



Universidad
Politécnica
Metropolitana de
Hidalgo

Science and Technology International
Education Program (STIEP)

RESEARCH TECHNIQUES OF ADVANCED CIVILIAN TILTROTOR TECHNOLOGIES

Spring-Summer Internship at Aeromechanics Branch

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OVERVIEW

- Background
- CFD Analysis of Large Civil Tiltrotor (LCTR) for Software Validation
- Tiltrotor test Calibration Rig
- Tiltrotor & TTR Scale Models
- Acknowledgements and References
- Questions

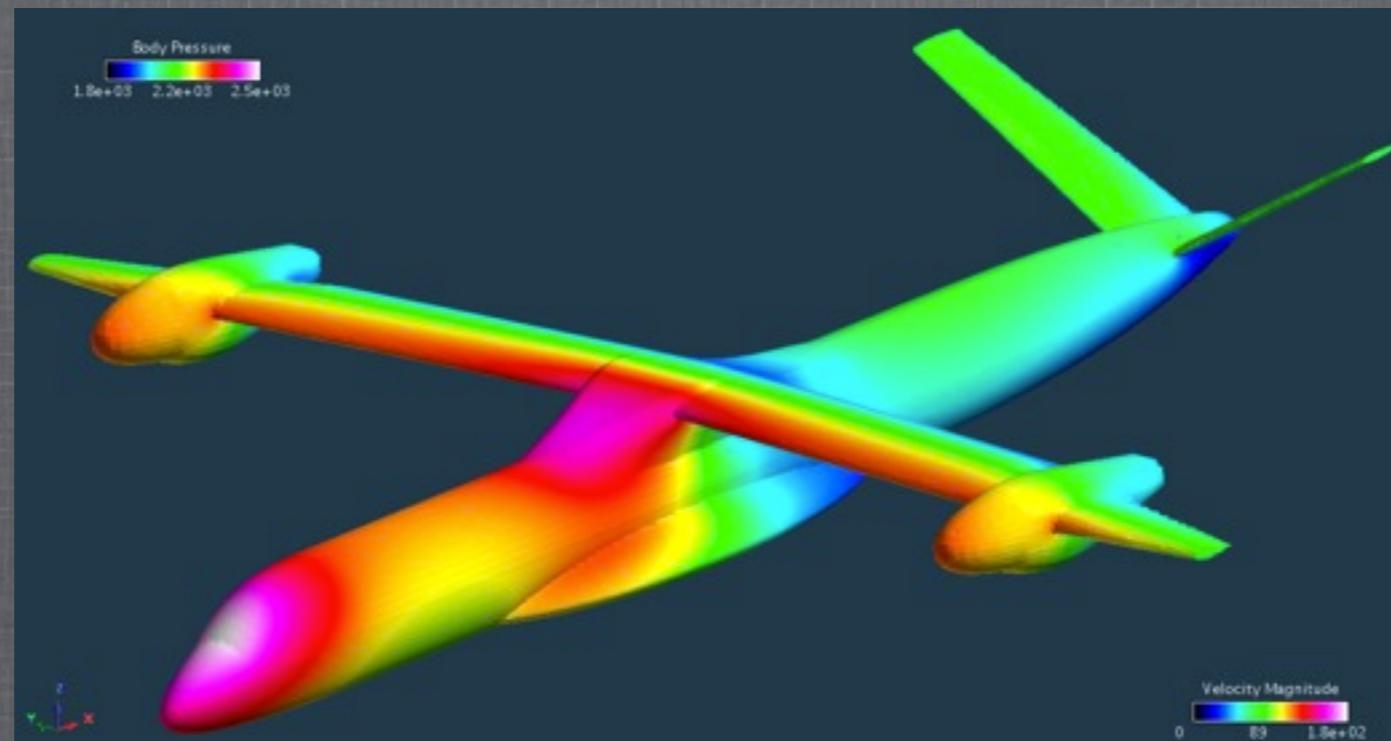
Background

- In response to the present challenges that aerospace industry is facing, NASA Aeromechanics Branch has dedicated significant efforts on research programs with the aim of developing new generation tiltrotor aircraft technologies that will provide an unprecedented alternative in transportation.

