*Presented at:*

**OpenVSP Workshop 2016**

# *ALPINE*

## *Automated Layout with a Python Integrated NDARC Environment*

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

*Presented by:*

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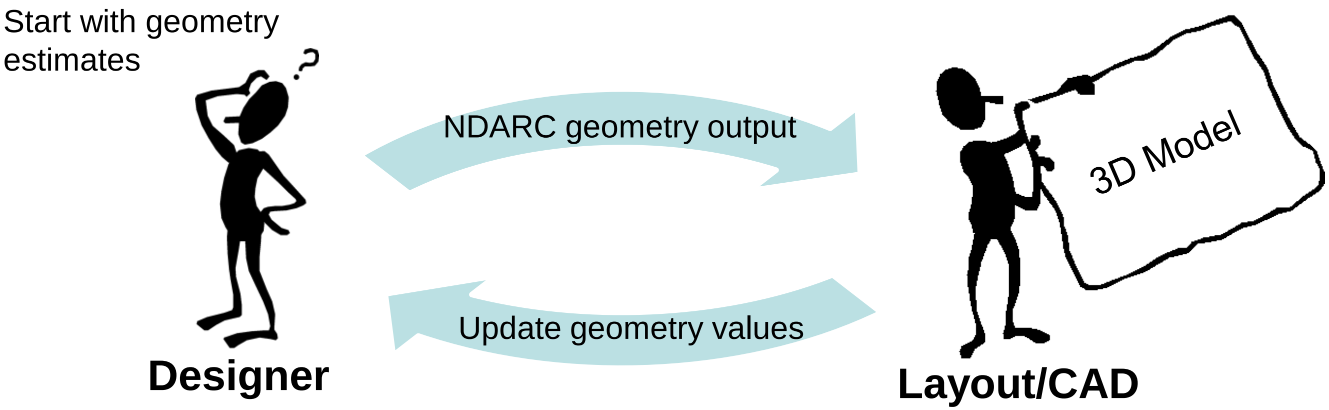
San Jose State University Research Foundation
Aviation Development Directorate, AMRDEC

***8/25/16***

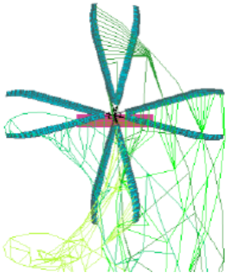
# Our Design Process

- Army Aviation Development Directorate - Concept Design & Assessment Tech Area
- The Army team for conceptual design of rotorcraft
- Our design tool is NDARC (NASA Design and Analysis of Rotorcraft)
- NDARC uses estimates for geometry driven values. In order to close on a design, we iterate with a 3d model
- NDARC does not use a 3d representation to check the values for model consistency
- Use VSP to iterate quickly and reach consistent geometry solution

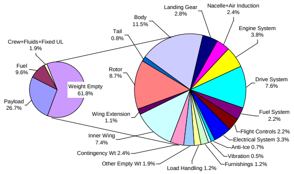


# CD&A Integrated Design Environment

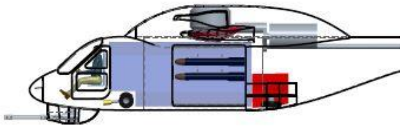
## Aeromechanics



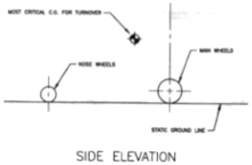
## Mass Properties



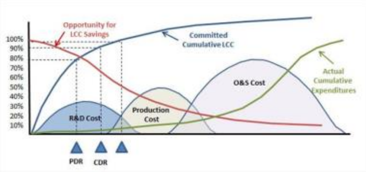
## Internal Layouts



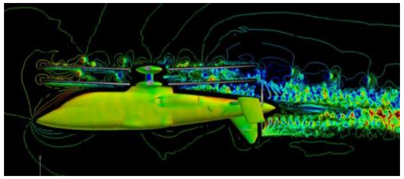
## Landing Gear Calculations



## Cost

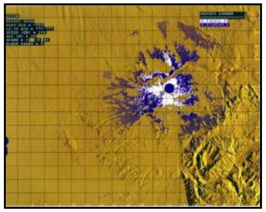


## Aerodynamics

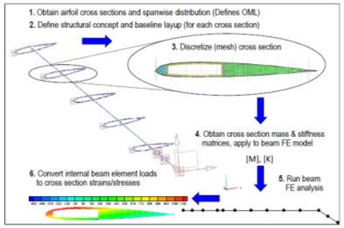


## Model Database / Geometry

## Signatures



## Structures



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2. Define structural concept and baseline layup (for each cross section)

