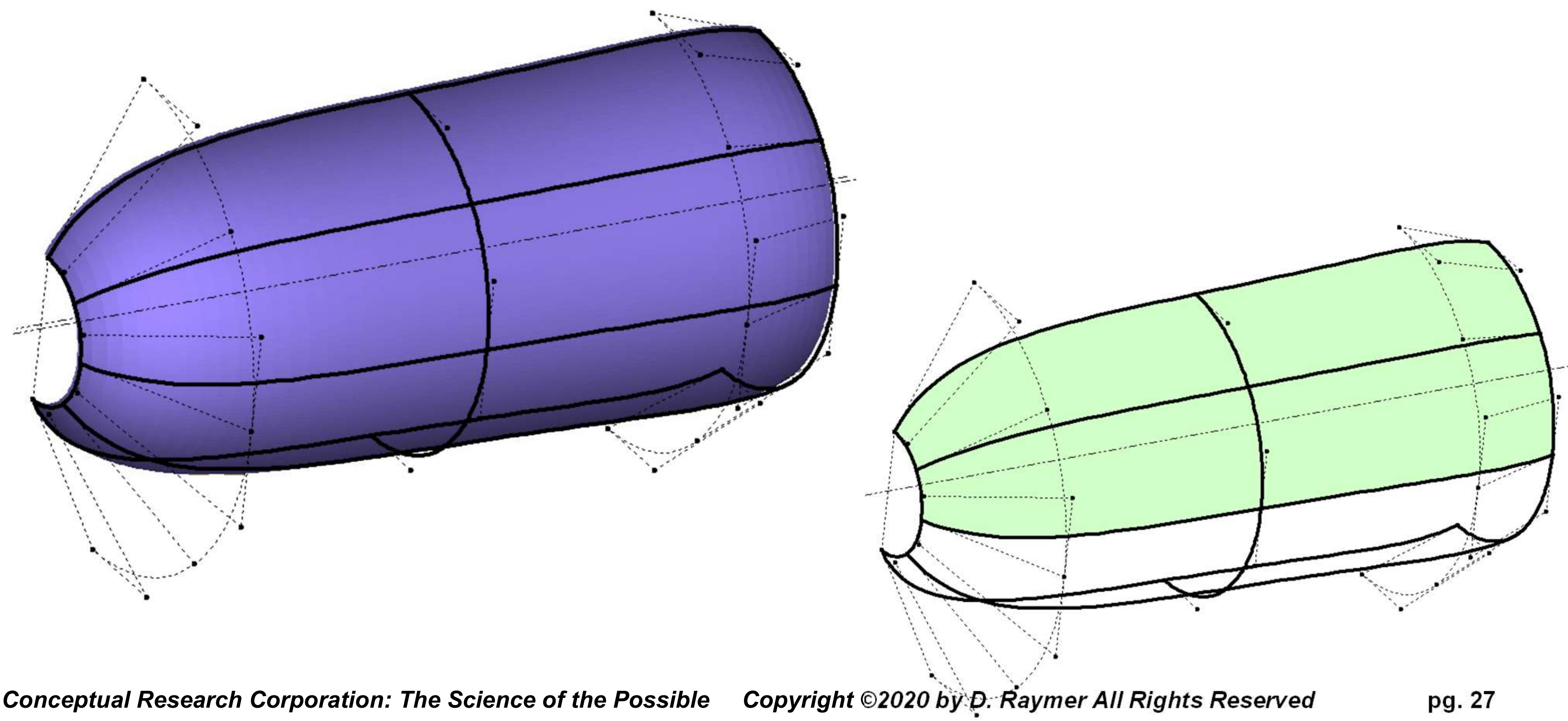
DisplayViewOptions-ChangeDisplay#Lines&Points



RDS^{win} Superconic surface components export to IGES as Entity Type 128 (Rational B-Spline Surface)

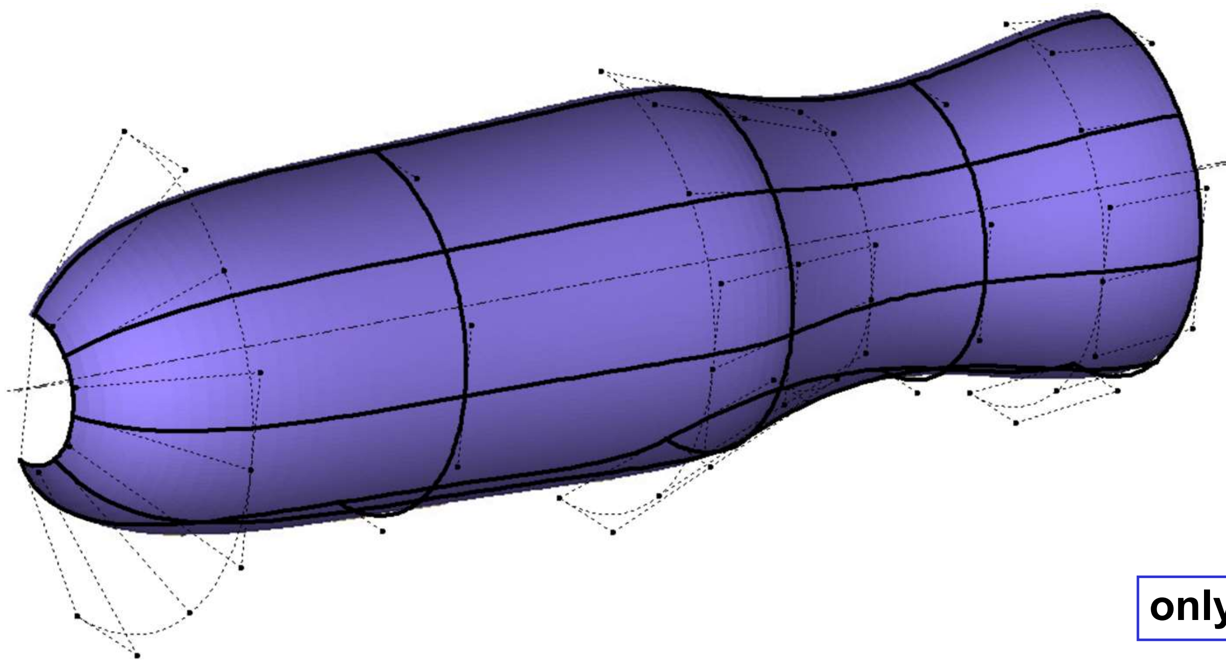
Cross Section Using Two SuperConic Patches

- 5 cross sections, each with two SuperConic curves
- Sections 1, 3, & 5 are on the surface
- Sections 2 & 4 are collars
- This is one longitudinal “patch bay”



Two Longitudinal SuperConic Patch Bays

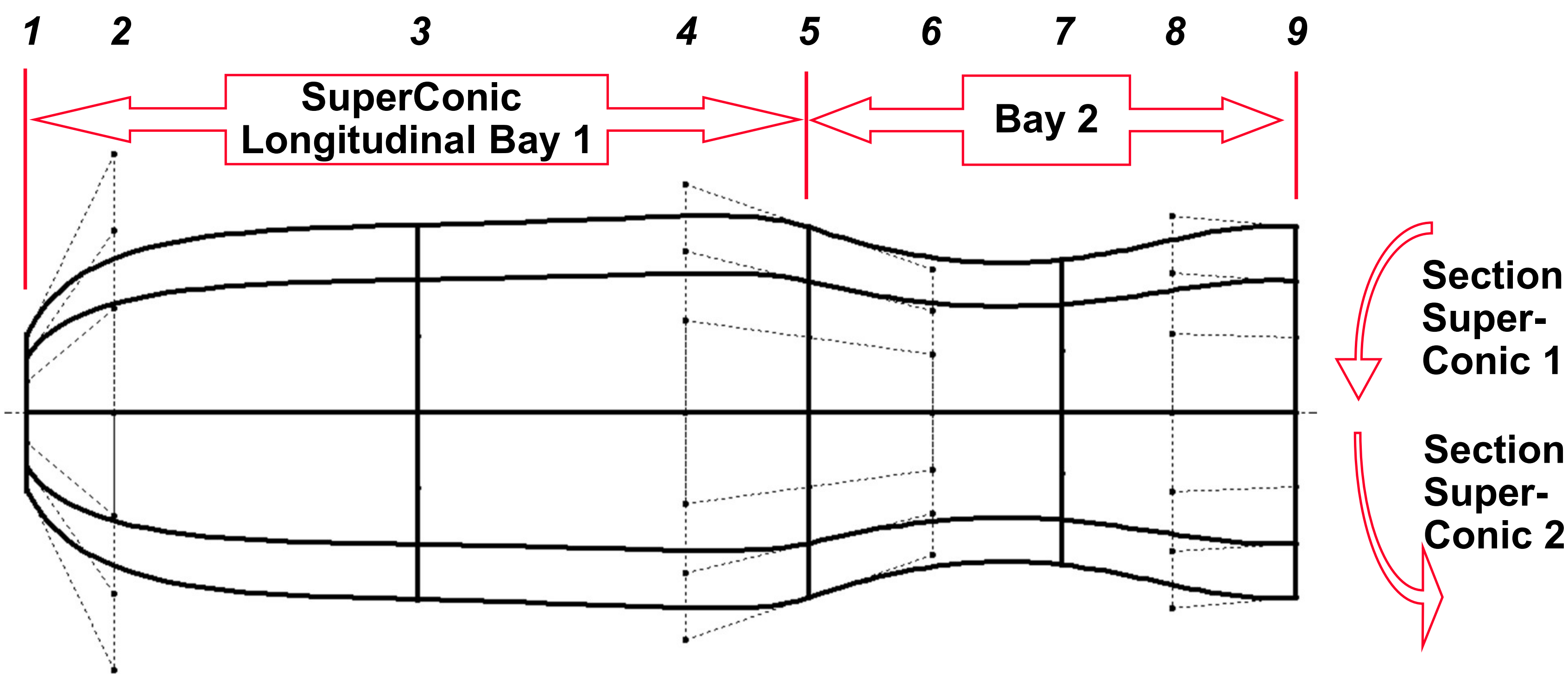
- 9 cross sections, each with two SuperConic curves
- Two longitudinal patch bays - ie., two SuperConic
- Sections 1, 3 , 5, 7, & 9 are on the surface
- Sections 2, 4, 6, & 8 are collars
- Sections 4 & 6 must be colinear for slope continuity



only in RDS^{win}-Pro

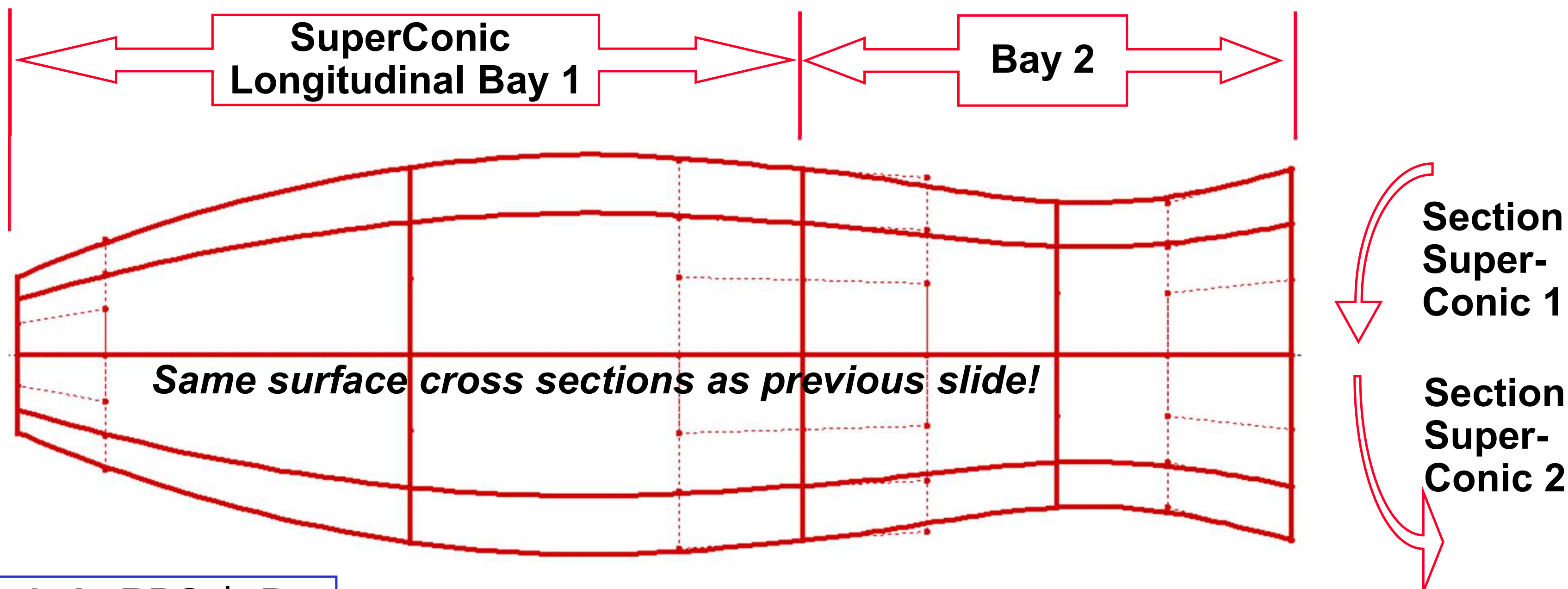
Two Longitudinal SuperConic Patch Bays

- Sections 1, 3 , 5, 7, & 9 are on the surface
- Sections 2, 4, 6, & 8 are collars
- Sections 4 & 6 must be colinear for slope continuity



Automatic Longitudinal Smoothing

- AutoSmooth uses Method of Akima to move the slope control "collar" sections to obtain a smooth shape with longitudinal slope continuity
- Instantly, with no further inputs!

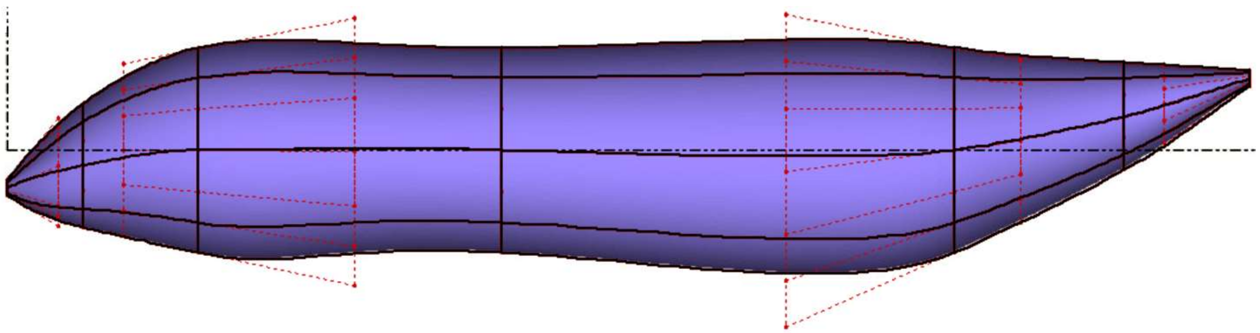


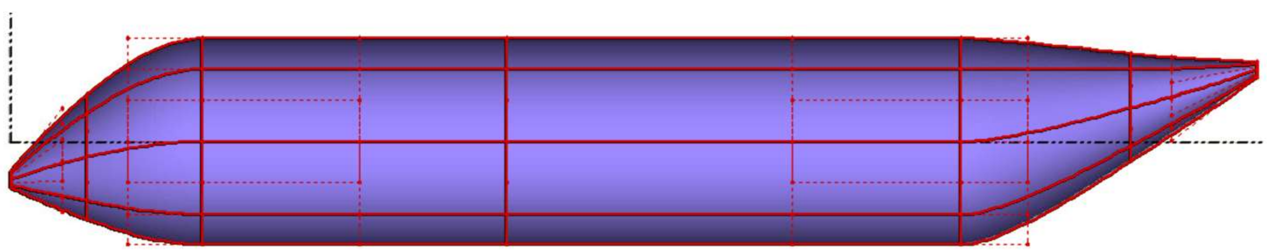
only in RDS^{win}-Pro

ShapeComponent-AutosmoothSuperConicSurfaceComp

Automatic Longitudinal Smoothing

- Automatically recognizes straight longitudinal lines, and creates constant cross section or straight taper