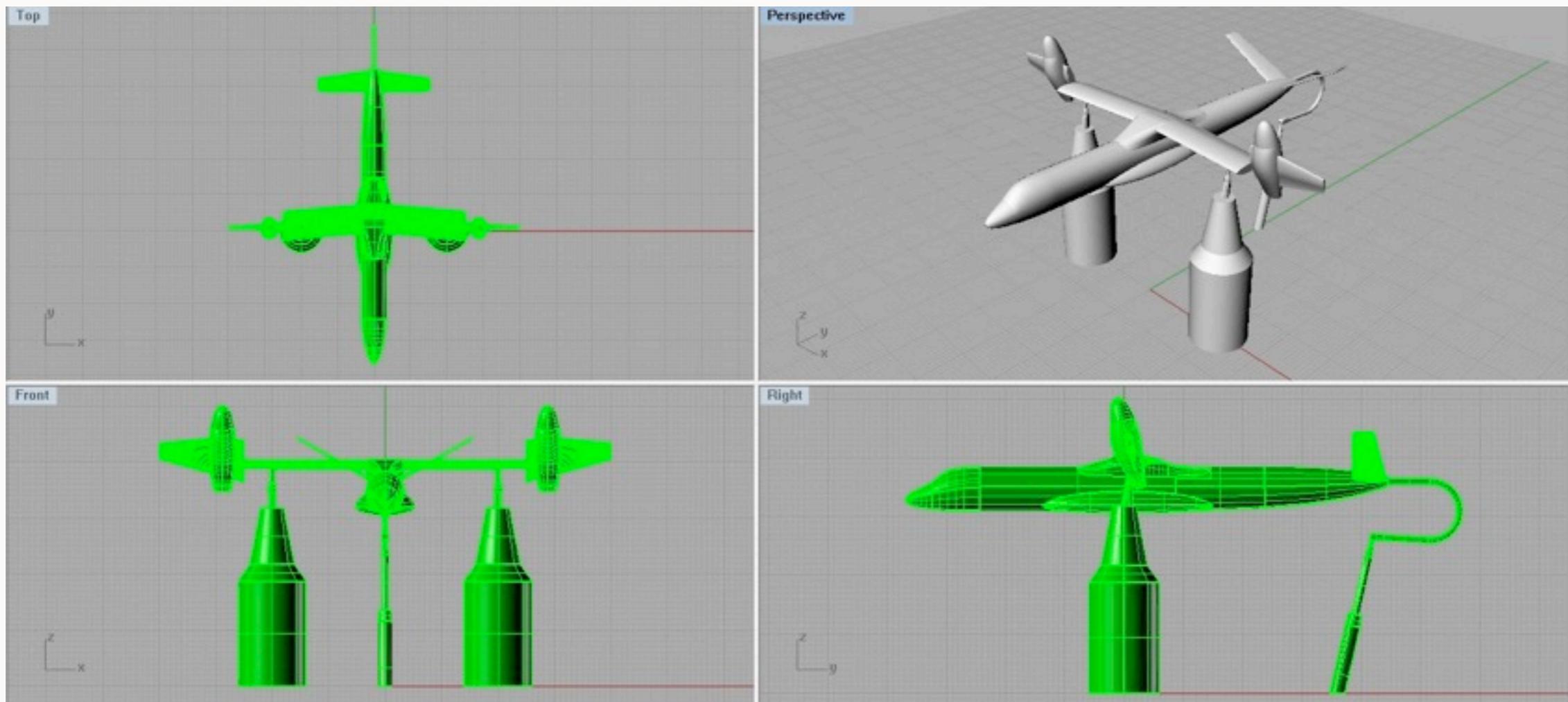




CFD ANALYSIS OF LARGE CIVIL TILTROTOR (LCTR) FOR SOFTWARE VALIDATION



LCTR MODEL



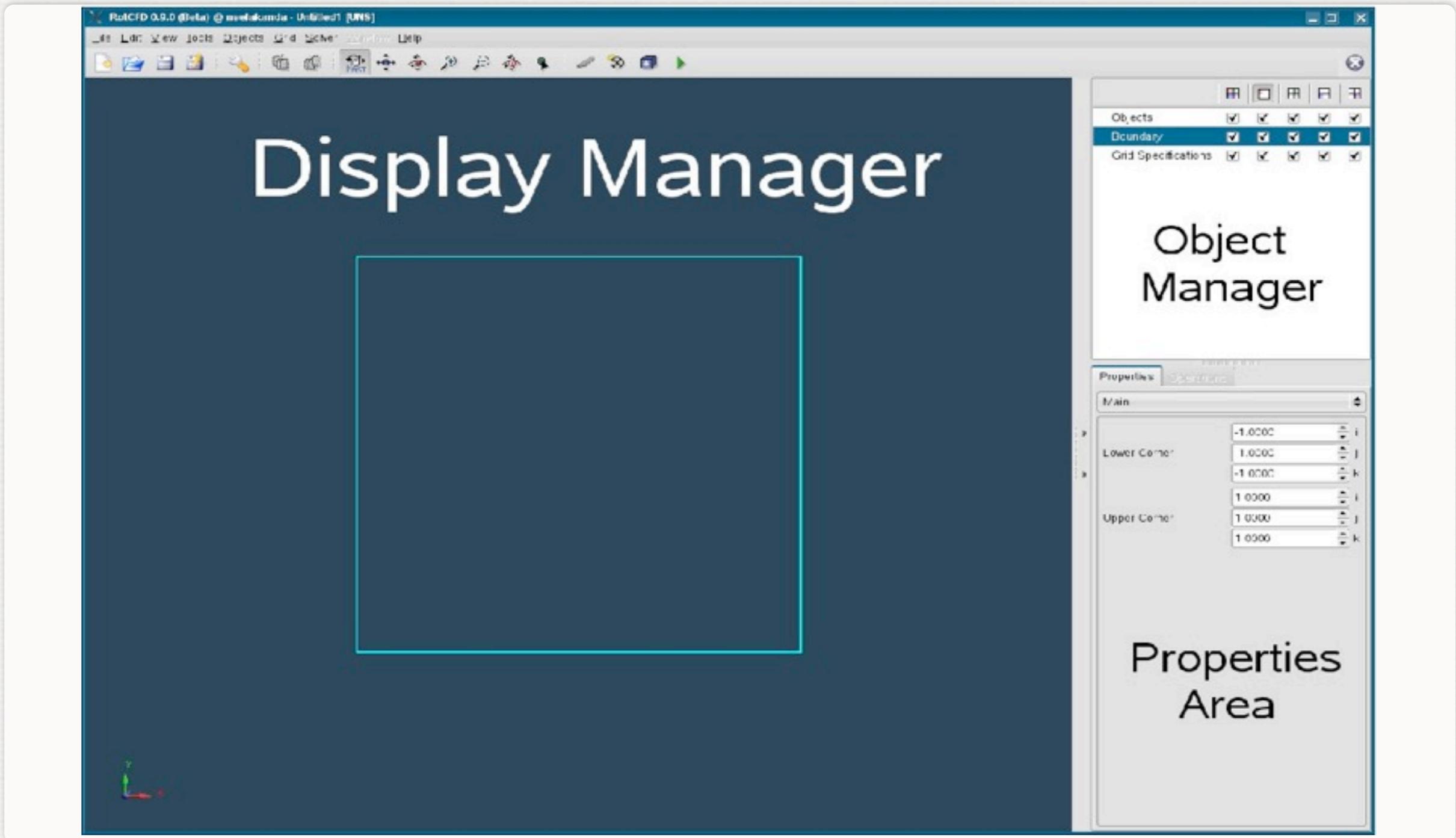
ROTCFD AS A ROTORCRAFT ANALYSIS TOOL

- Software developed by Sukra Helitek Inc.
- Follows the concept of Integrated Design Environment (IDE)
- Allows the simulation of complete rotor configurations including facility effects
- Emphasizes on user-friendliness and efficiency

ROTCFD COMPONENTS

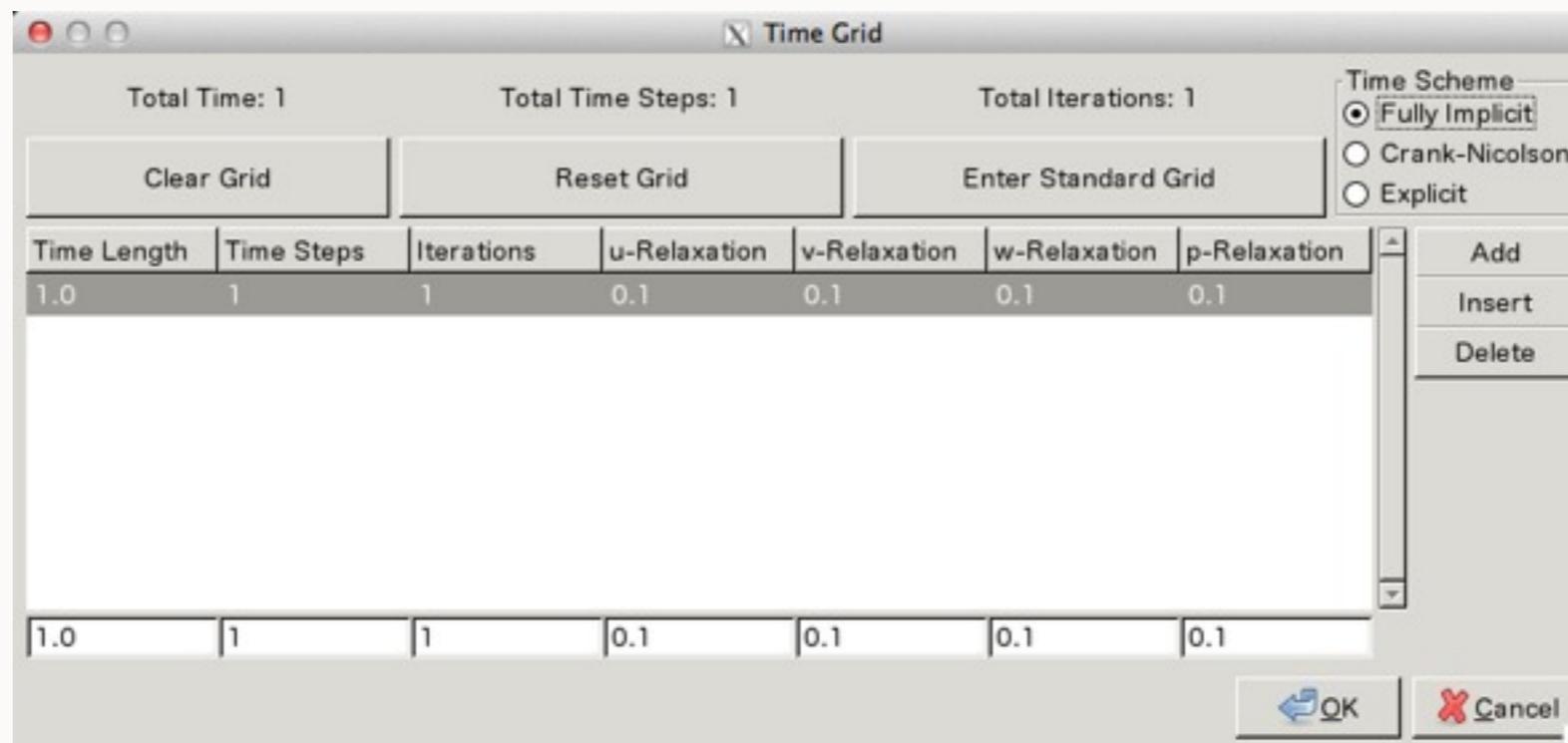
- Graphical User Interface (GUI)
- Geometry manipulation module
- Automated hybrid grid generator
- Rotor module
- Flow solver
- Post processing module