3. Discretize (mesh) cross section

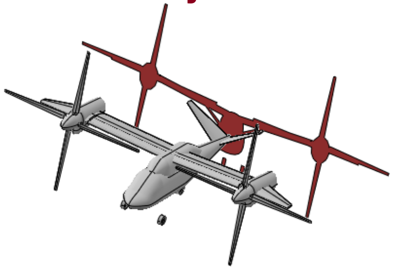
4. Obtain cross section mass & stiffness matrices, apply to beam FE model

[M], [K]

5. Run beam FE analysis

6. Convert internal beam element loads to cross section strains/stresses

## Wetted/Projected Areas



## Presentation Quality Graphics

# CD&A Integrated Design Environment

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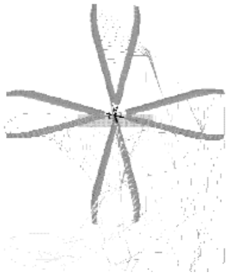
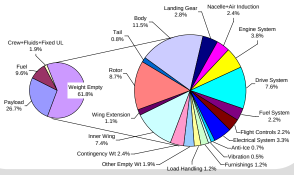


## Mass Properties



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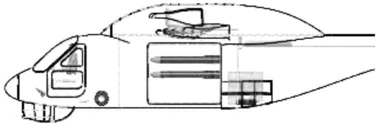

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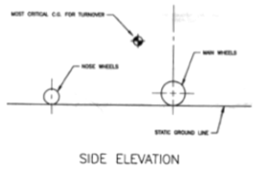

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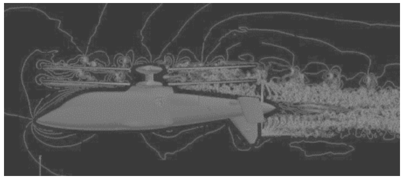

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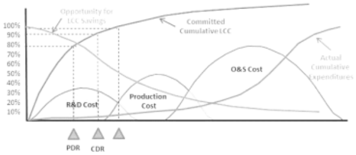

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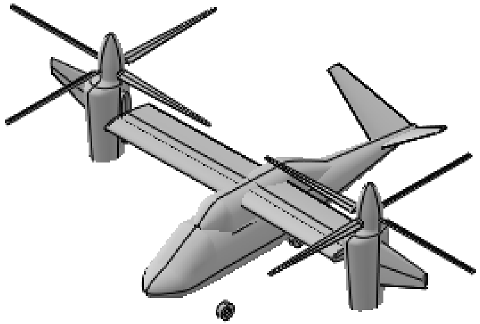

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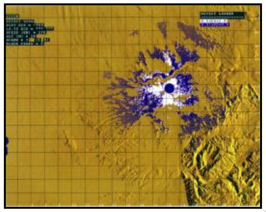

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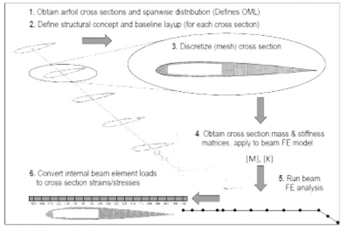

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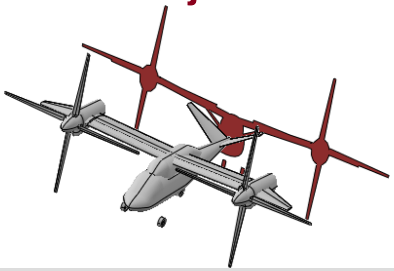

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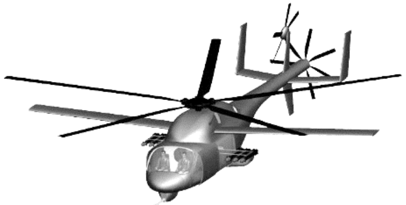


# ALPINE

- Automated Layout with a Python Integrated NDARC Environment (ALPINE)
- ALPINE is a python based toolset to generate rotorcraft geometry from NDARC output
- Allows designers to generate geometry rapidly for visual feedback
- Provides parameter feedback for model updates and optimization