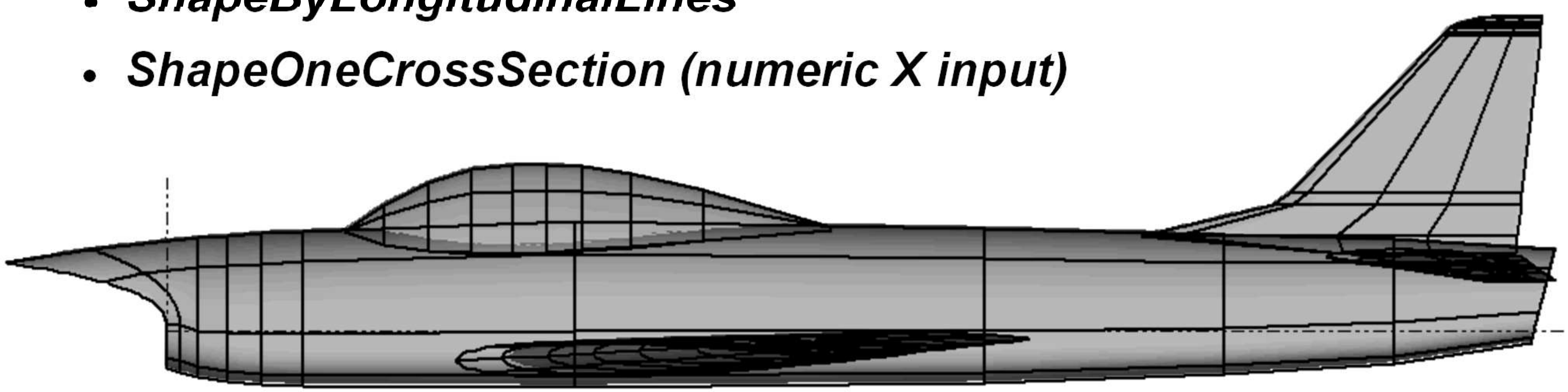




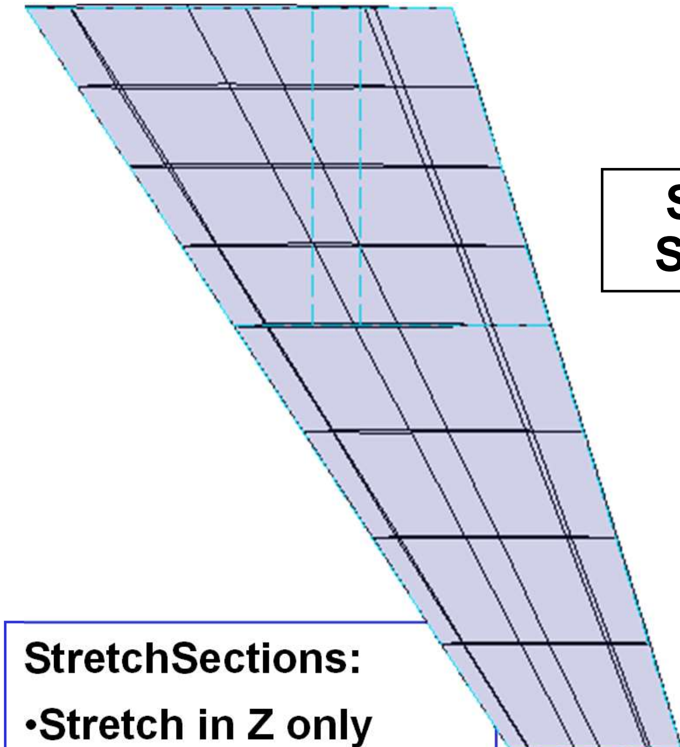
- 2^{nd} derivative continuity is approximated by having adjacent collars same distance from patch end section

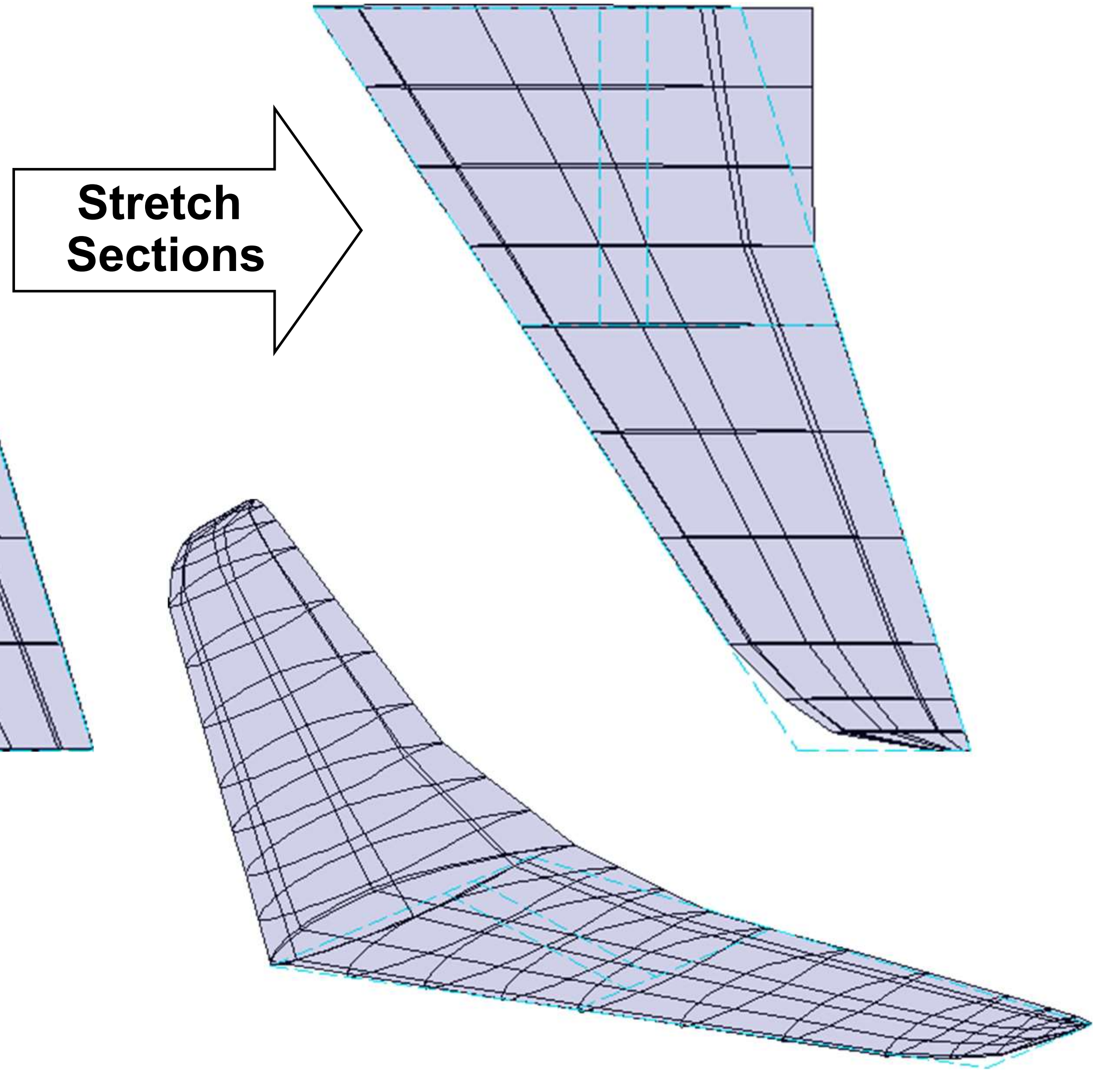
Non-Planar and Non-Parallel Sections

- Normally DLM components are built from parallel, planar cross sections, stacked in the X direction
- For a canted inlet front face or similar geometry, cross section X values can be canted and warped out of perpendicular using:
  - *ComponentParameters-AllowNonParallelSections*
  - *ShapeComponent-Cant Cross Section*
  - *ShapeByLongitudinalLines*
  - *ShapeOneCrossSection (numeric X input)*



Trapezoidal Wing Shaping



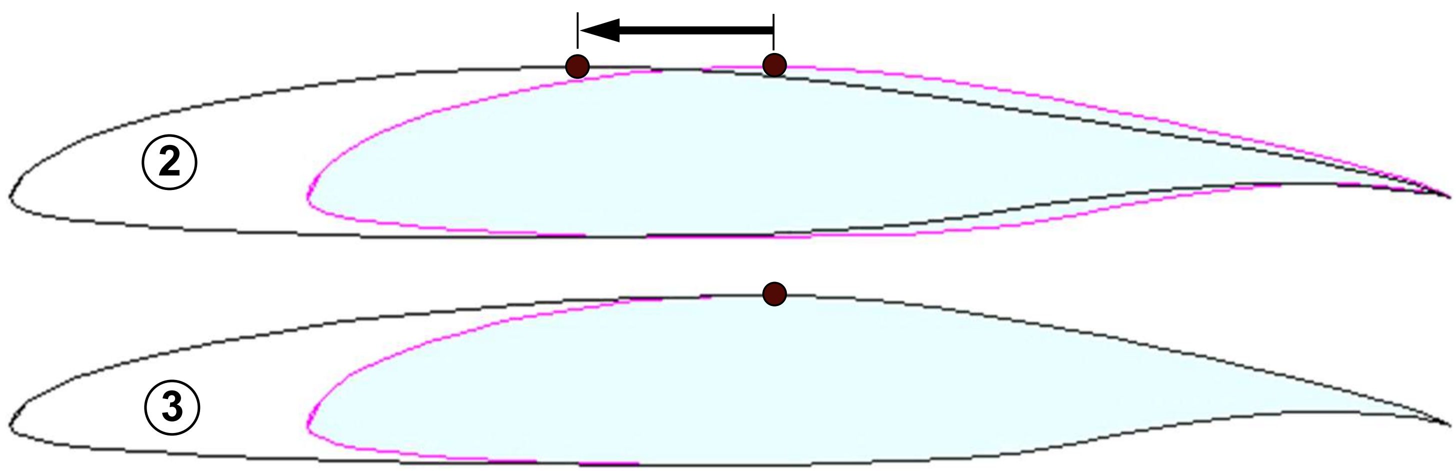


StretchSections:

- •Stretch in Z only
- •Stretch Proportional
- •Stretch in Y only
- •Stretch front/back
- •Stretch top/bottom
- • " to ditto last stretch

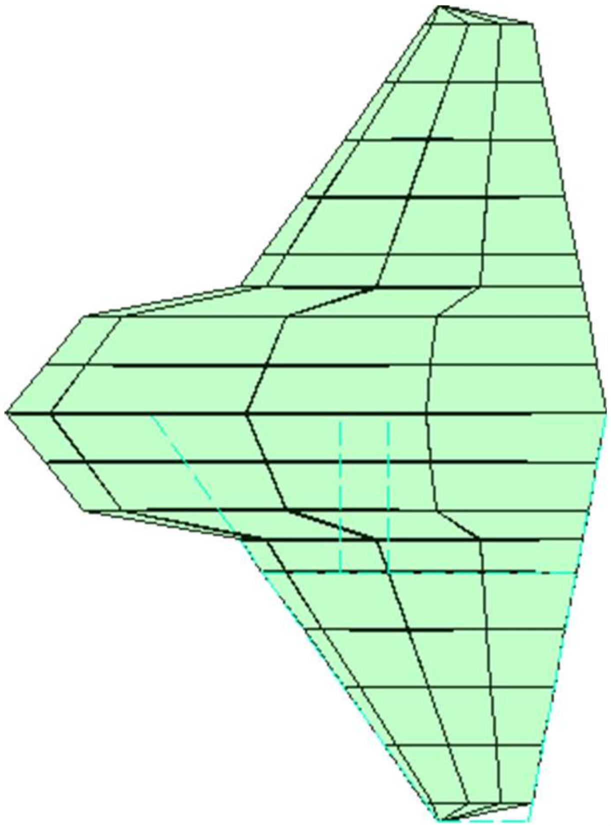
Stretch Airfoil Sections – Three Options

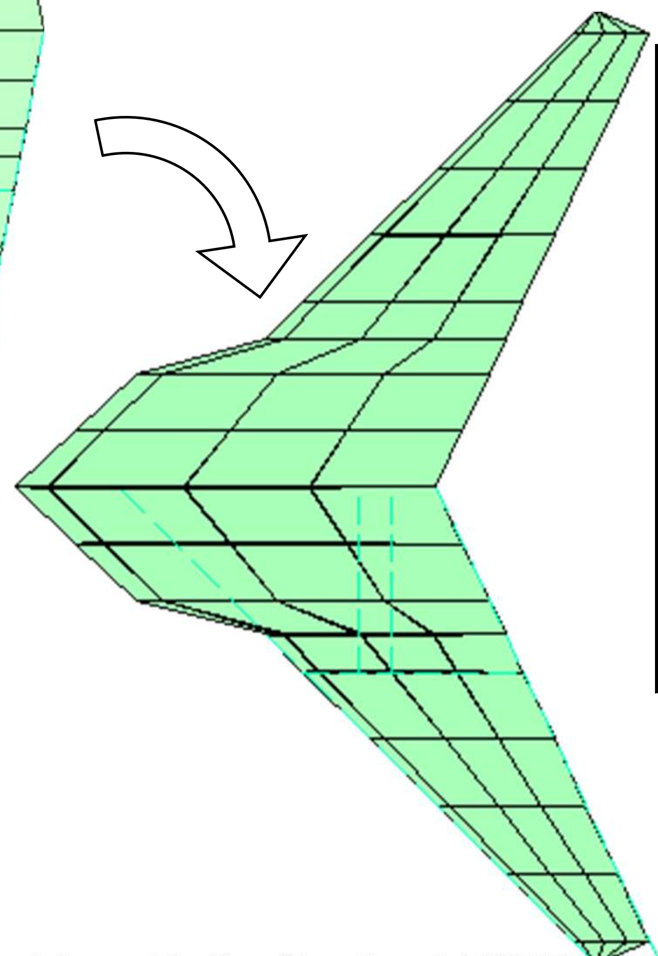
1. **Maintain t/c so thickness scales proportionally with chord, resulting airfoil is "photo-scaled"**
2. **Maintain actual thickness so t/c reduces as chord increases, resulting airfoil is "photo-stretched"**



3. **Keep thickness so t/c reduces as chord increases, but stretch only from maximum thickness point. Result is like a "glove." Sweep of wing's maximum thickness line is unchanged**

Reference Wing Redesign: Parameter Revision

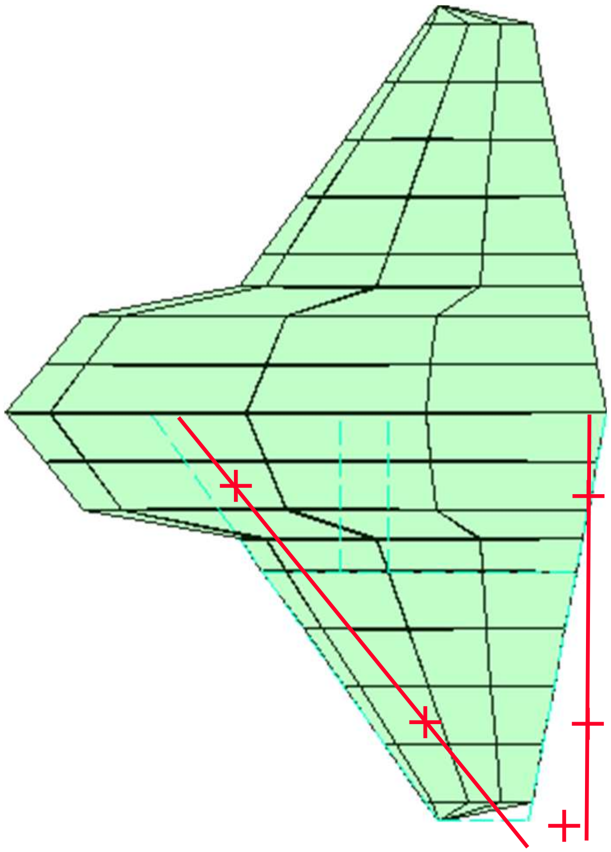


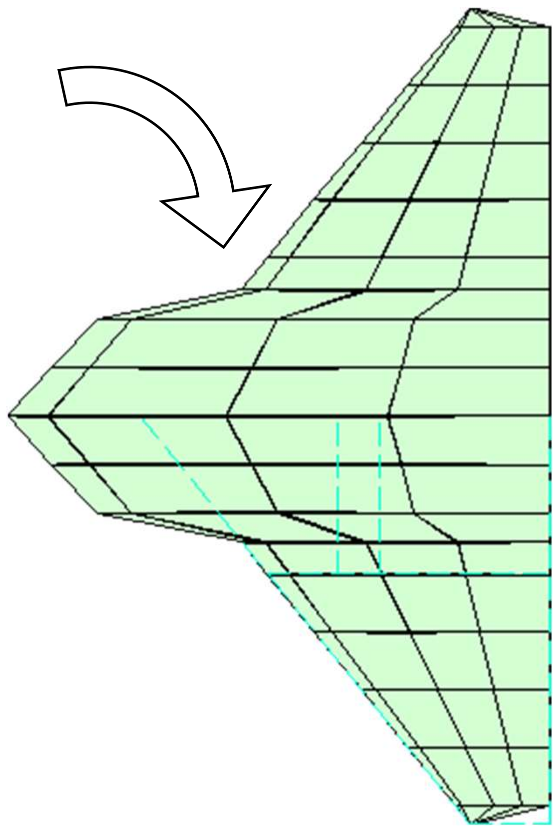


Area Sref	535	535
Aspect Ratio	3	5
Taper Ratio	0.2	0.2
Sweep (LE)	35	45
Sweep (c/4)	25.547	40.914
Airfoil	NACA 64-006	NACA 64-006
Thickness t/c	6%	6%
Dihedral	-2	-2
Incidence	0	0
Twist	0	0
Span	40.062	51.72
Root Chord	22.257	17.24
Tip Chord	4.451	3.448
Mean Chord	15.332	11.876
Y-bar	7.79	10.057
X loc (apex)	22.132	18.394
X loc (c/4)	31.42	31.42
Y location	0	0
Z location	0.7	0.7

…10 seconds

Reference Wing Redesign: LE/TE/Span Input





Area Sref	535	544.09
Aspect Ratio	3	3.329
Taper Ratio	0.2	0.197
Sweep (LE)	35	38.889
Sweep (c/4)	25.547	31.171
Airfoil	NACA 64-006	NACA 64-006
Thickness t/c	6%	6%
Dihedral	-2	-2
Incidence	0	0
Twist	0	0
Span	40.062	42.559
Root Chord	22.257	21.366
Tip Chord	4.451	4.203
Mean Chord	15.332	14.704
Y-bar	7.79	8.259
X loc (apex)	22.132	19.595
X loc (c/4)	31.42	29.932
Y location	0	0
Z location	0.7	0.7