ROTCFD GRAPHICAL USER INTERFACE (GUI)

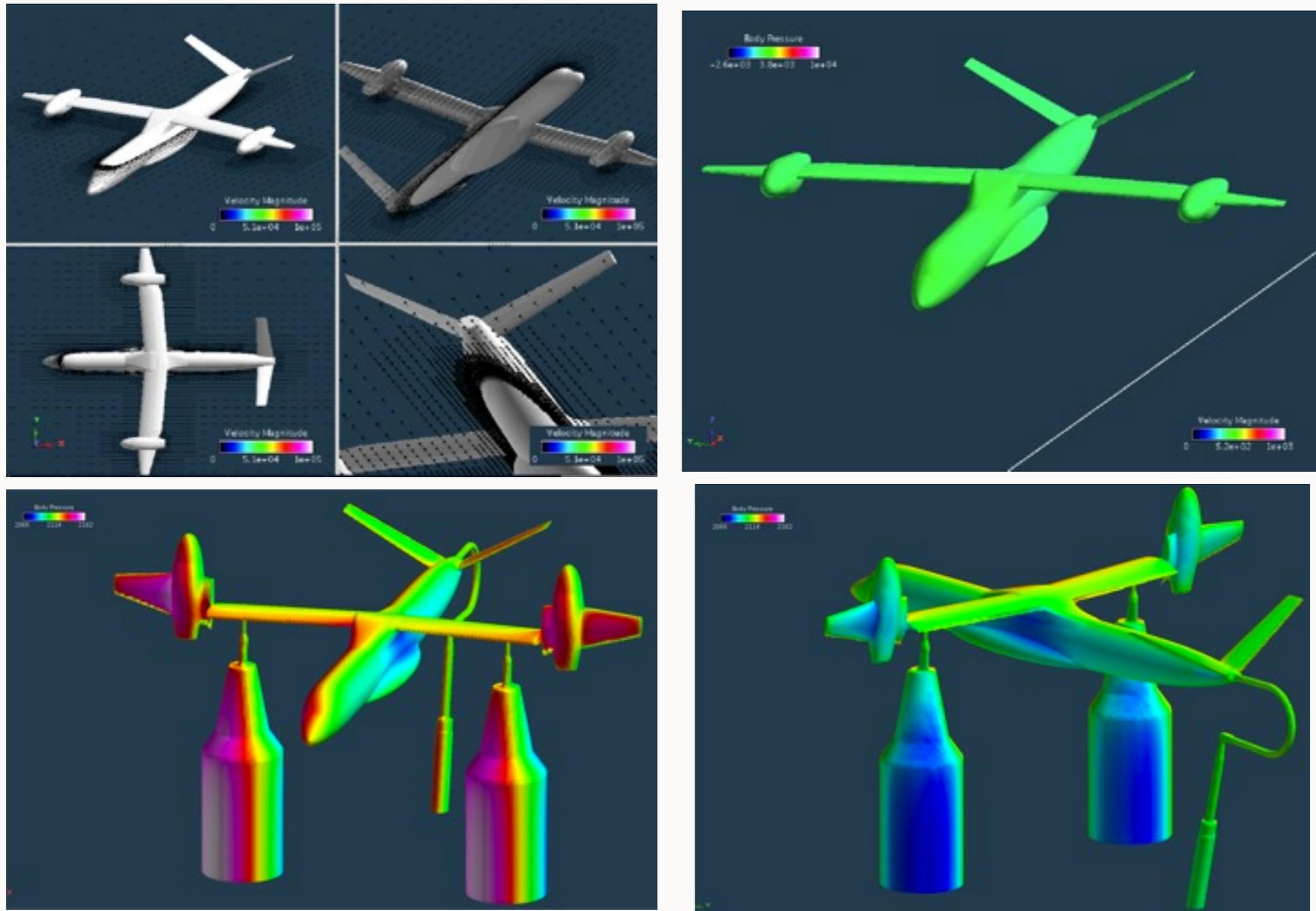


VARIATION OF SOLVER PARAMETERS

- Time Length: Time of the simulation
- Time Steps: Number of steps in the Time Length
- Iterations: Iterations for each Time Step