# VSP Python API

- The python wrapper is included in the source code but not in the packaged program
- Provides access to all API calls in python
- One to one translation from Angelscript
- Must be built with VSP on the platform that it will be used on

```
def BuildFuse(x, y, z, L, noseL, CckptL, W, H, boomW, boomH, boomL, cargoL):

    fuse_id = vsp.AddGeom('HeliFuse')

    # Set Geometric Values
    vsp.SetParmVal(vsp.GetParm(fuse_id, "cckLength", "Design"), CckptL)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "FuseHeight", "Design"), H)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "FuseWidth", "Design"), W)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "NoseLength", "Design"), noseL)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "FuseLength", "Design"), L)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "CabinLength", "Design"), cargoL * L)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "BoomDiameter", "Design"), boomW)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "BoomHeight", "Design"), boomH)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "BoomLength", "Design"), boomL)

    # Set Positions of each Fuselage Section
    vsp.SetParmVal(vsp.GetParm(fuse_id, "X_Rel_Location", "XForm"), x)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "Y_Rel_Location", "XForm"), y)
    vsp.SetParmVal(vsp.GetParm(fuse_id, "Z_Rel_Location", "XForm"), z)

    # Set Part Density to Default Zero
    vsp.SetParmVal(vsp.GetParm(fuse_id, "Density", "Mass_Props"), 0.0)

    vsp.SetSetFlag(fuse_id,3,True)

    return fuse_id
```

**The python API allows us to use VSP alongside a python NDARC wrapper and packages such as OpenMDAO**

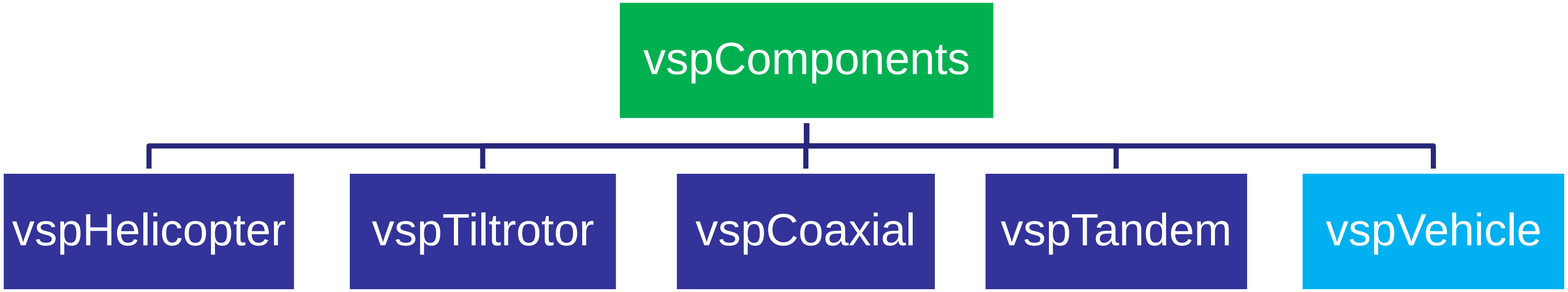
# VSP and NDARC Interface

- The interface chosen to have NDARC transfer to VSP is the optional .geom file output
- The .geom file is a simple text file that contains basic geometric information on all components
- This includes everything from wing and rotor specifics, overall dimensions, component locations, etc
- This geometry file is what is used as input for building a new model in our tool by parsing it into a python dictionary

```
/* Tail 1
  KIND_tail_t1                      = "horizontal"
  area_t1                           =   81.90000
  span_t1                           =   20.97000
  chord_t1                          =   3.905580
  AspectRatio_t1                    =   5.369241
  TailVol_t1                        =  0.7743096
  taper_t1                          =  0.2800000
  sweep_t1                          =   0.000000
  thick_t1                          =  0.1700000
  dihedral_t1                       =   0.00000
  cant_t1                           =   0.000000
  fchord_cont_t1                    =  0.3000000
  fspan_cont_t1                     =  0.8200000
```

# Configurations

- Configurations are separated into classes that build up the components in the .geom file
- Current configurations set up are: SMR, Coaxial, Tandem, and Tiltrotor
- Expandable to any configuration
- Each configuration is built from a library of custom components that chooses the proper components for the configuration
- Configurations complete the geometry information needed to take the NDARC output to a full 3d model