…10 seconds

RDS-Pro Only

Extended SAWE8 Group Weight Statement Component Categories

Used to identify component types for weights analysis and geometry listings

- 002-000:Ref Wing
- 002-001:2nd Wing
- 002-002:BiplaneWing2
- 002-003:LEX
- 002-004:Winglet
- 002-005:Wing Strut
- 002-006:WingStruct
- 002-999:Wing-Other
- 008-000:Aileron
- 008-001:Elevon
- 009-000:Spoiler
- 010-000:Flaps(TE)
- 011-000:Flaps(LE)
- 012-000:Slats

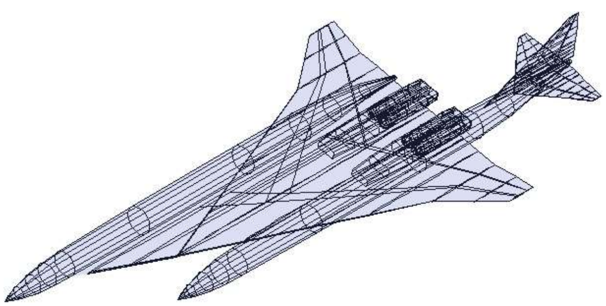
- 031-000:Fuselage
- 031-001:Canopy
- 031-002:Fairing/Pod
- 031-003:InletFairing
- 031-004:Tailboom
- 031-005:2nd Fuselage
- 031-006:Door
- 031-007:Speed Brake
- 031-008:Body Flap
- 031-009:Payload Bay
- 031-010:Bay-Other
- 031-011:PassngerComp
- 031-012:Structure
- 031-999:Fuslag-Other

- 080-999:MiscFltCntrl
- 081-000:CockpitCntrl
- 082-000:AutoFltCntrl
- 083-000:SystemCntrls
- 084-000:Aux Power
- 085-000:Instruments
- 086-000:Hydraulics
- 087-000:Pneumatics
- 088-000:Electrical
- 090-000:Avionics
- 090-001:Antenna
- 091-000:AvionicInstl
- 092-000:Armament
- 094-000:Accomodation

(Partial listing)

Geometric Output File (TAB)

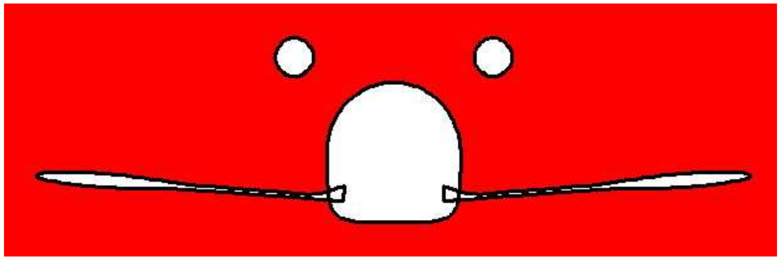
- Spreadsheet-formatted geometric data for reporting & analysis input
- Wing & Tail trapezoidal reference data (shown)
- Component L, W, H, S_{wet}, Volume, Location, Centroid, SAWE8 code, …
- Component Section Perimeters and Areas vs. X-distance
- Inputs for RDS analysis



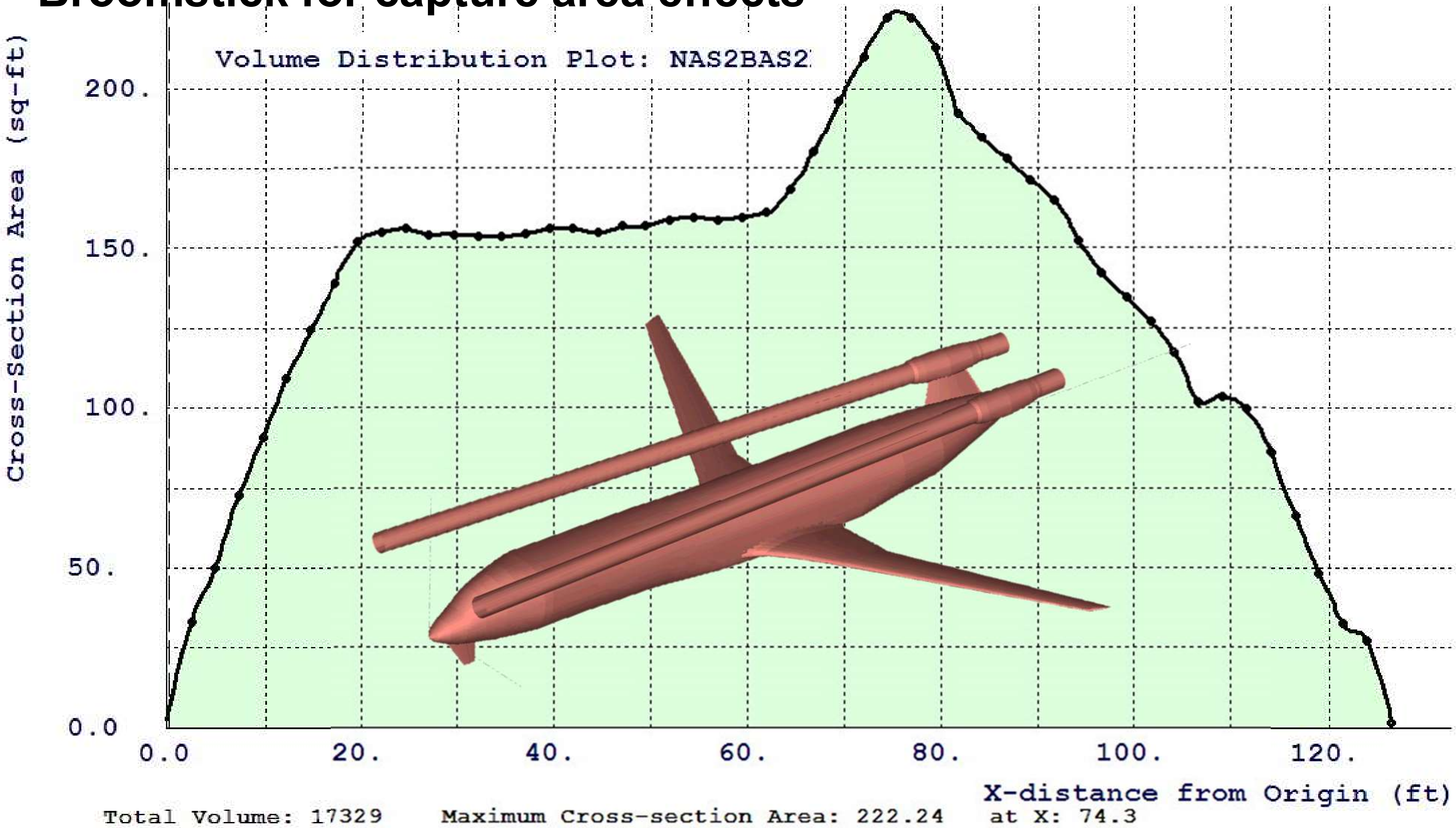
…10 seconds

	Wing	WingGlove	HorTail	VertTail
Area Sref	5833	5833	600	555
Aspect Ratio	1.82	1.82	2.5	0.9
Taper Ratio	0.05	0.05	0.15	0.1
Sweep (LE)	62.893	62.893	47.599	59.981
Sweep (c/4)	55.527	55.527	38.641	51.918
Airfoil	NACA 64A-010	NACA 64A-010	NACA 64A-010	NACA 64A-010
Thickness t/c	0.099	0.099	0.099	0.099
Dihedral	2	-2	0	0
Incidence	0	0	0	0
Twist	0	0	0	0
Span	103.034	103.034	38.73	22.349
Root Chord	107.833	107.833	26.942	45.15
Tip Chord	5.392	5.392	4.041	4.515
Mean Chord	72.059	72.059	18.313	30.374
Y-bar	17.99	17.99	7.297	8.127
X loc (apex)	102.139	102.14	233.001	217.661
X loc (c/4)	155.299	155.3	245.57	239.32
Y location	0	0	18	18
Z location	-6	-6	3.08	5.01
Tail Vol		0.129	0.078	
Comp Type	RefWing	HorizTail	VertTail	
SAWE8 Code	[002-000]	[002-003]	[020-001]	[020-003]

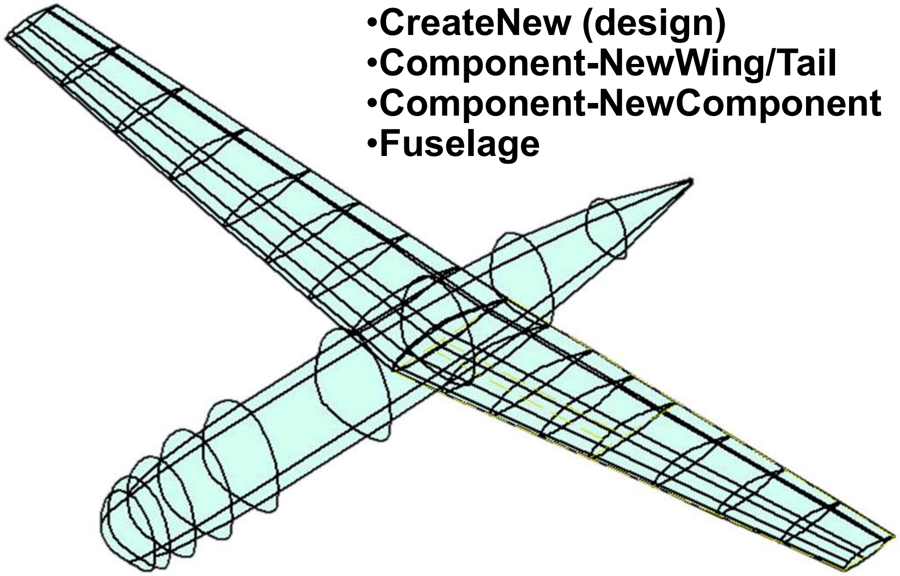
Volume Distribution Plot



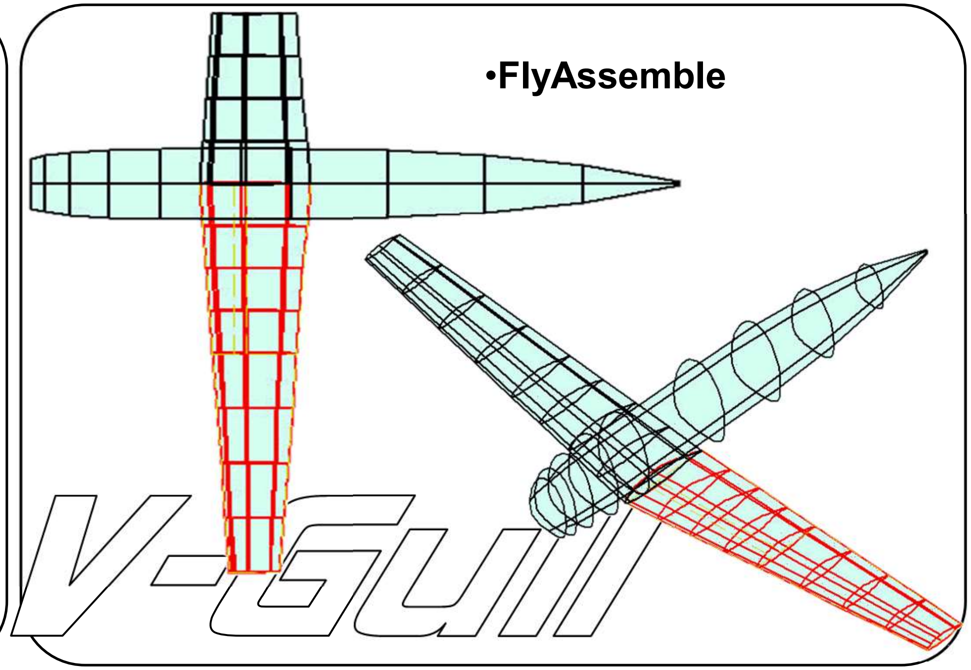
- •10 seconds
- •Watertight Solid Model not required
- •Broomstick for capture area effects



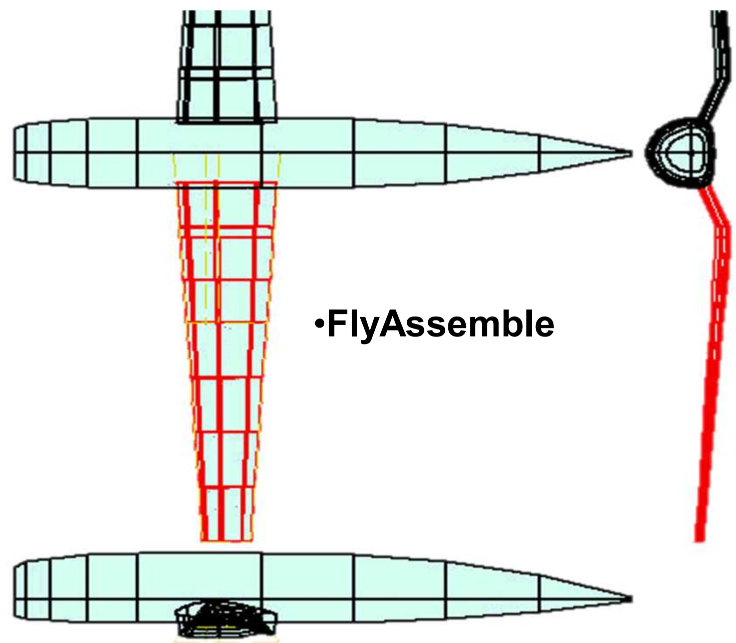
•CreateNew (design)
•Component-NewWing/Tail
•Component-NewComponent
•Fuselage