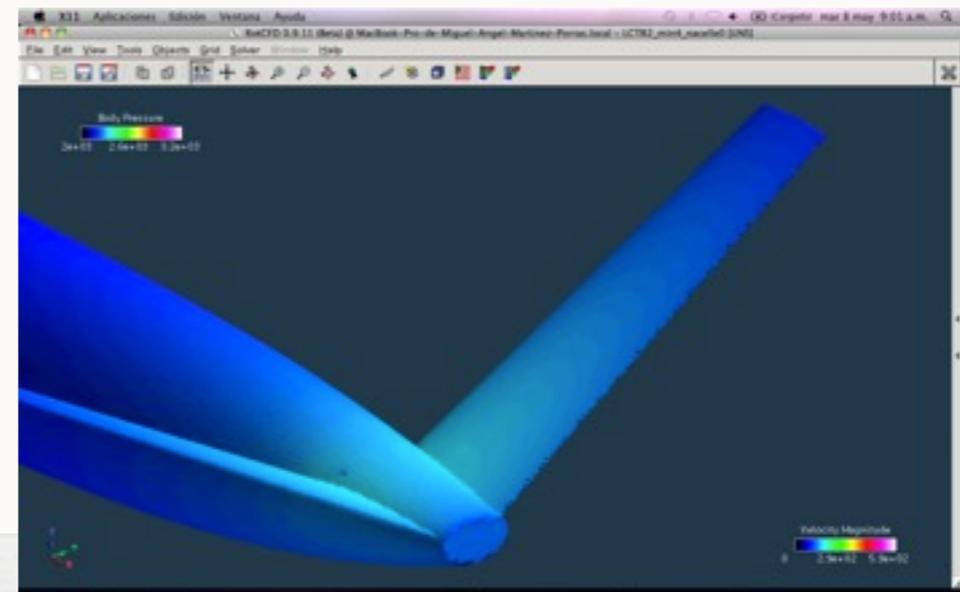
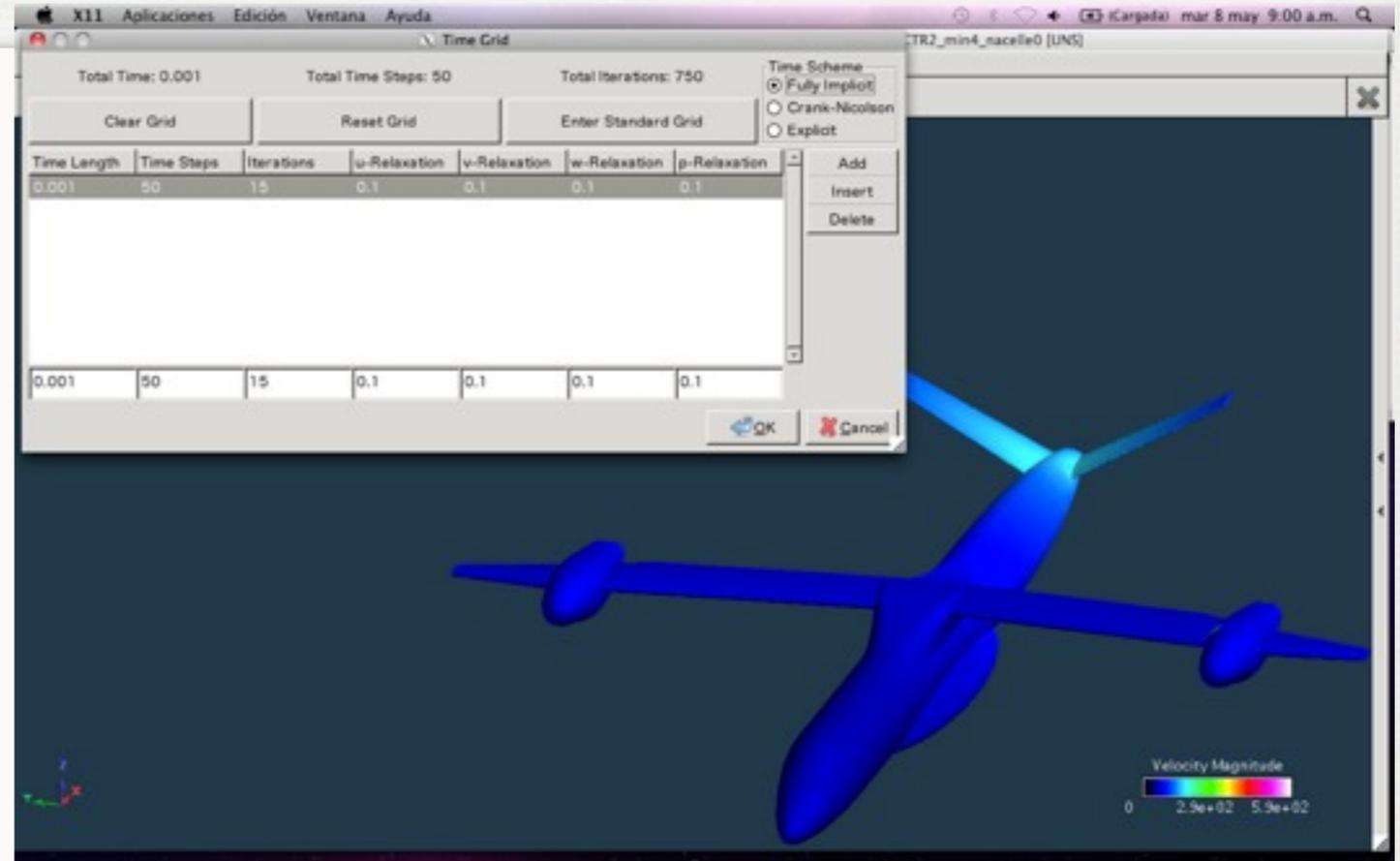
RESULTS