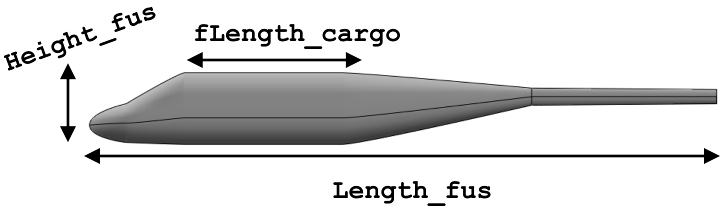


# Component Buildup

- The components used are nearly all custom components.
- We can have components that change based on the parameters given in the geom file.
- This also means that we can create new custom components for unorthodox designs that use the same parameters and they will plug into the code immediately

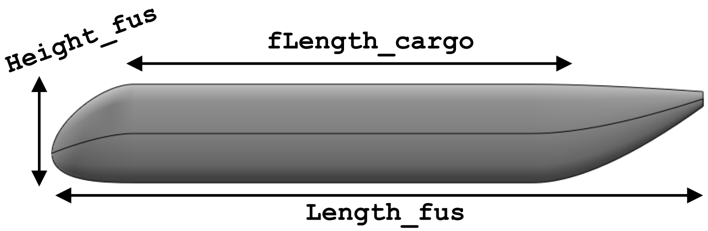
**Built Components**

- Cargo Fuselage
- Utility Fuselage
- Cowling
- Landing Gear Wheels
- Nacelles
- Rotor
- Rotor Hub
- Tilt wing



**Utility Fuselage**

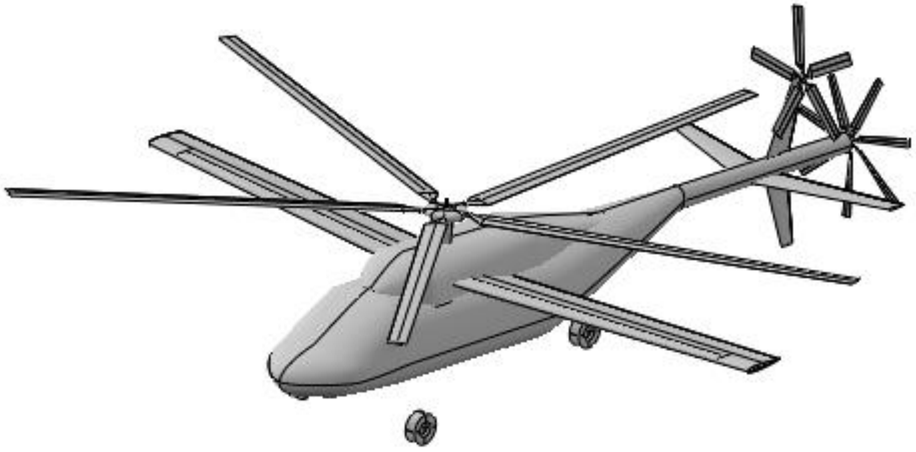
```
/* Fuselage
  Length_fus
  Length_nose
  Length_aft
  Width_fus
  Height_fus
  Swet_fus
  Sproj_fus
  Circum_boom
  Width_boom
  Height_ramp
  fLength_cargo
  KIND_ramp
```