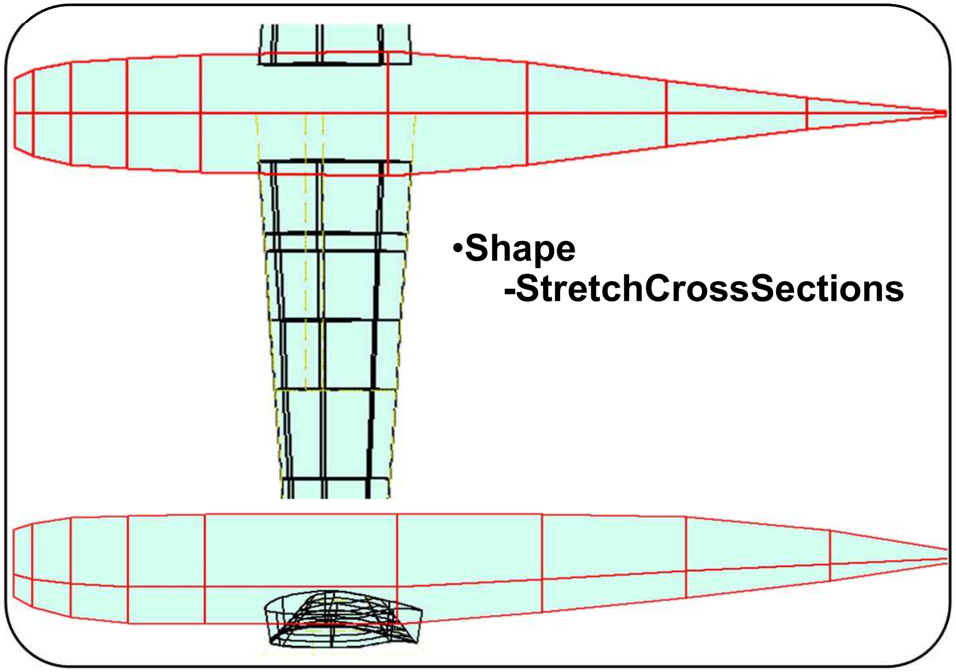
•FlyAssemble

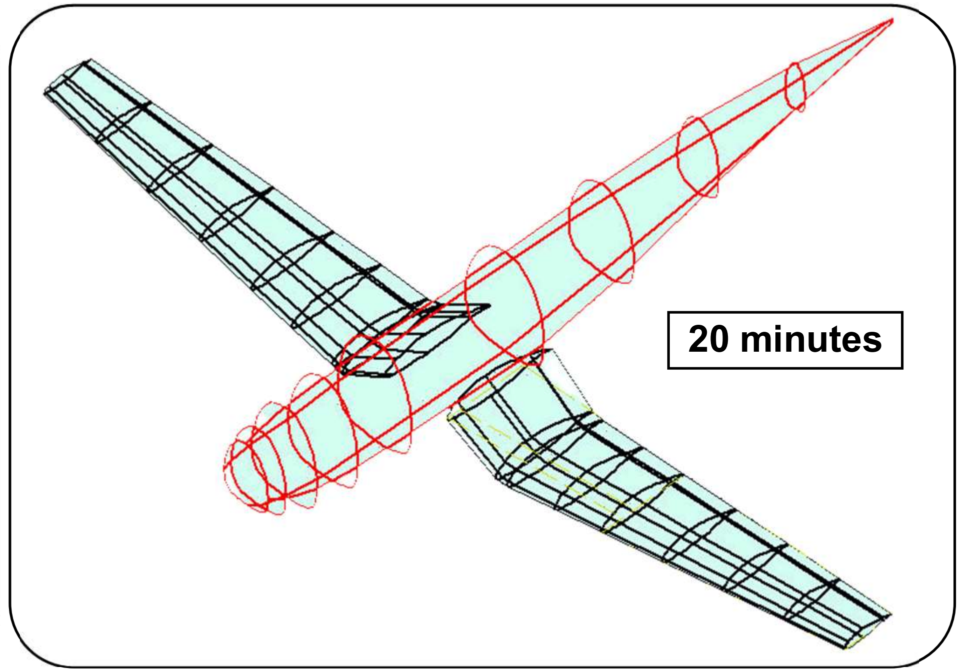


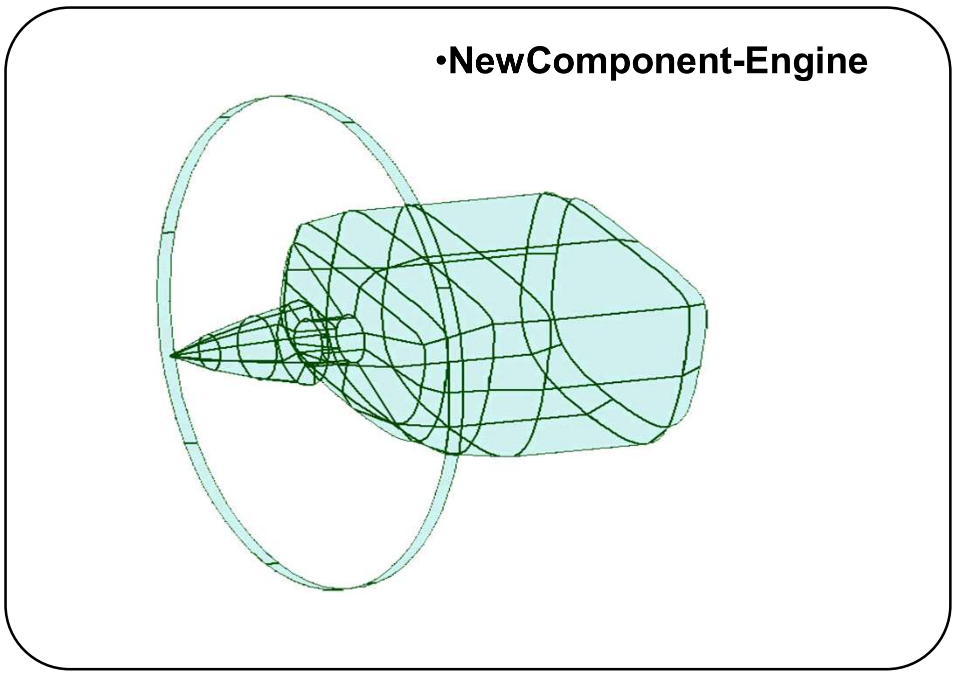
•ViewRelative-Front (of wing)
•ShapeComponent-MoveSections
•FlyAssemble

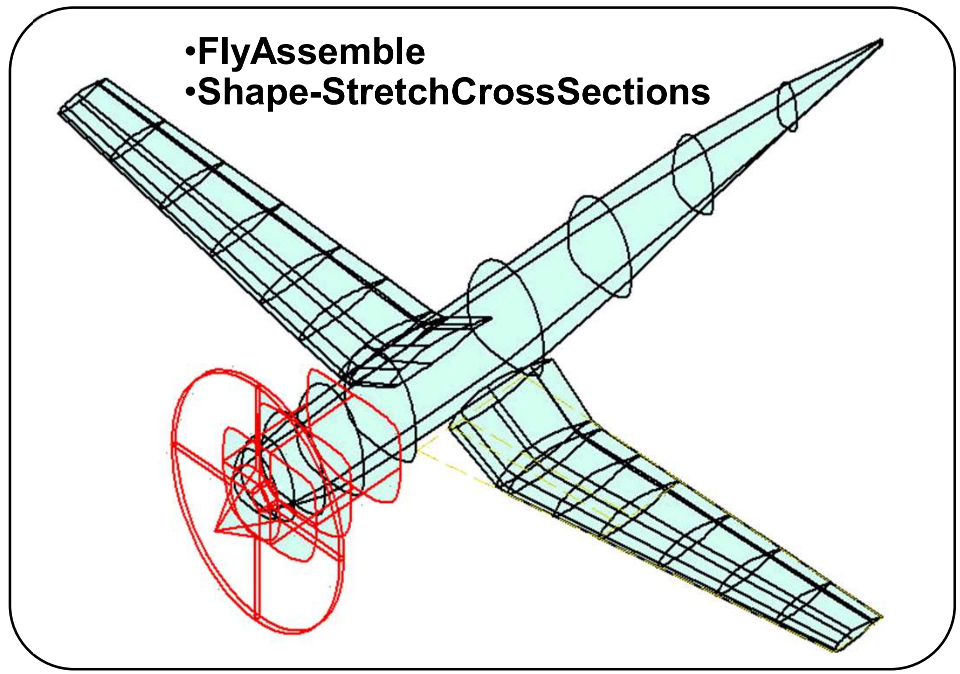


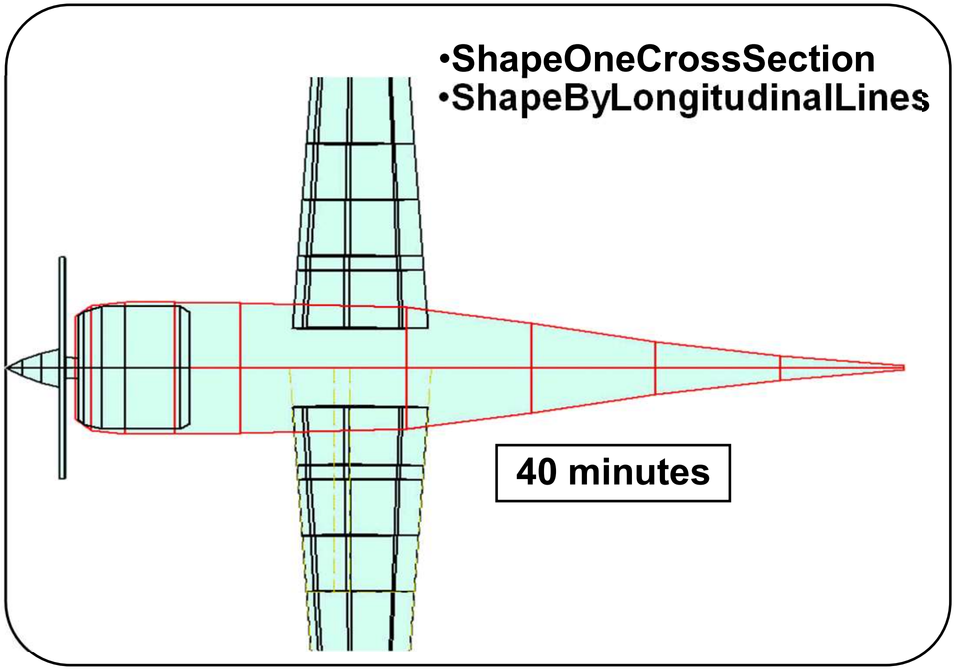
•FlyAssemble

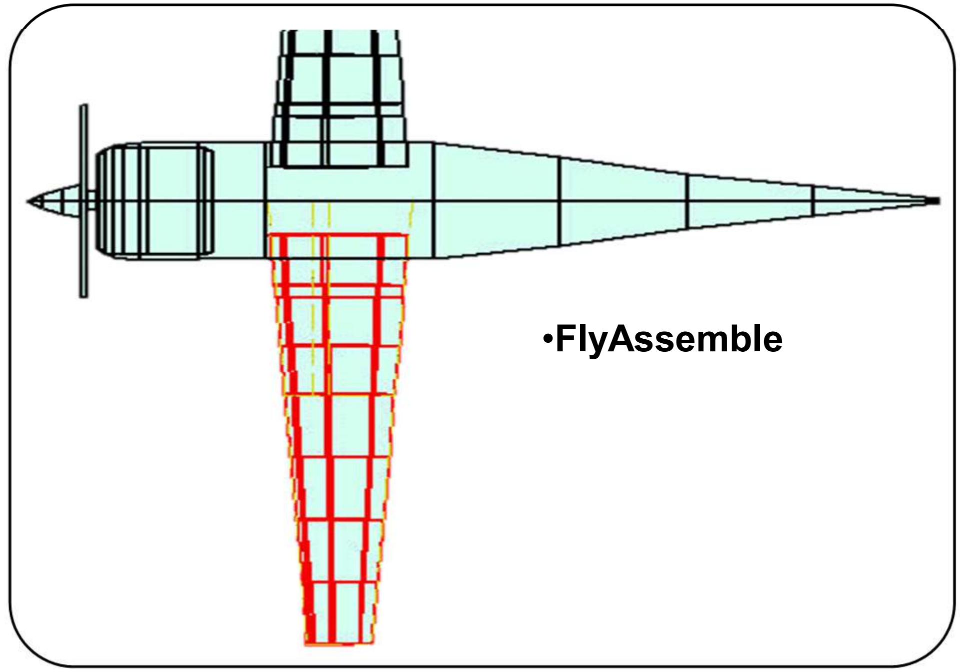

•Shape
-StretchCrossSections

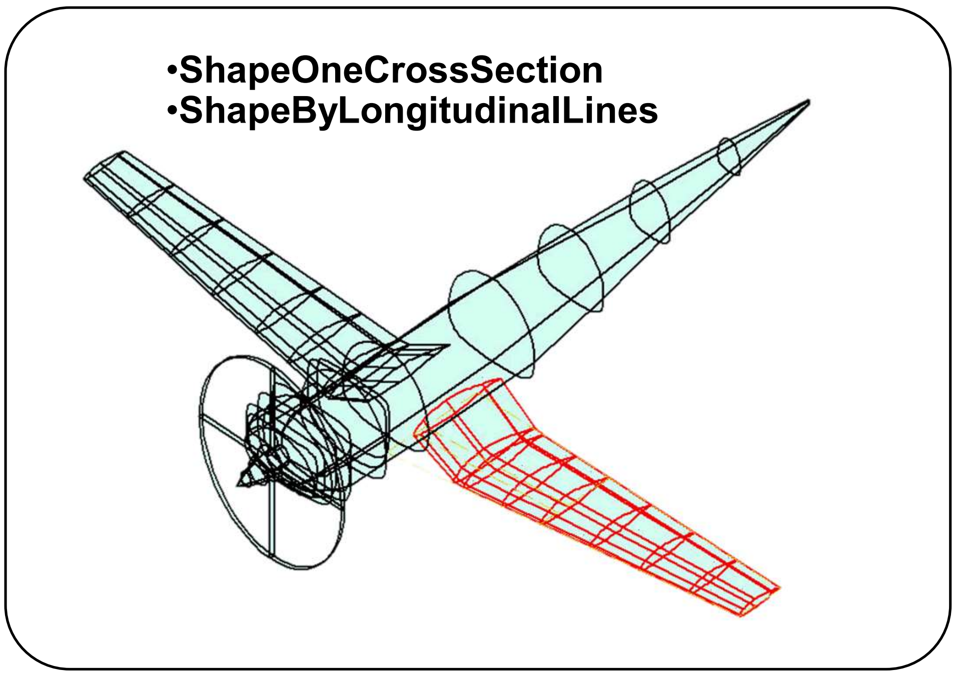

20 minutes

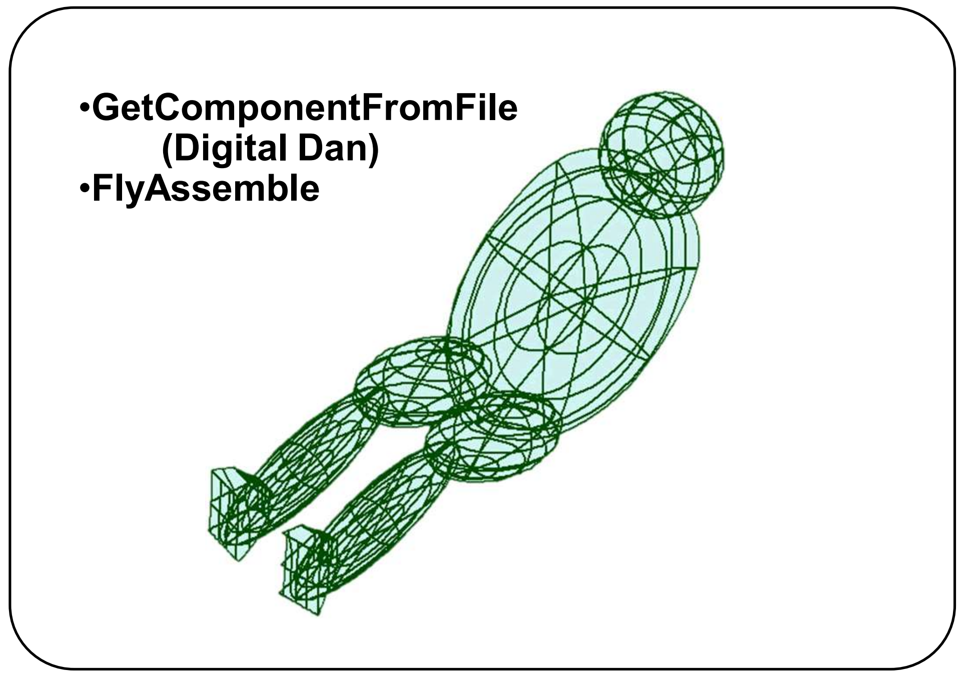

•NewComponent-Engine


•FlyAssemble
•Shape-StretchCrossSections

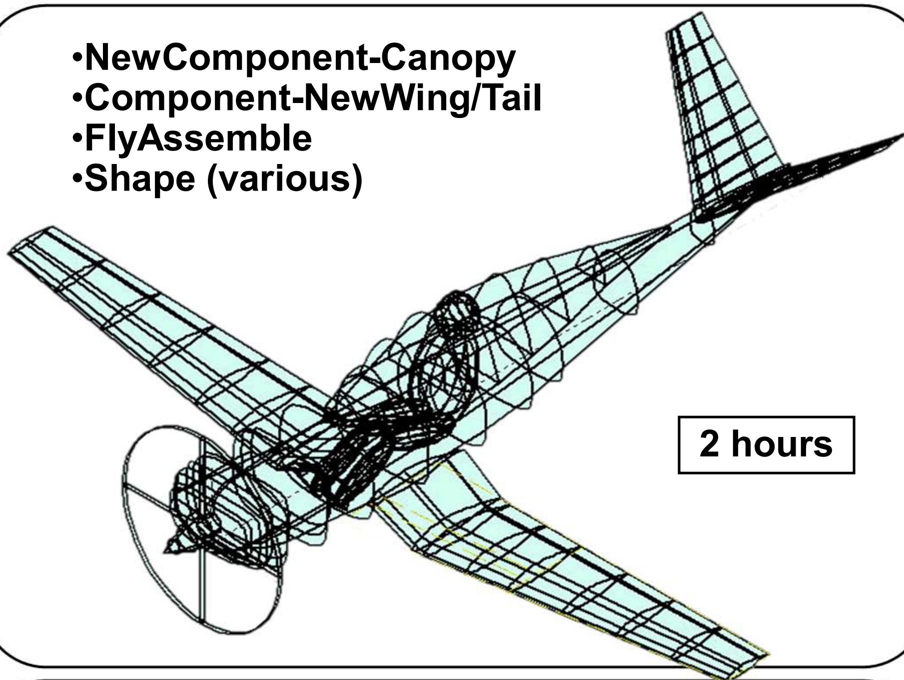

•ShapeOneCrossSection
•ShapeByLongitudinalLines
40 minutes

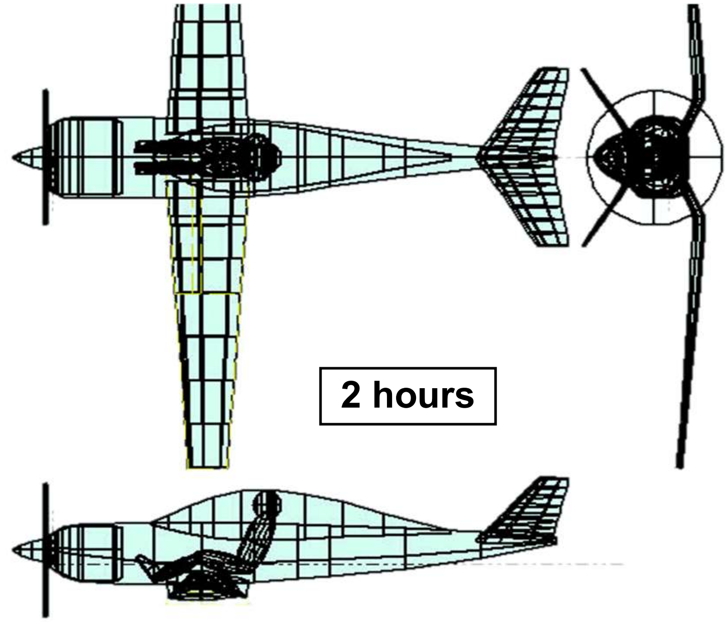

•FlyAssemble


•ShapeOneCrossSection
•ShapeByLongitudinalLines

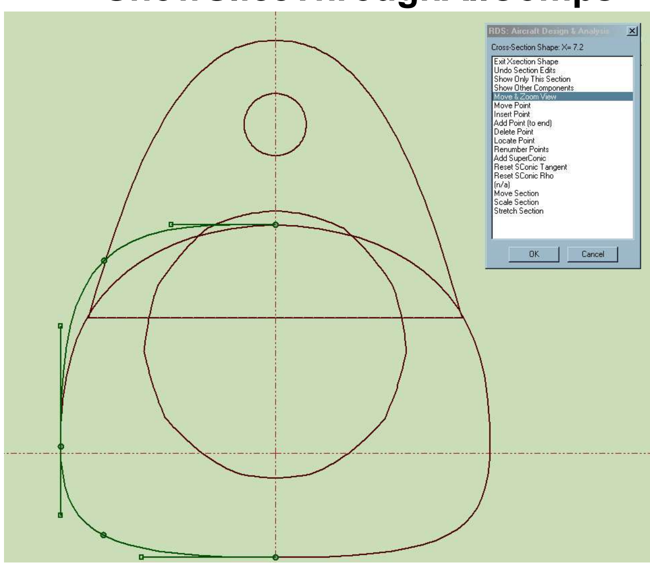

•GetComponentFromFile
(Digital Dan)
•FlyAssemble

- NewComponent-Canopy
- Component-NewWing/Tail
- FlyAssemble
- Shape (various)