RESULTS

MassRsd1.dat - Bloqueado

Time	Task	Iter	ppRm	ppRfr	Cell#	lchk	wchk	wchk	pchk
0.0000200	1	1	0.666180E-12	0.434476E-02	*****	0.933627E+02	0.164665E+02	-0.246899E+02	-0.295589E+03
		2	0.320545E-09	0.267196E-02	*****	0.886705E+02	0.240452E+02	-0.382776E+02	-0.473821E+03
		3	0.290267E-09	0.194467E-02	*****	0.865516E+02	0.288982E+02	-0.335697E+02	-0.591454E+03
		4	0.245866E-09	0.168594E-02	818552	0.892716E+02	-0.296850E+01	0.217467E+02	-0.340953E+03
		5	0.232283E-09	0.157529E-02	*****	0.793753E+02	-0.288354E+02	0.232676E+02	0.399667E+03
		6	0.320718E-09	0.149516E-02	*****	0.795958E+02	-0.289897E+02	0.233838E+02	0.452683E+03
		7	0.265233E-09	0.143347E-02	*****	0.797664E+02	-0.291549E+02	0.233794E+02	0.583479E+03
		8	0.279771E-09	0.138389E-02	*****	0.799266E+02	-0.292975E+02	0.234588E+02	0.552663E+03
		9	0.306288E-09	0.134367E-02	*****	0.880719E+02	-0.294289E+02	0.235499E+02	0.680486E+03
		10	0.294855E-09	0.131825E-02	*****	0.882878E+02	-0.295493E+02	0.236363E+02	0.647181E+03
		11	0.407729E-09	0.128238E-02	*****	0.883375E+02	-0.296612E+02	0.237288E+02	0.692938E+03
		12	0.373861E-09	0.125878E-02	*****	0.884538E+02	-0.297659E+02	0.238208E+02	0.737876E+03
		13	0.364889E-09	0.123856E-02	*****	0.885695E+02	-0.298647E+02	0.239128E+02	0.782138E+03
		14	0.283482E-09	0.122115E-02	*****	0.886788E+02	-0.299587E+02	0.240038E+02	0.825782E+03
		15	0.340815E-09	0.120504E-02	*****	0.887847E+02	-0.300485E+02	0.240918E+02	0.869983E+03
0.0000400	2	1	0.279562E-09	0.111968E-02	*****	0.180748E+03	-0.118484E+00	0.282364E+00	0.713954E+02
		2	0.295118E-09	0.119335E-02	*****	0.180716E+03	-0.133789E+00	0.318182E+00	0.777934E+02
		3	0.281976E-09	0.122928E-02	*****	0.180685E+03	-0.148854E+00	0.351375E+00	0.845818E+02
		4	0.334478E-09	0.123971E-02	*****	0.180658E+03	-0.161121E+00	0.381579E+00	0.913516E+02
		5	0.270875E-09	0.123617E-02	*****	0.180633E+03	-0.172865E+00	0.408675E+00	0.982383E+02
		6	0.279785E-09	0.122564E-02	*****	0.180611E+03	-0.183363E+00	0.432899E+00	0.105181E+03
		7	0.303427E-09	0.121214E-02	*****	0.180591E+03	-0.192739E+00	0.454488E+00	0.111911E+03
		8	0.269698E-09	0.127209E-02	820813	0.536273E+02	0.637957E+03	0.256765E+03	0.442456E+03
		9	0.275458E-09	0.118363E-02	*****	0.180558E+03	-0.208628E+00	0.498746E+00	0.125332E+03
		10	0.340217E-09	0.142954E-02	820813	0.483536E+02	0.809354E+03	0.325115E+03	0.480488E+03
		11	0.321238E-09	0.115795E-02	*****	0.180529E+03	-0.221444E+00	0.519777E+00	0.138486E+03
		12	0.265472E-09	0.159927E-02	820813	0.286759E+02	0.987270E+03	0.395818E+03	0.535358E+03
		13	0.344827E-09	0.116454E-02	*****	0.180998E+03	-0.320922E+00	-0.445848E-03	0.889628E+01
		14	0.242288E-09	0.176694E-02	820813	0.137926E+02	0.115698E+04	0.462589E+03	0.581113E+03
		15	0.265938E-09	0.117836E-02	*****	0.180984E+03	-0.335184E+00	-0.468686E-03	0.987788E+01
0.0000600	3	1	0.333546E-09	0.209599E-02	820813	-0.125669E+02	0.158397E+04	0.688313E+03	0.676192E+03
		2	0.362184E-09	0.125340E-02	*****	0.180982E+03	-0.388987E-03	-0.528863E-03	0.189278E+02
		3	0.262615E-09	0.218063E-02	820813	-0.219488E+02	0.164443E+04	0.653847E+03	0.761885E+03
		4	0.327687E-09	0.138831E-02	*****	0.180988E+03	-0.432344E+00	-0.582289E-03	0.128328E+02
		5	0.283918E-09	0.223788E-02	820813	-0.288422E+02	0.175535E+04	0.695398E+03	0.843482E+03
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		7	0.359366E-09	0.227333E-02	820813	-0.337733E+02	0.184171E+04	0.727157E+03	0.921968E+03
		8	0.273244E-09	0.133817E-02	*****	0.180977E+03	-0.493333E+00	-0.688968E-03	0.143213E+02
		9	0.340892E-09	0.229322E-02	820813	-0.372644E+02	0.198914E+04	0.751482E+03	0.997132E+03
		10	0.322135E-09	0.133936E-02	*****	0.180976E+03	-0.514458E-03	-0.679973E-03	0.154826E+02
		11	0.265815E-09	0.238129E-02	820813	-0.397778E+02	0.196296E+04	0.778536E+03	0.106959E+04
		12	0.256392E-09	0.133899E-02	*****	0.180976E+03	-0.531223E-03	-0.698839E-03	0.166474E+02
		13	0.282784E-09	0.238373E-02	820813	-0.416374E+02	0.208771E+04	0.785898E+03	0.113993E+04
		14	0.340486E-09	0.134439E-02	*****	0.181088E+03	-0.144996E-03	0.968791E-04	0.119127E+02
		15	0.328182E-09	0.238296E-02	820813	-0.438762E+02	0.204448E+04	0.798723E+03	0.128859E+04
0.0000800	4	1	0.339116E-09	0.178771E-02	820813	0.278996E+03	-0.198799E+04	-0.788983E+03	0.588798E+03
		2	0.141348E-09	0.219586E-02	820813	-0.384257E+02	0.191882E+04	0.744883E+03	0.116838E+04
		3	0.298274E-09	0.168446E-02	820813	0.272898E+03	-0.198885E+04	-0.781851E+03	0.558329E+03
		4	0.293378E-09	0.208828E-02	820813	-0.218887E+02	0.183292E+04	0.789122E+03	0.118274E+04
		5	0.286833E-09	0.168238E-02	820813	0.275477E+03	-0.192342E+04	-0.798288E+03	0.587319E+03
		6	0.216296E-09	0.281415E-02	820813	-0.151636E+02	0.176868E+04	0.679318E+03	0.184187E+04
		7	0.250711E-09	0.168641E-02	820813	0.278425E+03	-0.195298E+04	-0.882767E+03	0.452549E+03
		8	0.272761E-09	0.196913E-02	820813	-0.967794E+01	0.169863E+04	0.653893E+03	0.979688E+03
		9	0.337818E-09	0.169426E-02	820813	0.281588E+03	-0.198918E+04	-0.817566E+03	0.393837E+03
		10	0.365744E-09	0.193697E-02	820813	-0.588249E+01	0.164355E+04	0.631661E+03	0.916351E+03
		11	0.219536E-09	0.178339E-02	820813	0.284848E+03	-0.202911E+04	-0.833784E+03	0.332398E+03
		12	0.381542E-09	0.191362E-02	820813	-0.893874E+00	0.159325E+04	0.611427E+03	0.852156E+03
		13	0.354884E-09	0.171273E-02	820813	0.288137E+03	-0.207133E+04	-0.858564E+03	0.269817E+03
		14	0.388228E-09	0.189658E-02	820813	0.288226E+03	-0.154641E+04	0.592716E+03	0.787217E+03
		15	0.314186E-09	0.172177E-02	820813	0.291404E+03	-0.211472E+04	-0.867768E+03	0.284225E+03
0.0001000	5	1	0.332718E-09	0.233294E-02	820813	-0.388294E+02	0.198788E+04	0.767288E+03	0.861788E+03
		2	0.372869E-09	0.166582E-02	820813	0.281818E+03	-0.195378E+04	-0.886588E+03	0.284846E+03
		3	0.373731E-09	0.221663E-02	820813	-0.262889E+02	0.196883E+04	0.751889E+03	0.917718E+03
		4	0.388358E-09	0.159812E-02	820813	0.275451E+03	-0.185891E+04	-0.778876E+03	0.373579E+03
		5	0.217913E-09	0.214748E-02	820813	-0.236763E+02	0.196438E+04	0.749388E+03	0.992669E+03
		6	0.215718E-09	0.156583E-02	820813	0.271615E+03	-0.176713E+04	-0.748619E+03	0.464388E+03
		7	0.316958E-09	0.289441E-02	820813	-0.222634E+02	0.198194E+04	0.752681E+03	0.187292E+04
		8	0.326535E-09	0.156637E-02	*****	0.181088E+03	-0.198631E+04	-0.248487E+03	0.178899E+02