**Cargo Fuselage**

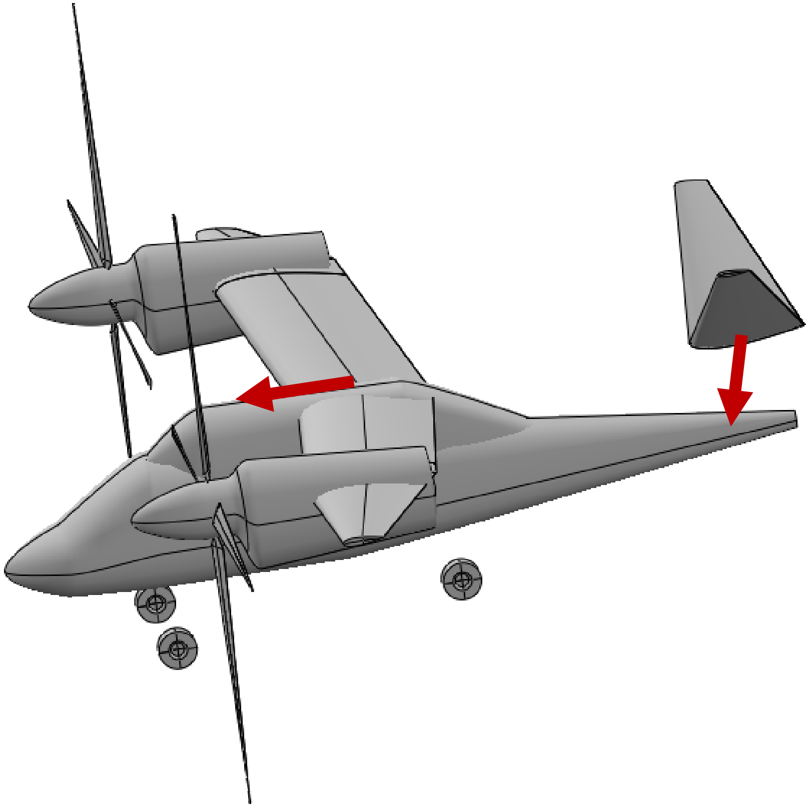
# Model Output

- **Outputs a .vsp3 file**
- **This is an example of a large wing compound made with the tool**
- **The model can now be queried for various values**
  - Wetted area
  - Projected area
  - Wing tank fuel volume
  - Run a geometry update
  - Mass Properties
  - Landing gear sizing and Optimization



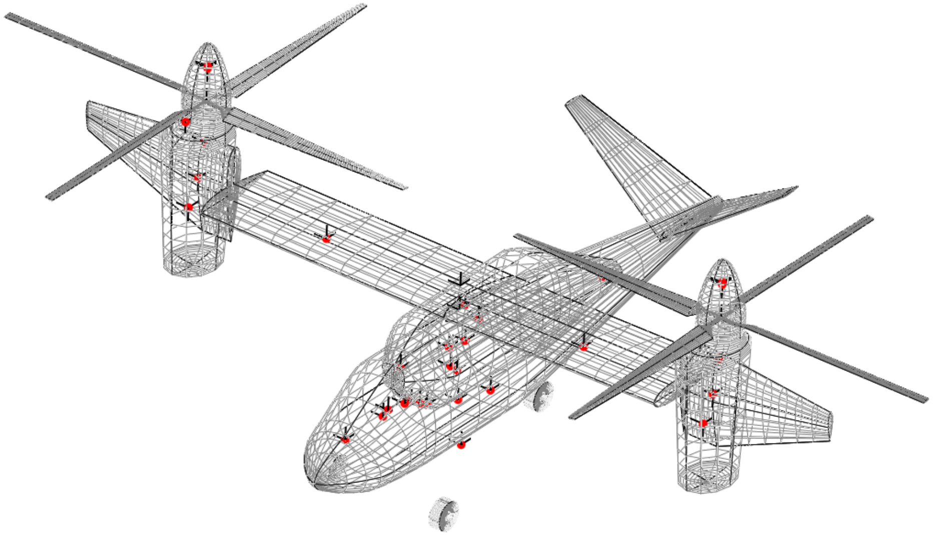
# Geometry Update

- Geometric inconsistencies occur due to NDARC using scaled estimates for geometric placements
- We can run a routine that checks the model versus our own geometry rules
- The routine adjusts placements to fix the inconsistencies of the model to be passed back for iteration



# Mass Properties Analysis

- NDARC design file lists the weight breakdown
- All surfaces are given weight over their areas
- Internal components are represented by ‘BLANKS’ and are assigned corresponding masses
- VSP’s Mass Prop Analysis is run to compute the inertial properties
- You can then use the mass prop output to size and place landing gear



# Demo

# Status and Next Steps

- Current features
  - Reads NDARC geom file and builds from parts library
  - Aircraft: SMR, Tiltrotor, Coaxial, Tandem
  - Mass properties for flight dynamics and tipover
  - Landing gear sizing and layout
  - Tested on Windows, with 32-bit Python 2.7
- Future work:
  - Close loop with NDARC and OpenMDAO
  - Aircraft: UAS (multiple configurations), non-conventional designs
- We are working to release the software as open source to the general public

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