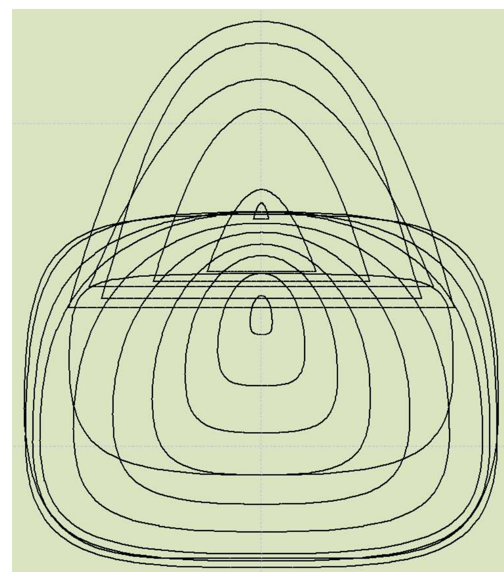


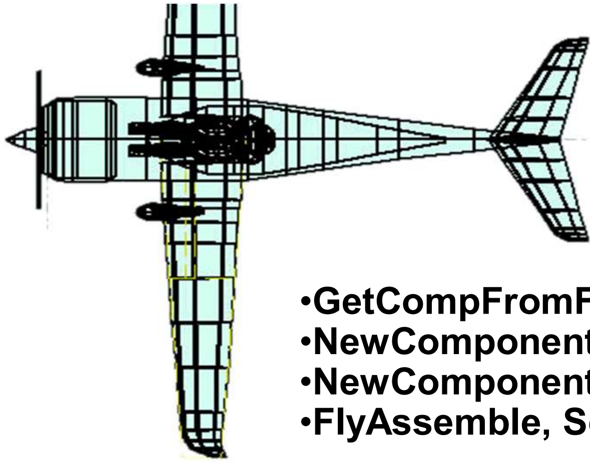


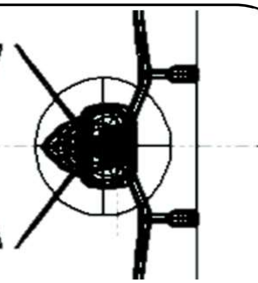
- ShapeOneCrossSection
- ShowSliceThroughAllComps



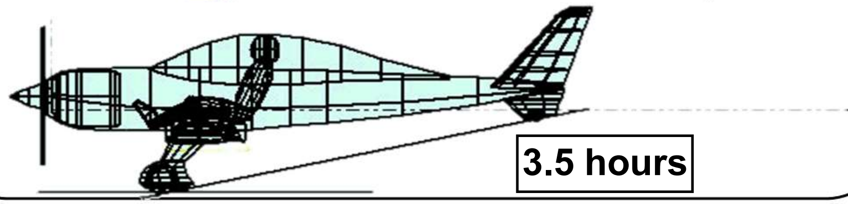
- View-SliceViews-CrossSections





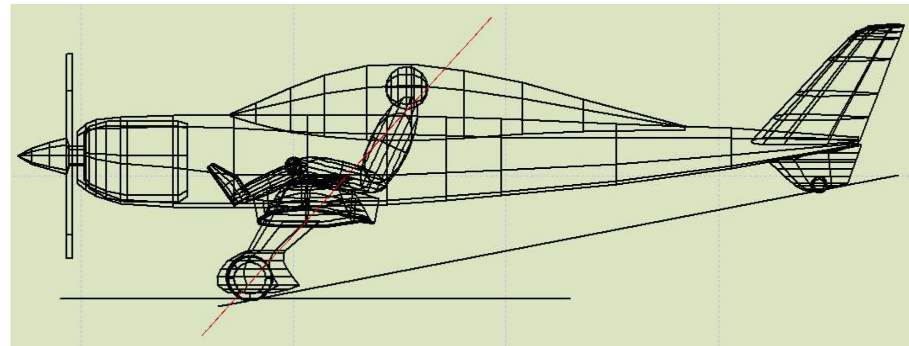


- GetCompFromFile (ground)
- NewComponent-wheel
- NewComponent-strut
- FlyAssemble, Scale, Stretch,…

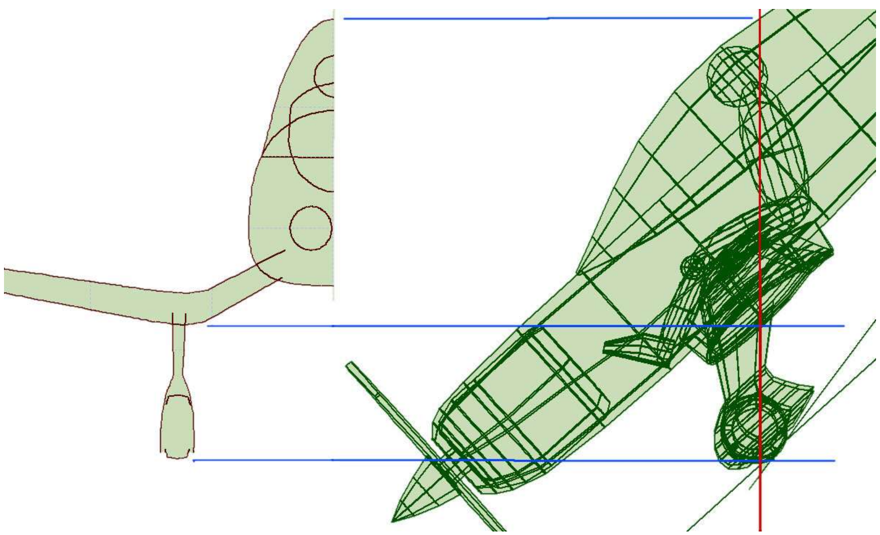


3.5 hours

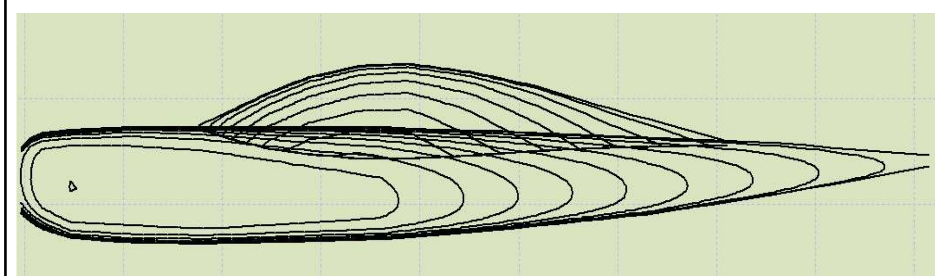
- GetCompFromFile (cut plane)
- FlyAssemble

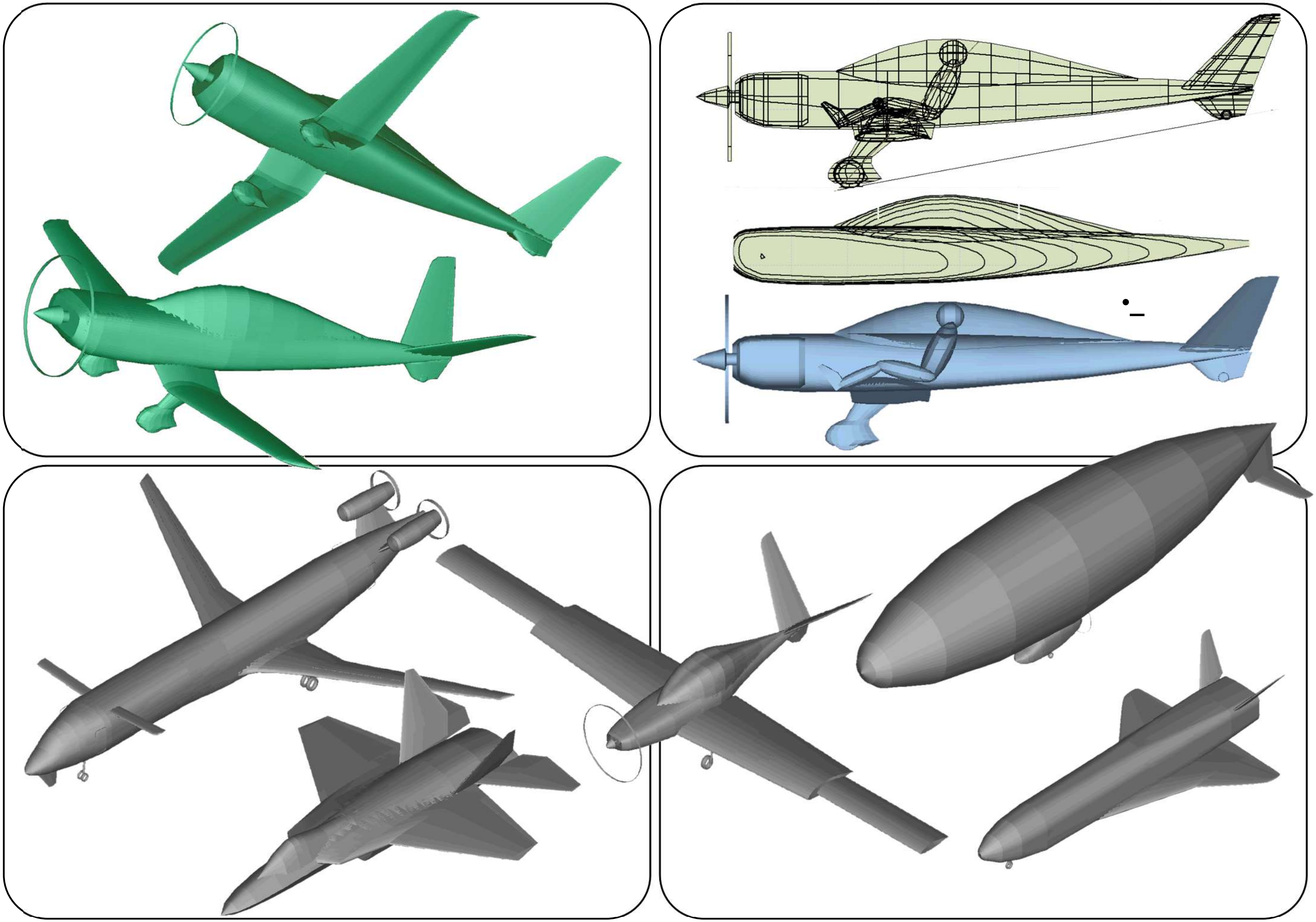


- View-SliceWithCutPlane

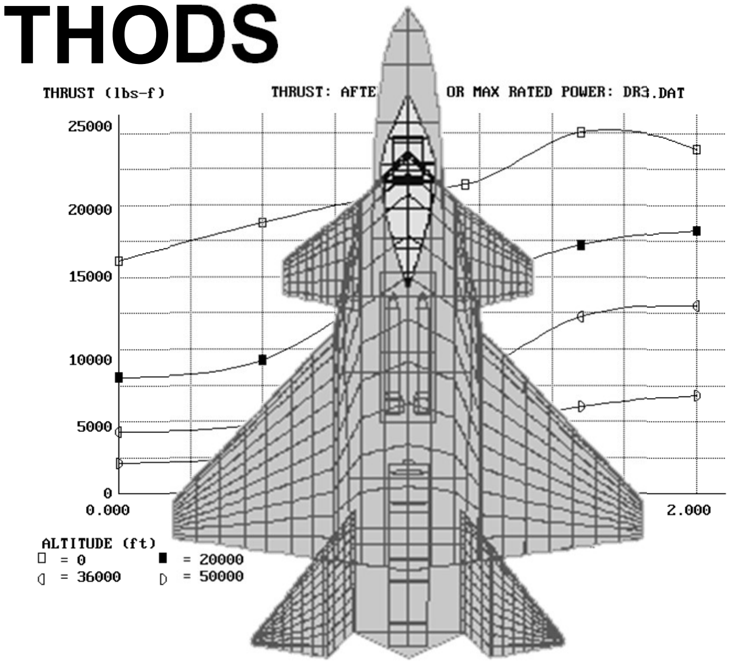


- View-SliceViews-ButtockPlane





RDS ANALYTICAL METHODS

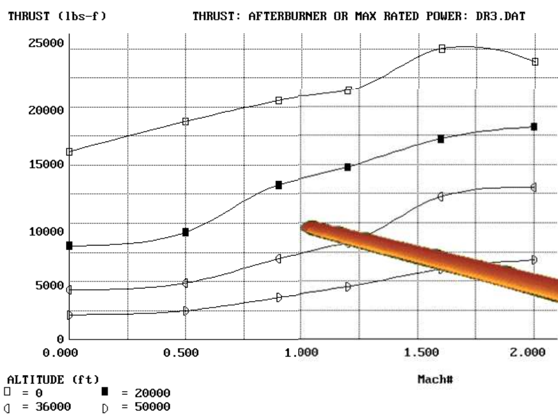


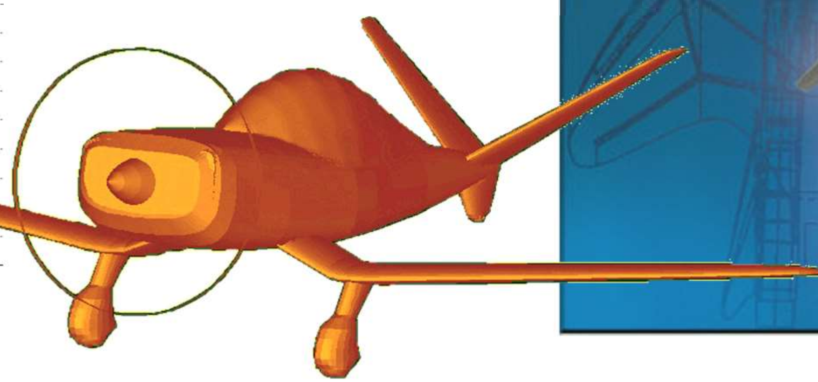
Most methods are described in Raymer's text "AIRCRAFT DESIGN: A Conceptual Approach"

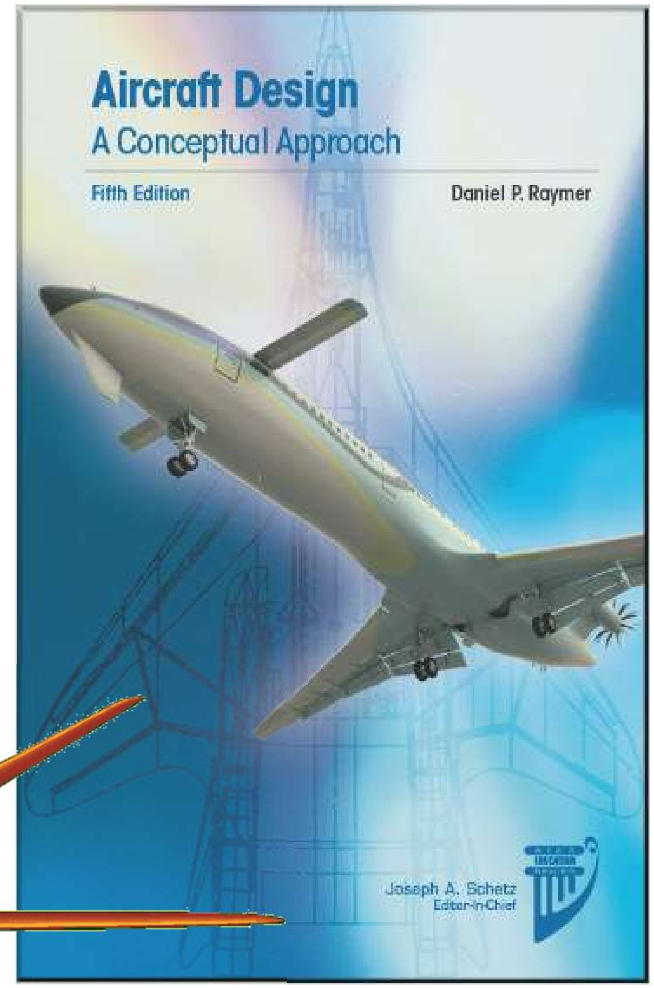
- **Classical aerodynamics methods**
  - **DATCOM lift curve & max lift**
  - **Component buildup for parasitic drag**
  - **Leading-edge suction (drag-due-to-lift)**
  - **Empirical transonic estimations**
- **Longitudinal stability & trim**
- **Statistical component weights**
- **Jet, Turboprop, and Piston-Prop**
- **Full mission sizing, range, & performance analysis capabilities**
- **Development & procurement cost, yearly O&S costs**
- **"Canned" trade studies - Cdo, range-payload, cost,…** RDS-Pro Only
- **Carpet Plots & Multivariable Optimizer** RDS-Pro Only