LCTR WIND TUNNEL TEST

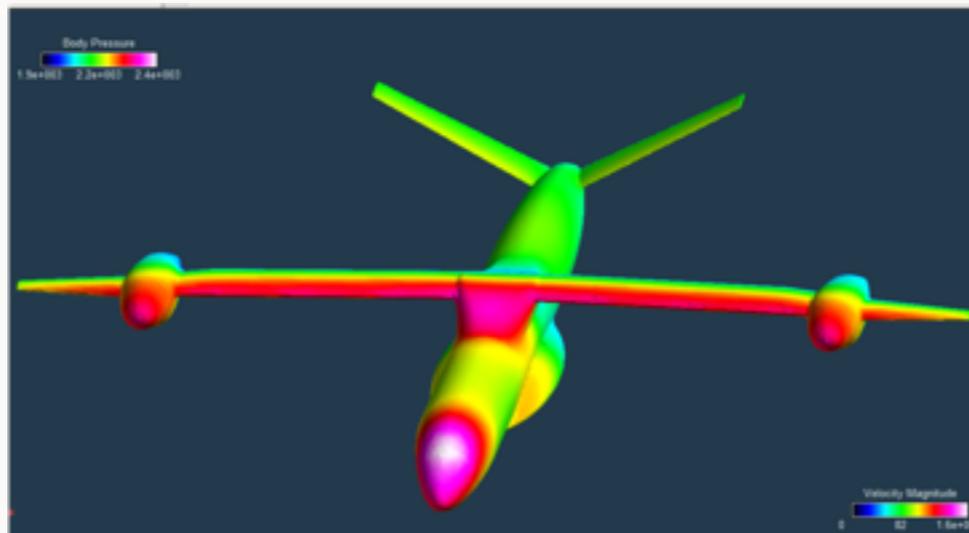
- Small-scale model of the LCTR in the Army 7 x 10 ft wind tunnel
- Isolated fuselage model (no rotors)
- Variation of pitch and yaw angles
- Airplane and Helicopter mode configurations



LCTR WIND TUNNEL TEST

CFD simulations matrix

Different cases run
simulating different
situations

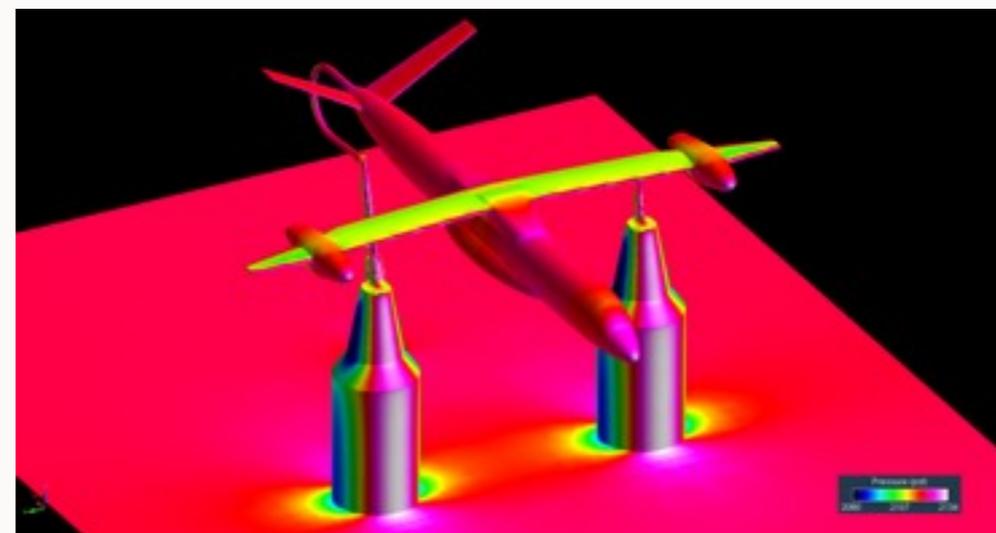


ALPHA ANGLE (PITCH ANGLE DEGREES)	BETA ANGLE (YAW ANGLE DEGREES)	WIND TUNNEL AIR SPEED
-4	0,+5,+10	60 KTS
0	0,+5,+10	60 KTS
+4	0,+5,+10	60 KTS
-4	0,+5,+10	160 KTS
0	0,+5,+10	160 KTS
+4	0,+5,+10	160 KTS
-4	0,+5,+10	193 KTS
0	0,+5,+10	193 KTS
+4	0,+5,+10	193 KTS

LCTR WIND TUNNEL TEST

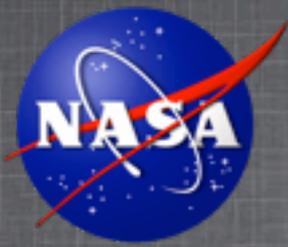
Configurations tested:

- Wind Tunnel
- CFD



FUTURE WORK

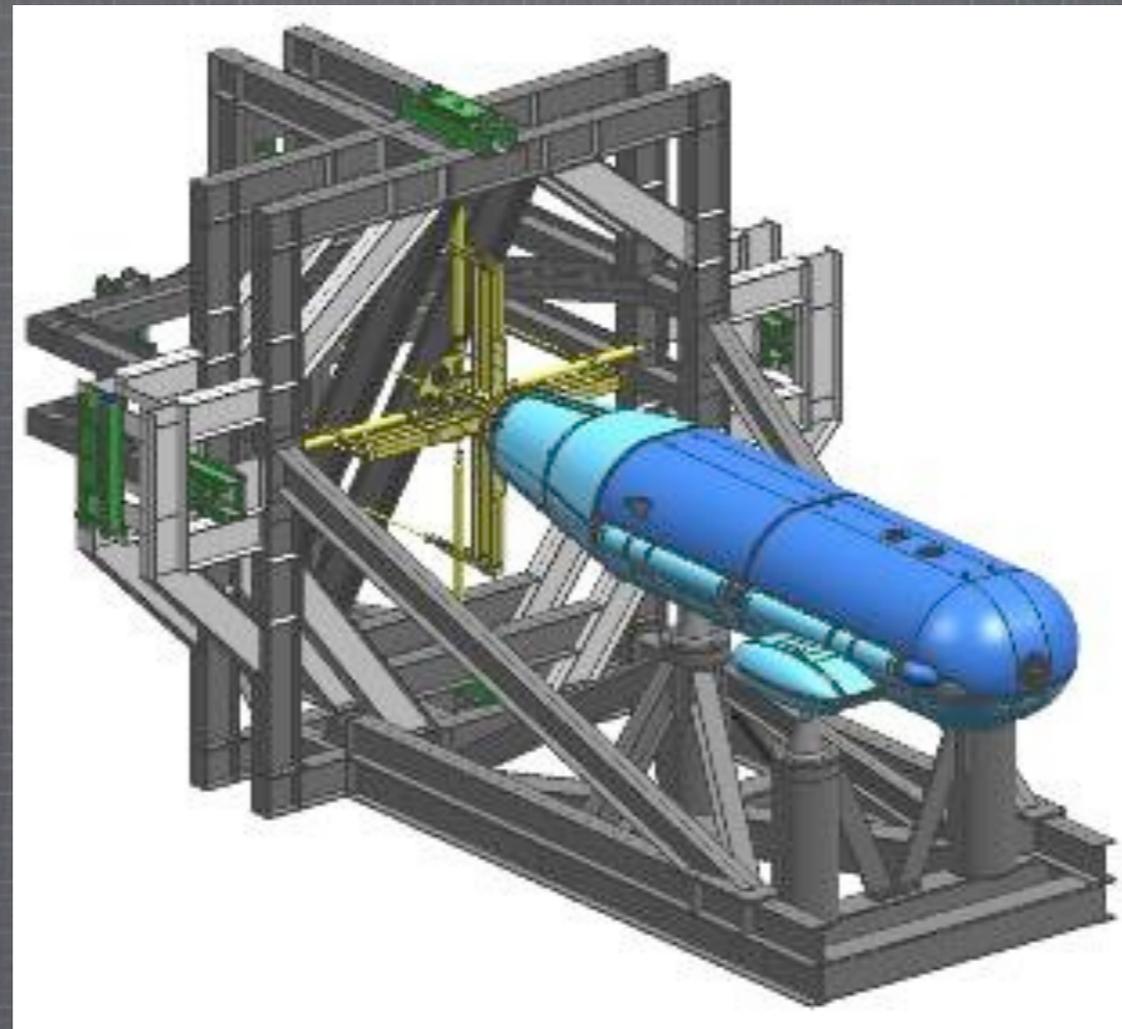
- Testing new configurations
- Software improvement
- Taking advantage of Multiprocessor computing
- Testing multiple aircraft interaction



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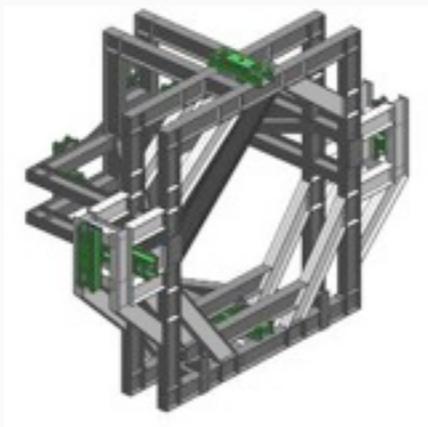
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TILTROTOR TEST CALIBRATION RIG

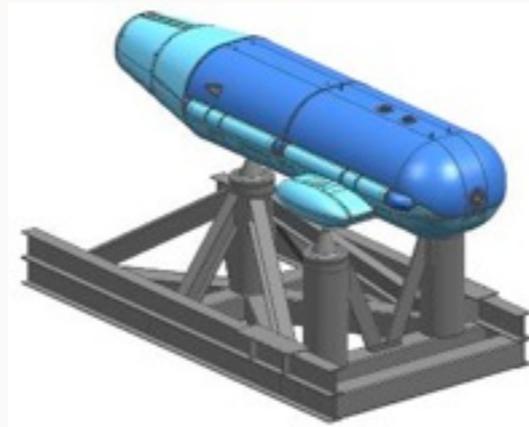


TTR CALIBRATION RIG DESCRIPTION

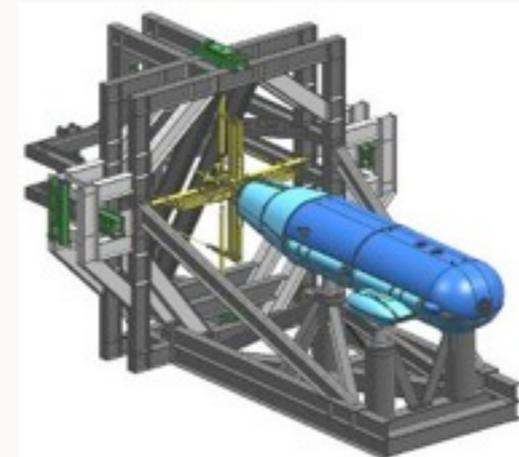
- Designed to calibrate the TTR which is used to measure rotor forces and moments
- I-beam structure to provide an attachment for the hydraulic load actuators