RDS ANALYTICAL METHODS

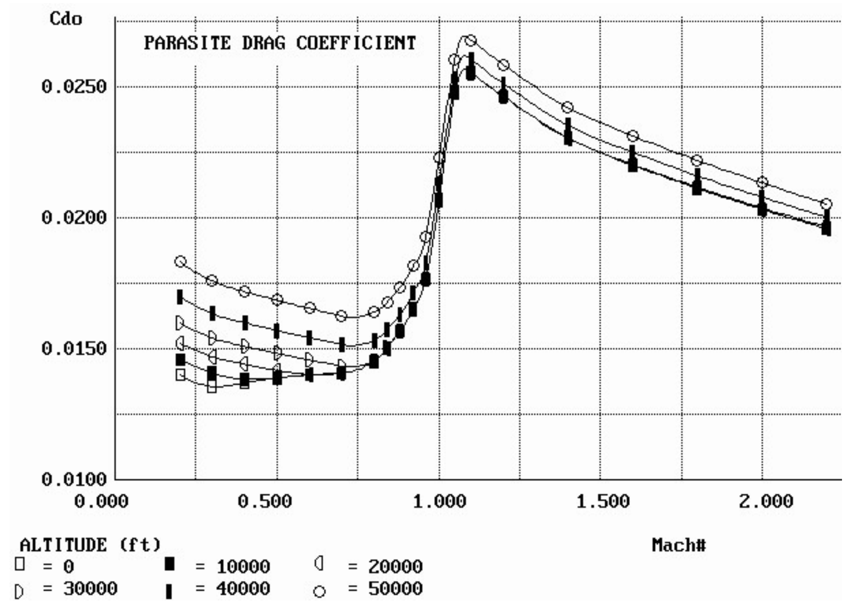
- **Most methods are described in Dr. Raymer's classic text *AIRCRAFT DESIGN: A Conceptual Approach*, now in its 5th edition**
- **With 50,000 copies sold, it is the premier textbook in the world today for learning aircraft conceptual design**
- **Well-worn copies are commonly seen in industry and government design offices**

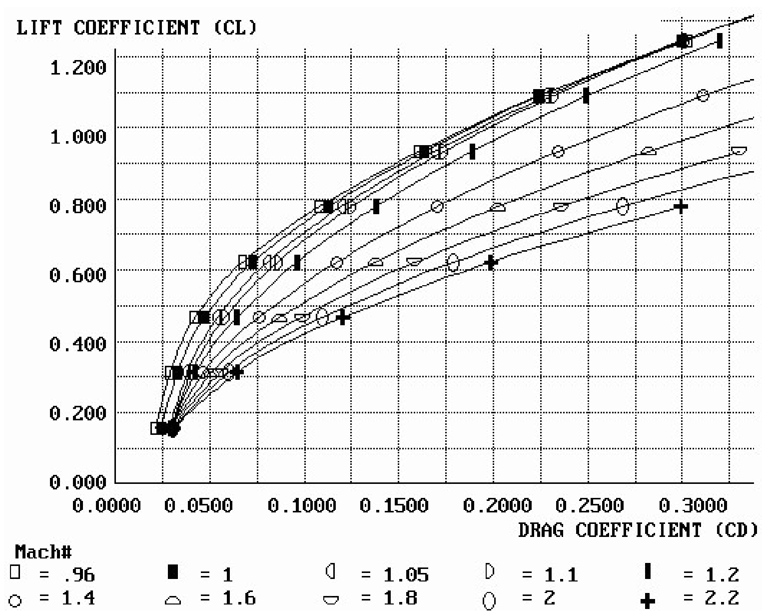


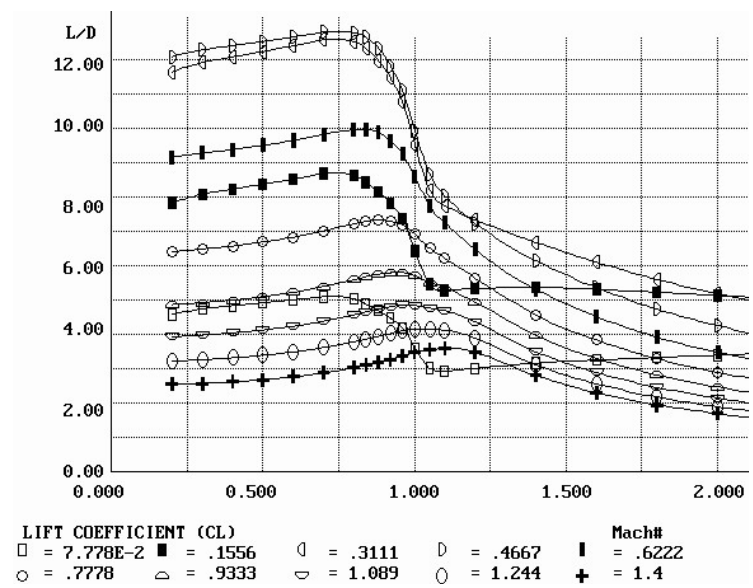




AERODYNAMICS RESULTS







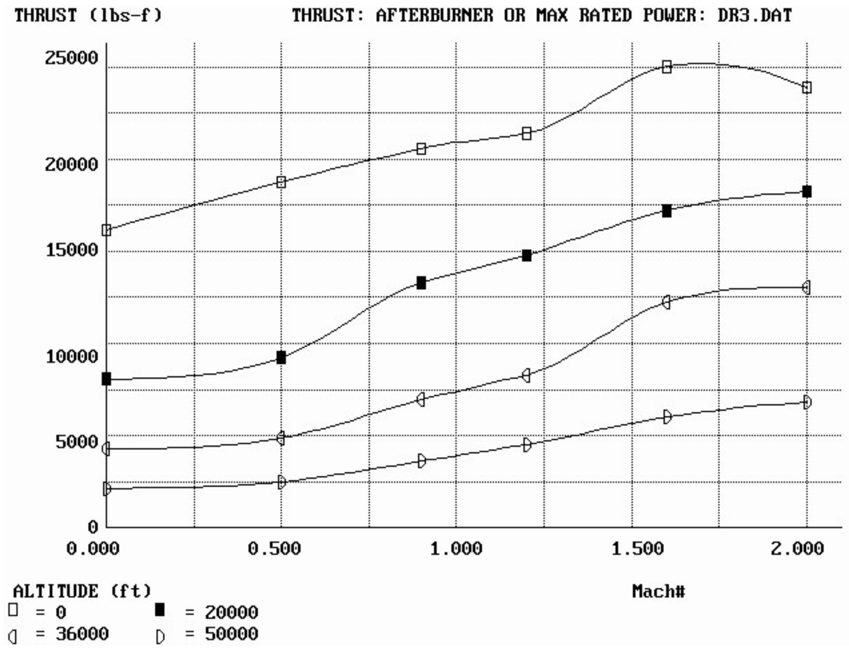
TYPICAL WEIGHTS RESULTS

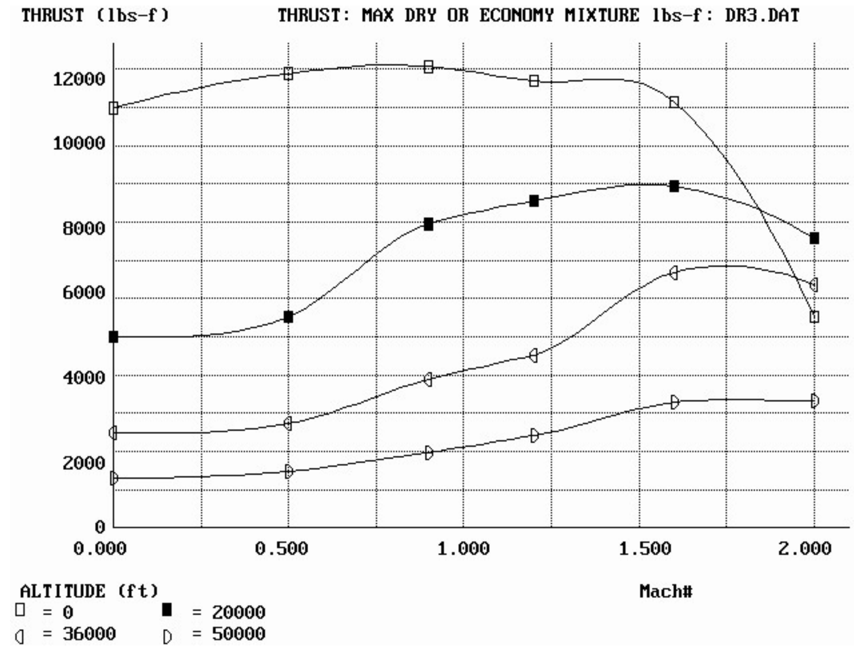
FIGHTER/ATTACK GROUP WEIGHT STATEMENT: MKS Units

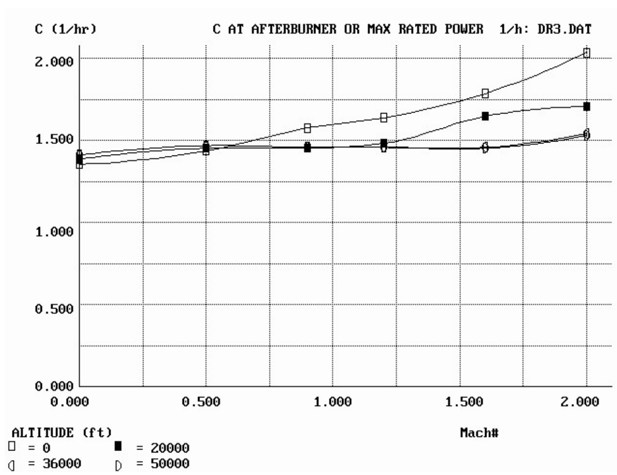
STRUCTURES GROUP	2053.1	EQUIPMENT GROUP	1391.0
Wing	662.0	Flight Controls	297.4
Horiz. Tail	127.2	Instruments	55.7
Vert. Tail	0.0	Hydraulics	77.9
Fuselage	713.9	Electrical	323.5
Main Lndg Gear	286.4	Avionics	448.9
Nose Lndg Gear	77.6	Furnishings	98.7
Engine Mounts	17.7	Air Conditioning	86.5
Firewall	26.7	Handling Gear	2.4
Engine Section	9.5	MISC EMPTY WEIGHT	453.6
Air Induction	132.0	TOTAL WEIGHT EMPTY	4965.6
PROPULSION GROUP	1067.9	USEFUL LOAD GROUP	2509.6
Engine(s)	688.1	Crew	99.8
Tailpipe	0.0	Fuel	2006.1
Engine Cooling	78.0	Oil	22.7
Oil Cooling	17.2	Payload	381.0
Engine Controls	9.1	Passengers	0.0
Starter	17.9	Misc Useful Load	0.0
Fuel System	257.6	TAKEOFF GROSS WEIGHT	7475.2

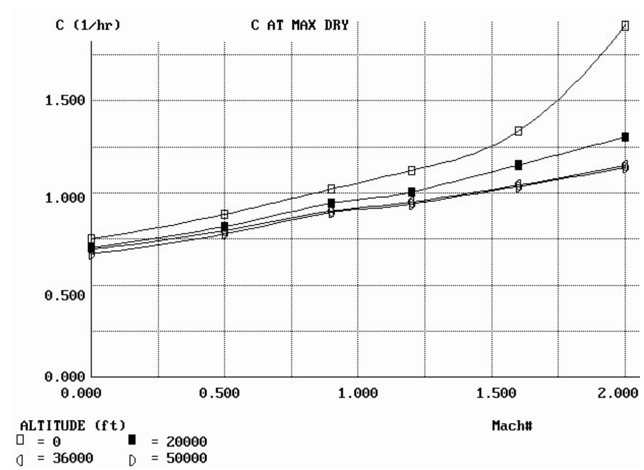
EMPTY CG= 7.2 LOADED-NO FUEL CG= 7.1 GROSS WT CG= 7.0

PROPULSION RESULTS - JET

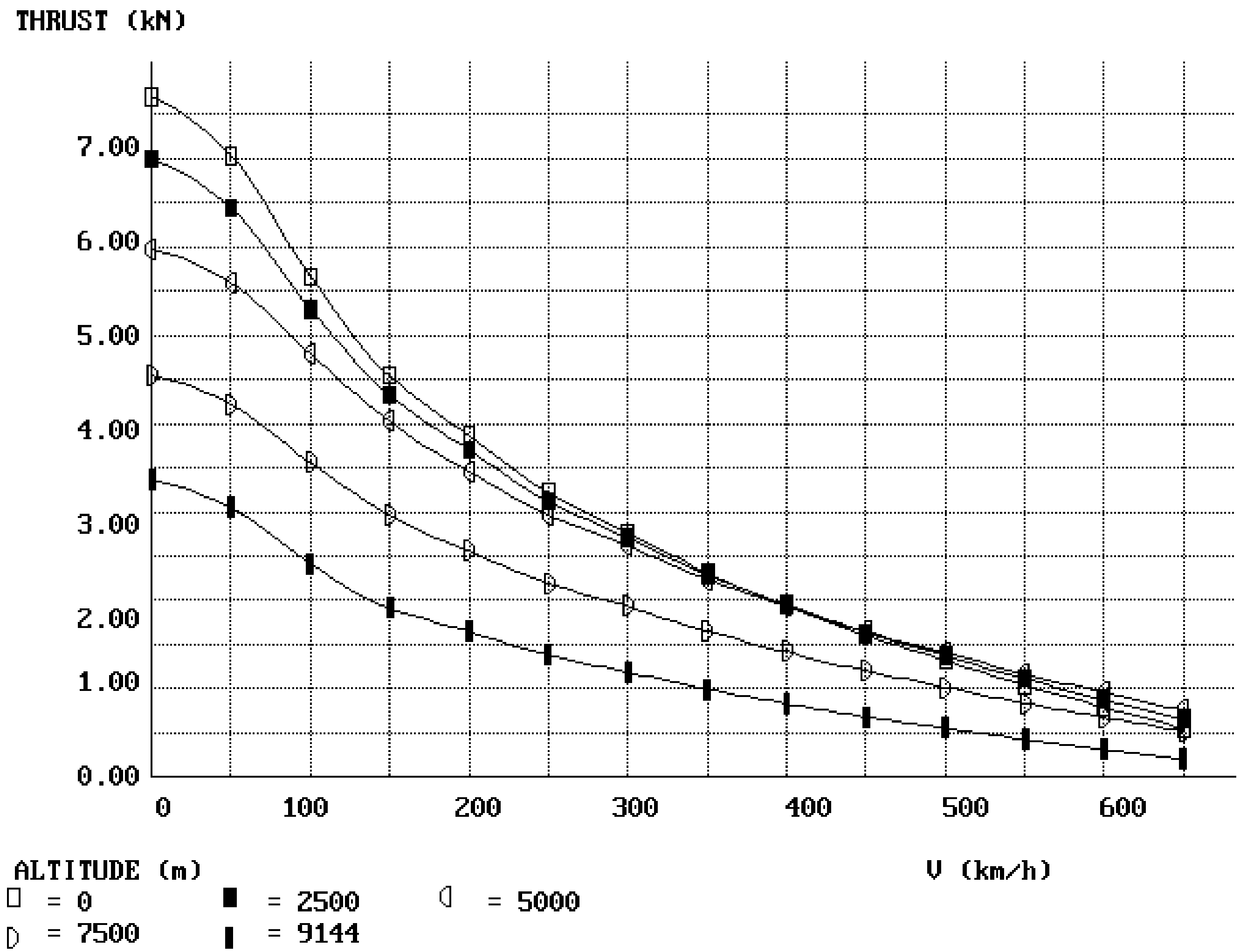








PROPELLER ANALYSIS RESULTS

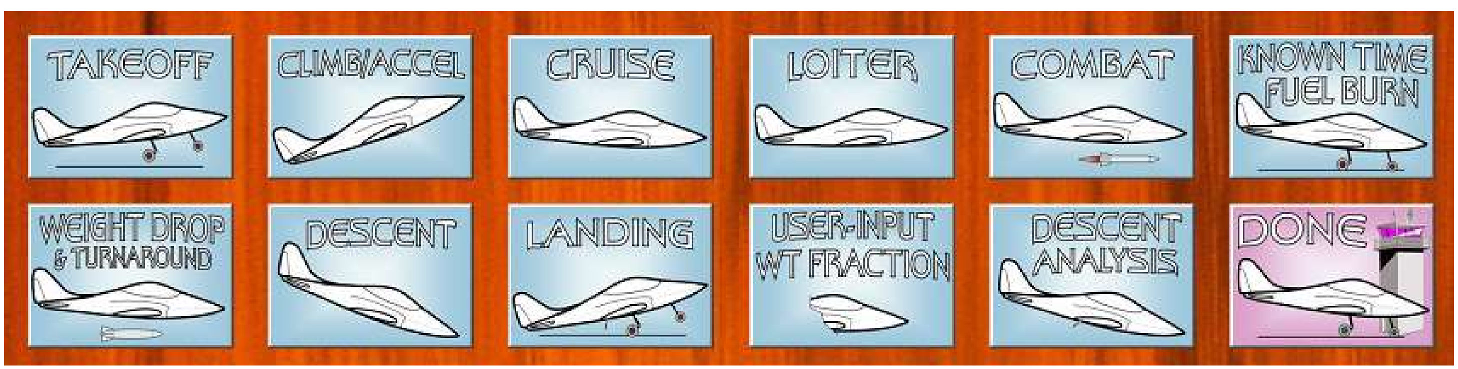


Sizing and Mission Range

•Typical Sizing Missions can be selected from a list, or you can pick mission segments from the buttons shown below. Then you are taken to an input grid to enter required information such as range, throttle setting, speed, and altitude. A complicated new mission can be created in 5 minutes or less.

•When Do Analysis is selected, the aircraft in your Aircraft Data File (DAT) is sized to the mission, or the range that your aircraft can attain is calculated. RDS^{win} then shows a full printout.

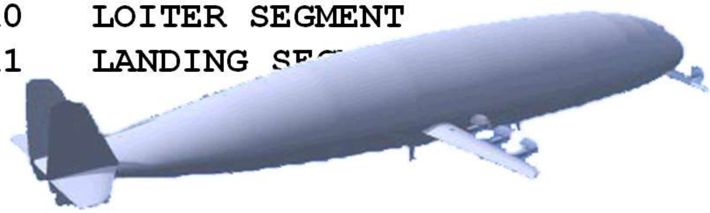
•In RDS^{win}-Pro, automatic trade studies such as range vs. SFC can be done instantly. Students must do such trades "manually," using RDS to calculate the effect of changes in the parametric variable. With RDS this only takes 5-10 minutes.



SIZING & RANGE CALCULATION

Sample: Ohio Airship Dynalifter

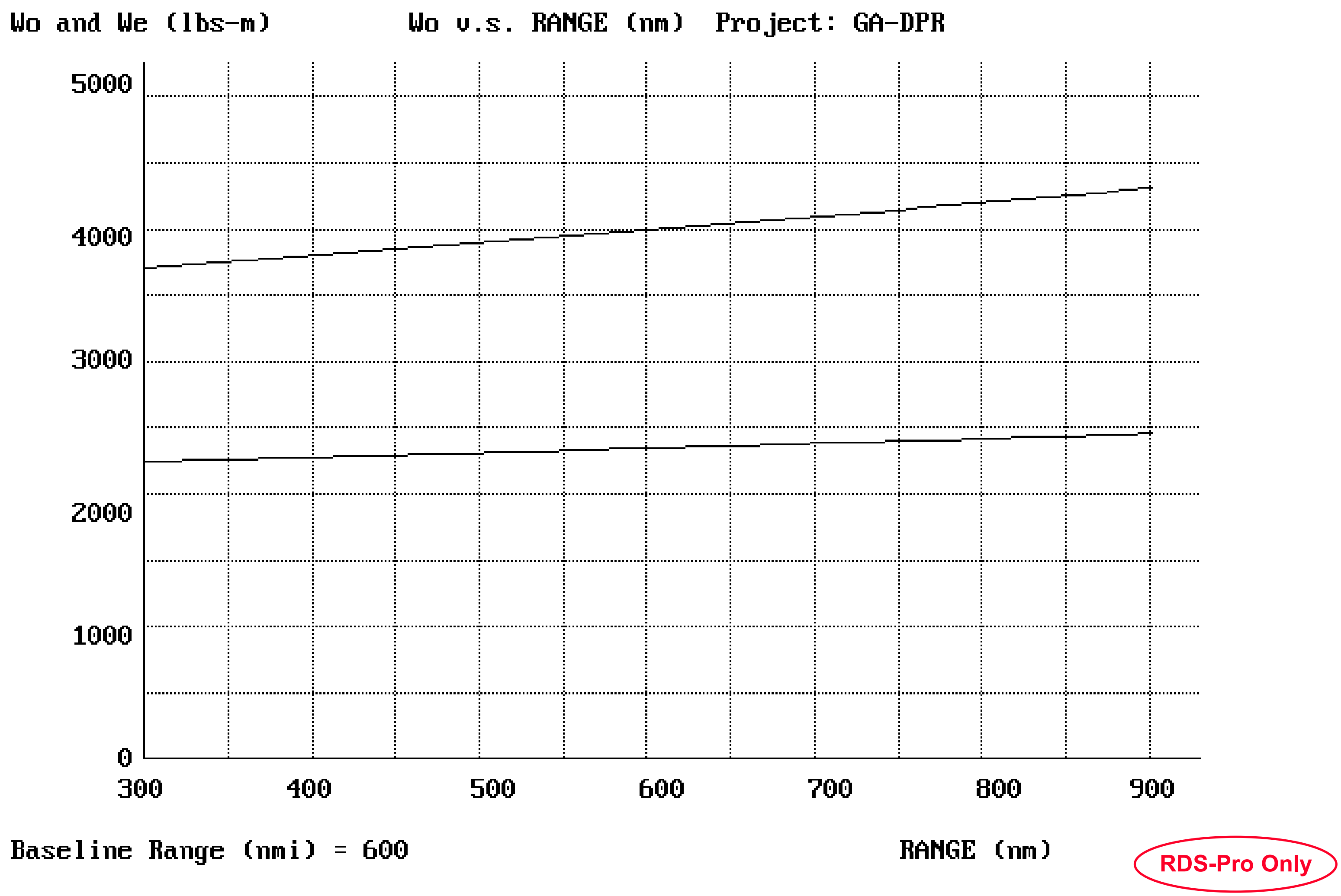
MISSION SEGMENT		MISSION SEGMENT WEIGHT FRACTION	Wi/WO	FUEL BURN (lbs-m) SEGMENT	FUEL BURN (lbs-m) TOTAL
1	TAKEOFF SEGMENT	0.9990	0.9990	227.2	227.2
2	TAKEOFF SEGMENT	0.9992	0.9982	177.2	404.4
3	CLIMB and/or ACCEL.	0.9935	0.9917	1453.0	1857.3
4	CRUISE SEGMENT	0.5401	0.5356	102625.5	104482.9
5	DESCENT ANALYSIS	0.9990	0.5351	125.8	104608.6
6	LOITER SEGMENT	0.9945	0.5321	667.0	105275.7
7	CLIMB and/or ACCEL.	0.9959	0.5299	493.3	105769.0
8	CRUISE SEGMENT	0.9595	0.5084	4833.8	110602.8
9	DESCENT ANALYSIS	0.9989	0.5079	123.0	110725.8
10	LOITER SEGMENT	0.9949	0.5053	587.3	111313.1
11	LANDING SE	0.9990	0.5048	113.7	111426.8
				Reserve & trap :	6685.6
				Total fuel :	118112.4



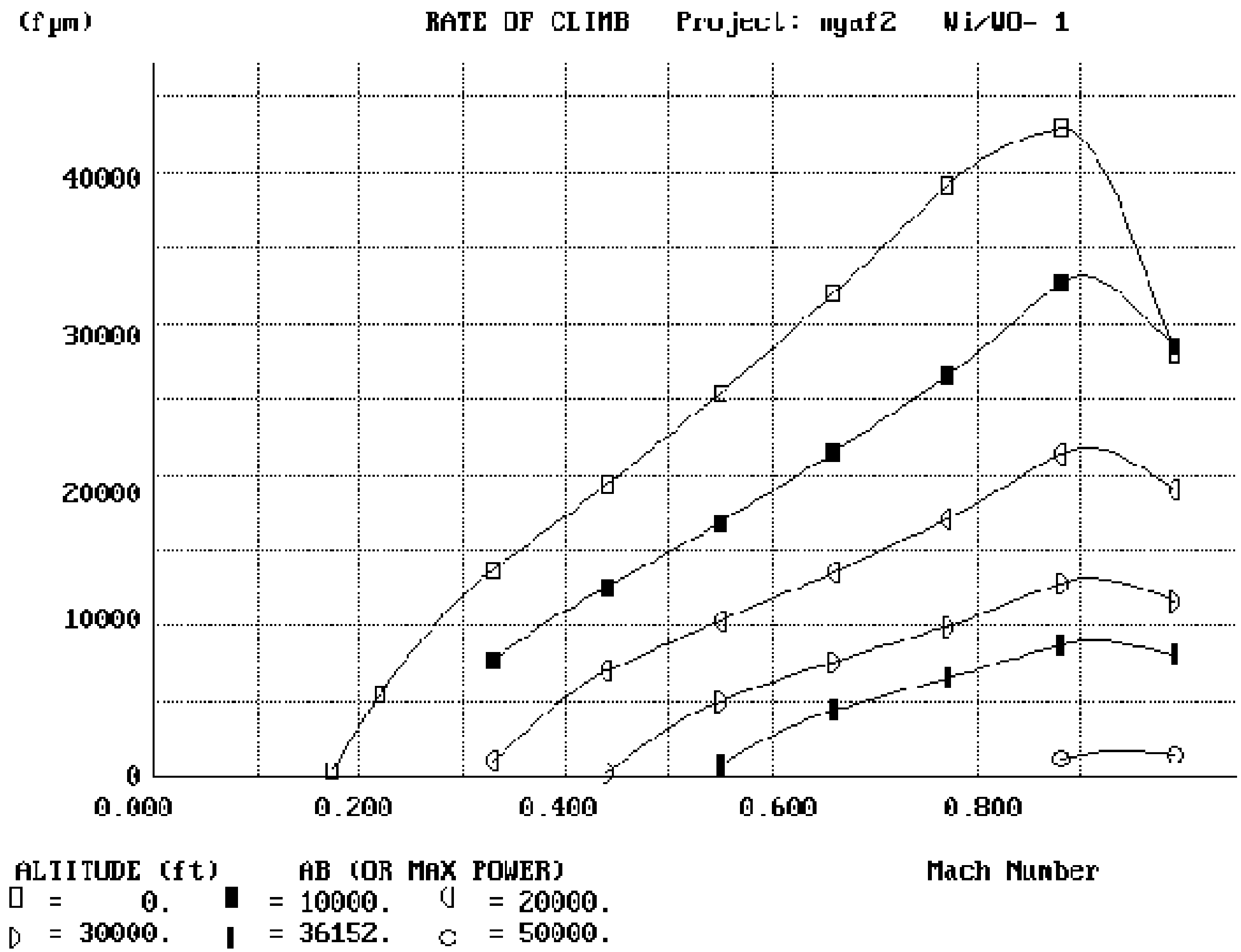
Seg. 4	CRUISE :	100.0 kts at	10000.0 ft	RANGE =	2880.5 nmi
Seg. 6	LOITER :	70.0 kts at	2000.0 ft	ENDURANCE =	0.3 hrs
Seg. 8	CRUISE :	75.0 kts at	10000.0 ft	RANGE =	200.0 nmi
Seg. 10	LOITER :	60.0 kts at	2000.0 ft	ENDURANCE =	0.3 hrs

TOTAL RANGE =	3080.5	TOTAL LOITER TIME =	0.66
FUEL WEIGHT =	118094.3	EMPTY WEIGHT =	250637.7
USEFUL LOAD (less Wf)=	81,268.0	AIRCRAFT GROSS WEIGHT =	450000.0

IMPACT OF RANGE ON SIZED WEIGHT



RATE OF CLIMB



RDS COST ANALYSIS: CHECK CASE F-16

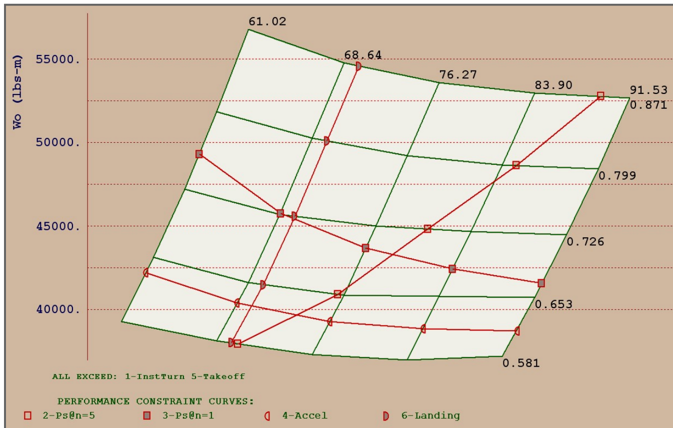
RAND DAPCA IV MODEL

```
                                                     PROJECT FILE: F16COST
Investment Cost Factor = 1.15                            15 Aircraft/month
    DAPCA Fudge Factor = 1.25                                   ( 1994 k$)
-------------------------------------------------------------------------------
    ENGINEERING HOURS :     21,093.        ENGINEERING COST : $  1,641,001.
        TOOLING HOURS :     12,373.            TOOLING COST : $    988,592.
  MANUFACTURING HOURS :     65,853.      MANUFACTURING COST : $  4,344,331.
QUALITY CONTROL HOURS :     10,948.    QUALITY CONTROL COST : $    798,663.
                                         DEVEL SUPPORT COST : $    289,498.
                                           FLIGHT TEST COST : $    164,698.
                                         MFG MATERIALS COST : $  2,049,986.
                                       ENGINE PROD COST (ea): $      3,300.
                                        AVIONICS (per plane): $      3,000.

          TOTAL HOURS :    110,267.               TOTAL  COST : $ 15,946,769.
                                          COST PER AIRCRAFT : $     17,719.
                                         PRICE PER AIRCRAFT : $     20,376.
-------------------------------------------------------------------------------
```

Wikipedia says F-16C/D price was $18.8 million in 1998 dollars

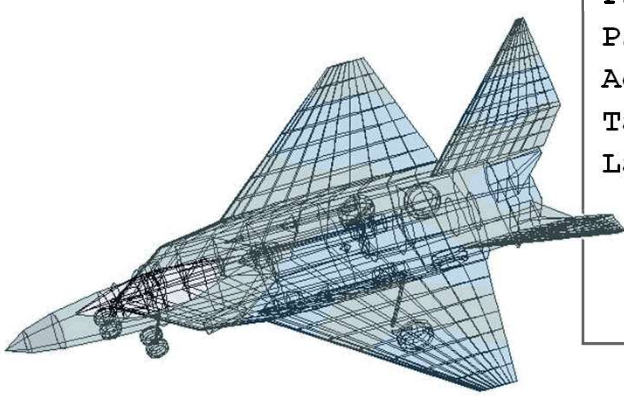
RDS Carpet Plot & MDO



	Minimum	Baseline	Maximum	Best
T/W	0.5808	0.726	0.8712	0.6223
W/S	61.02	76.271	91.53	68.284
ASPECT	2.	2.5	3.	3.
SWEEP	38.4	48.	57.6	39.314
TAPER	0.096	0.12	0.144	0.112
t/c	0.036	0.045	0.054	0.054
Fus l/d	11.08	13.846	16.62	16.532
CL-dsgn	0.16	0.2	0.24	0.2222
Sized Wo		45004		37208
Sized We		23870		20287
Sized Wf		18004		13791

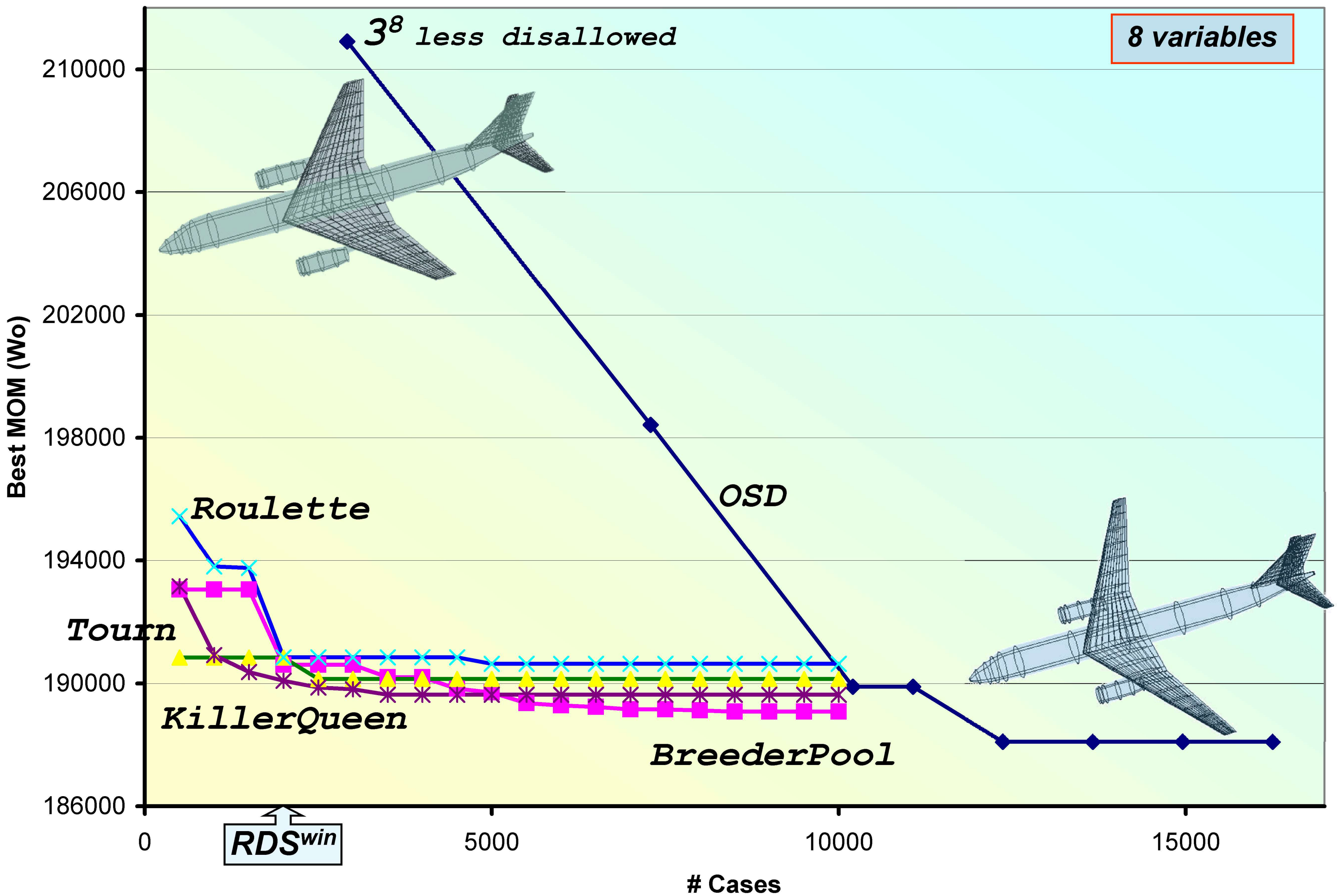
Perf:	Required	Baseline		Best
InstTurn	20.	25.819		27.918
Ps@n=5	0.0	53.072		115.32
Ps@n=1	0.0	30.679		44.2
Accel	30.	24.257		29.709
Takeoff	2000.	1221.3		1258.
Landing	2000.	2194.2		1964.8

		Baseline		Best
PRICE k$		40547		36173
LCC k$		93953		88241



RDS-Pro Only

MDO Results: Transport



ROAST: 3-DOF Trajectory Simulation

"RDS Optimal AeroSpace Trajectories" or "Raymer's POST Approximation"

Rapid simulation of aircraft flight path or rocket vertical launch

Optimal trajectories or direct user control

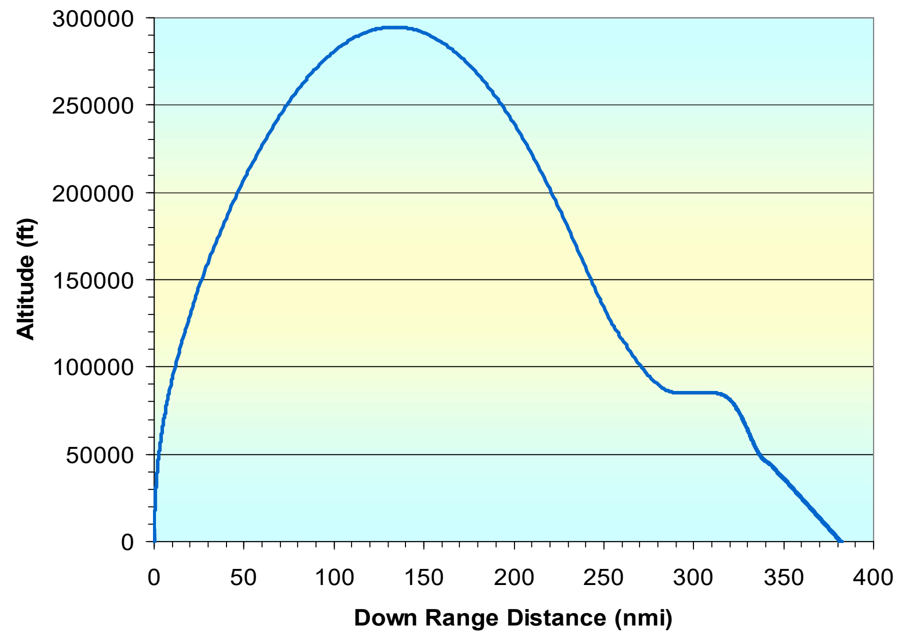
Time step integration of *F=ma*:

- **Gravitational weight vector**
- **Round-Earth centrifugal force**
- **Staging & Orbit Circularization**

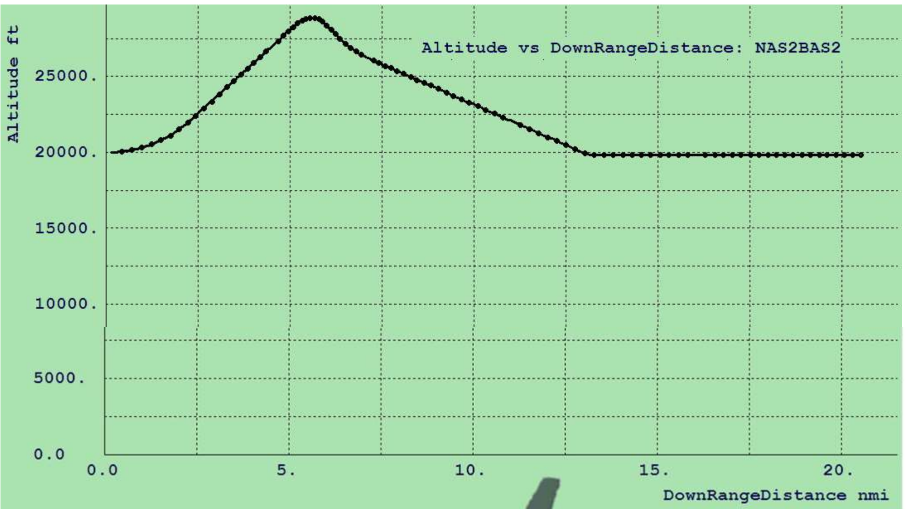
Vehicle data from Aircraft Data File

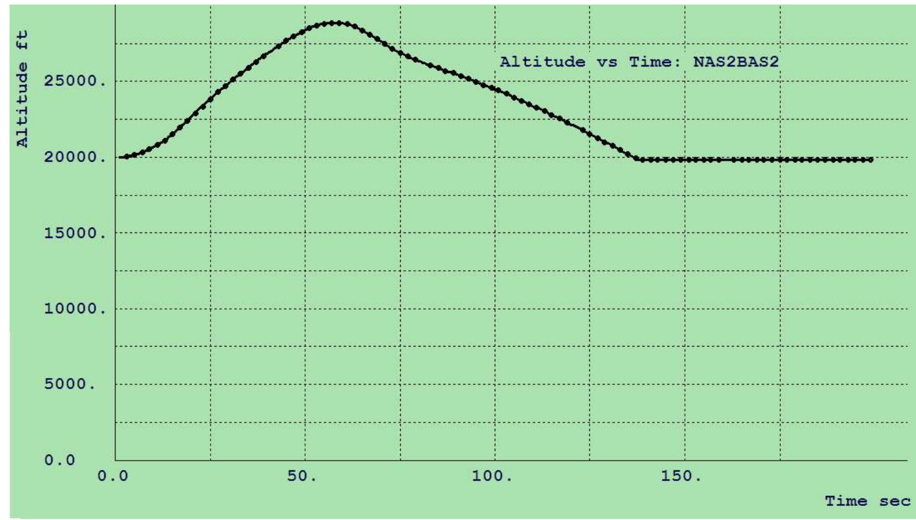
- **Thrust & SFC or I_{SP}**
- **Lift and Drag (Newtonian if >M6)**
- **Weights**

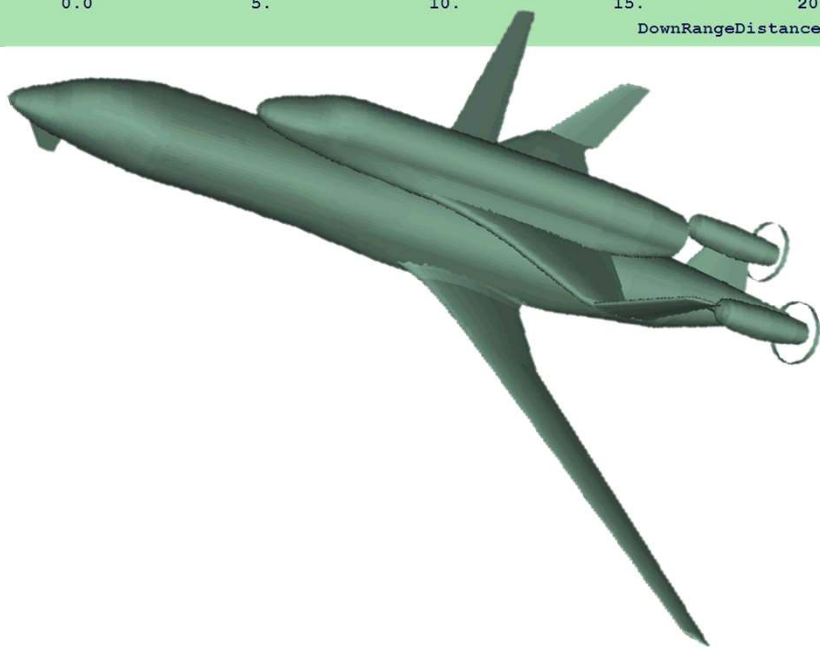
User-input limits on q, M, n_{axial}, $n_{lateral}$

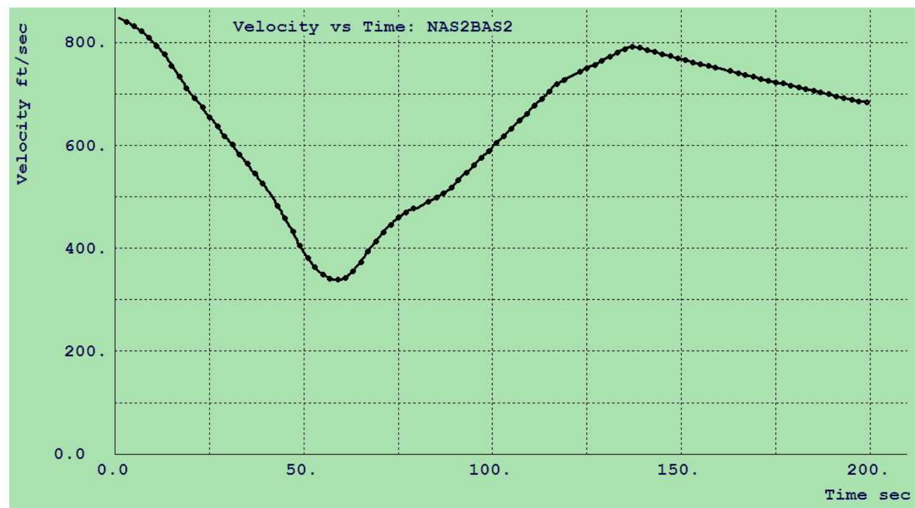


ROAST Trajectory Results - Pullup to Launch



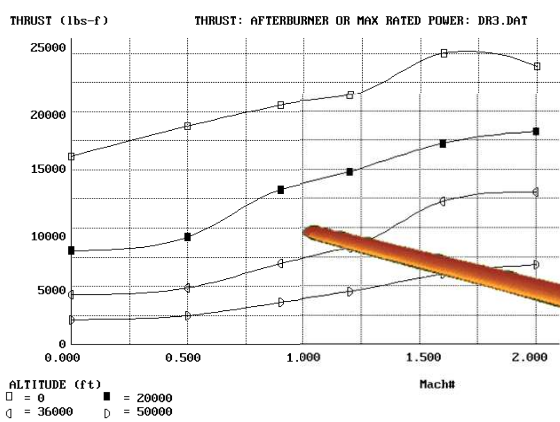


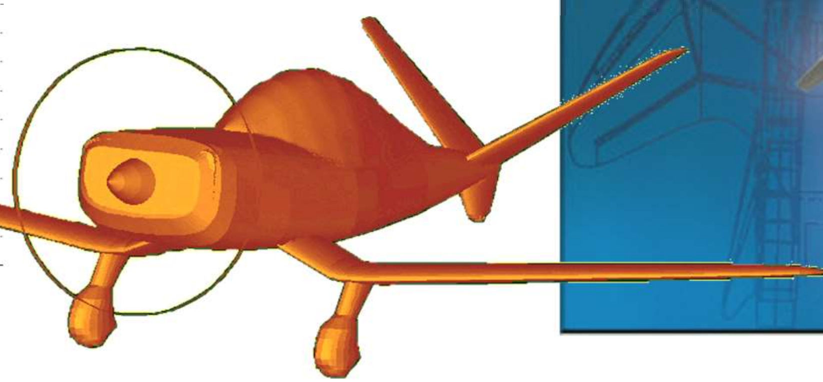


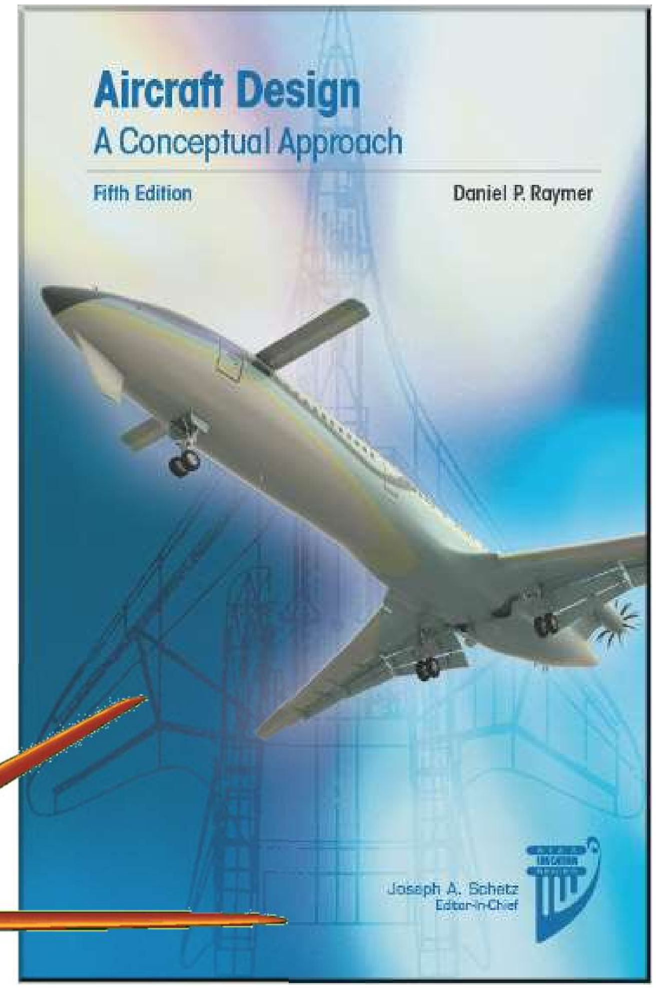


RDS ANALYTICAL METHODS

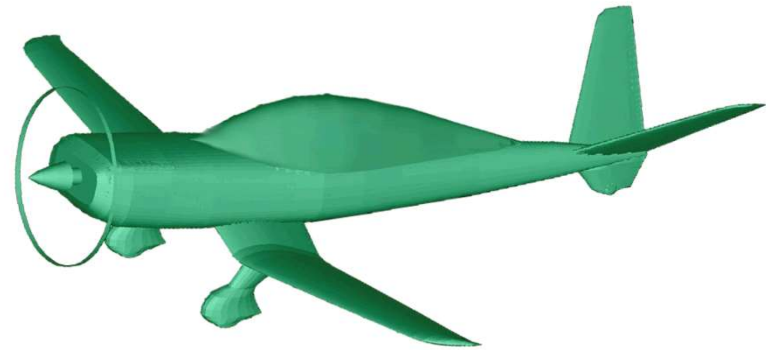
- **Most methods are described in Dr. Raymer's classic text *AIRCRAFT DESIGN: A Conceptual Approach*, now in its 6th edition**
- **With 50,000 copies sold, it is the premier textbook in the world today for learning aircraft conceptual design**
- **Well-worn copies are commonly seen in industry and government design offices**







Wow, Great Program !
– where do I get it and
what does it cost?



Nice of you to say so!

- **RDS^{win}-Student is available separately or bundled with Dr. Raymer's textbook. It is fairly cheap, priced as "charity" to students and is not to be used for professional (money-making) activities. Get it at www.aiaa.org or www.amazon.com or other retailers. Make sure the seller sends you RDS^{win}, not the old DOS version!**
- **RDS^{win}-Pro is available only from Conceptual Research Corporation. It is relatively cheap – one customer has estimated that it would take at least $100,000 per year to develop and support a similar capability in-house.**

For more information see *www.aircraftdesign.com*

This document is not an offer to sell nor a promise of functionality nor a warrantee of any sort. RDS is delivered with a "shrink-wrap" license agreement which supersedes any other warrantees, explicit, implied, or assumed.

RDS^{win}-Stud vs. RDS^{win}-Pro

- RDS^{win}-Student is written so students don't waste time doing calculations
- RDS^{win}-Pro is for professionals who work in industry, government, or academia to develop and analyze new aircraft concepts. It includes:
  - SuperConic Surface Component Design (4th degree Bezier Polynomical)
  - Break mission into small step sizes for better sizing, range, and climb accuracy
  - Find optimal cruise, loiter, and climb during sizing and range analysis
  - Do automatic sizing trade studies – drag, SFC, weight, payload, and range
  - Input and use jet engine part-power tables
  - Use alternative atmosphere models (ISO+10, etc.)
  - Calculate effects of winds on range and sizing calculations
  - Customize analysis constants and Leading Edge Suction Schedule
  - Underlay images for 3D "tracing", allowing quick modeling of existing designs
  - Create standard NACA airfoils, and import airfoils data in common formats
  - Automatically scale design to match sizing and MDO (wings, tails, fuselage, tires, gear struts, engine, inlet, nacelle, tanks, etc…)
  - Export design layout in DXF, RhinoCAD, and VSAERO formats
  - Carpet Plots and Multidisciplinary Design Optimizer (MDO) including GA
  - ROAST trajectory code (aircraft, rocket, & launch vehicle time-step performance)

- Compiled from same source code with portions skipped by metacommand