FWD Frame



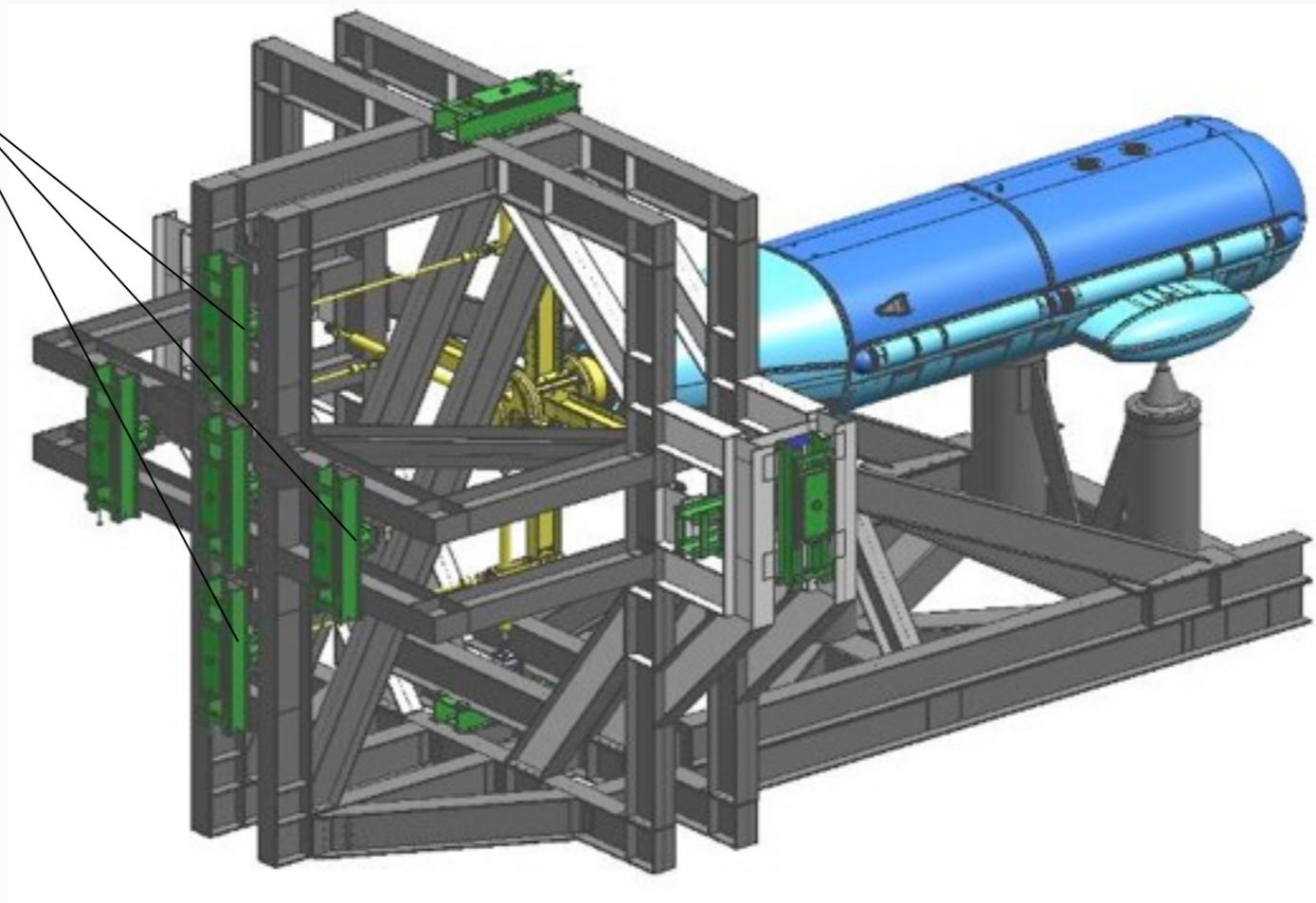
AFT Frame with TTR installed



FWD + AFT Frames =
TTR Cal Rig

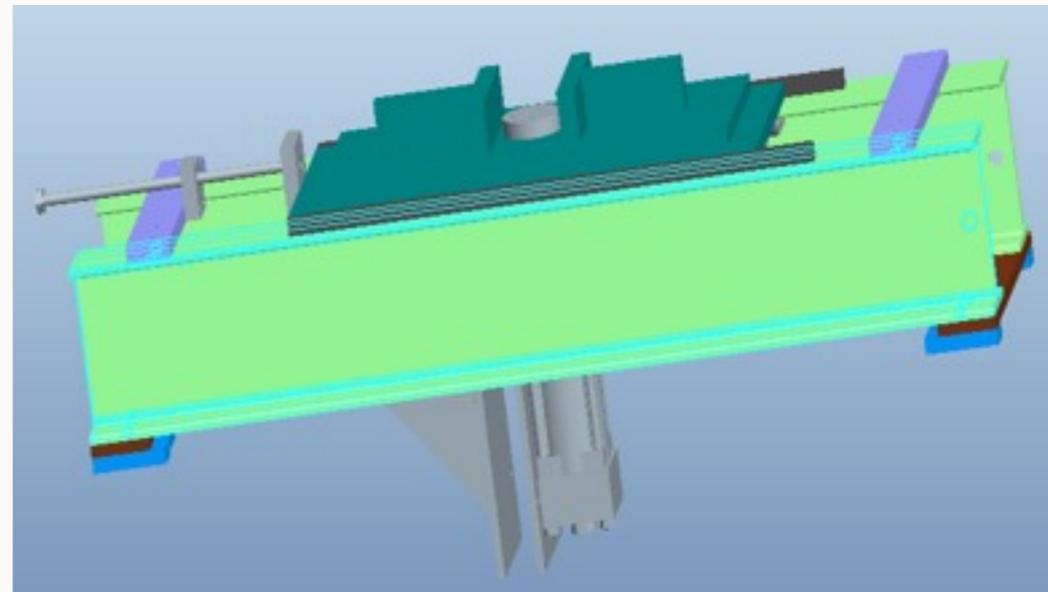
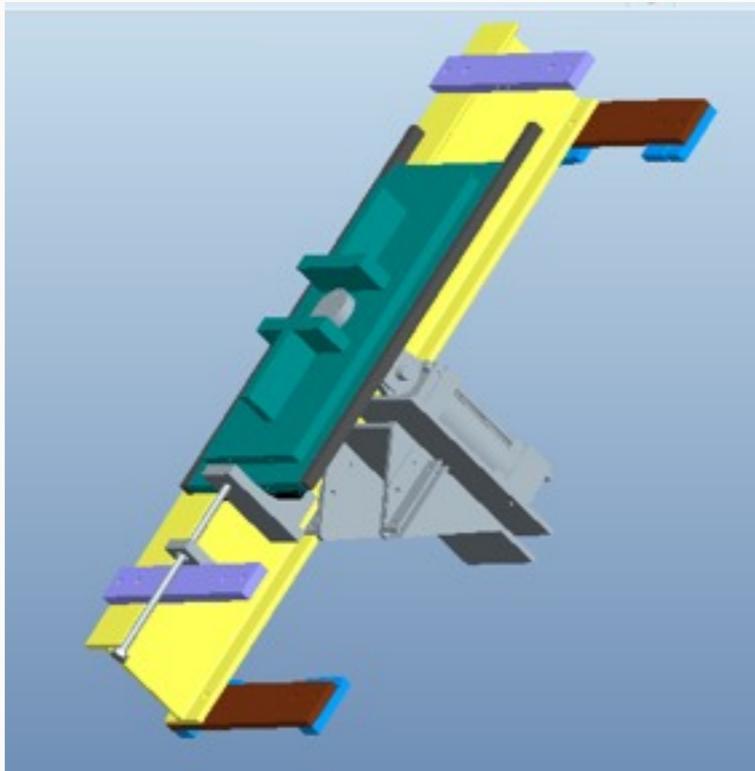
PITCH & ROLL ANCHOR DESIGN

**MOMENT
ACTUATORS**

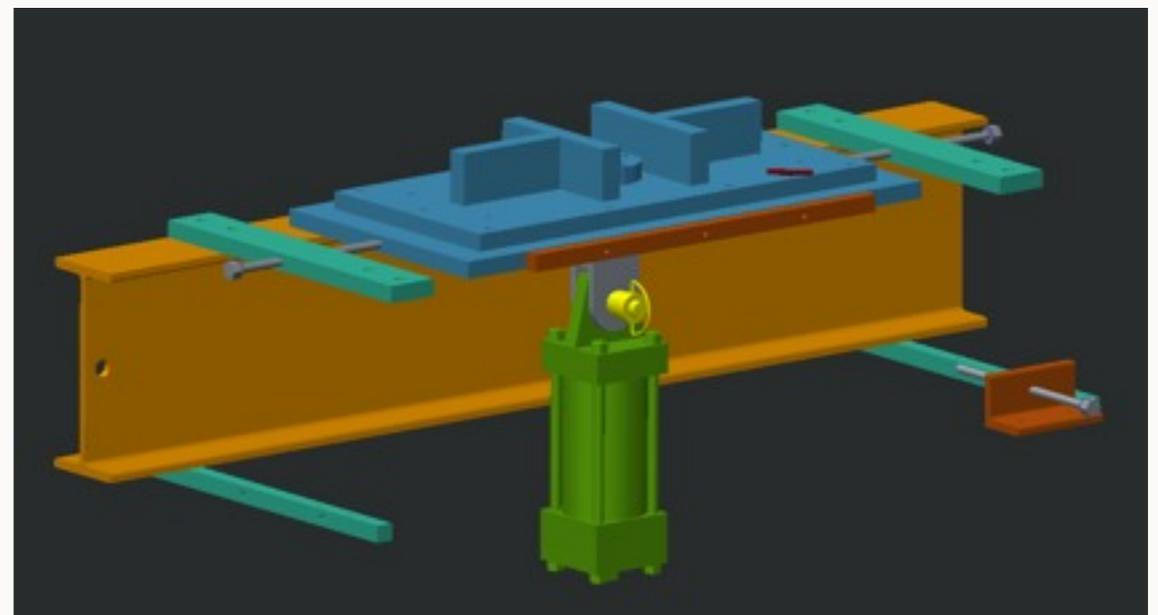
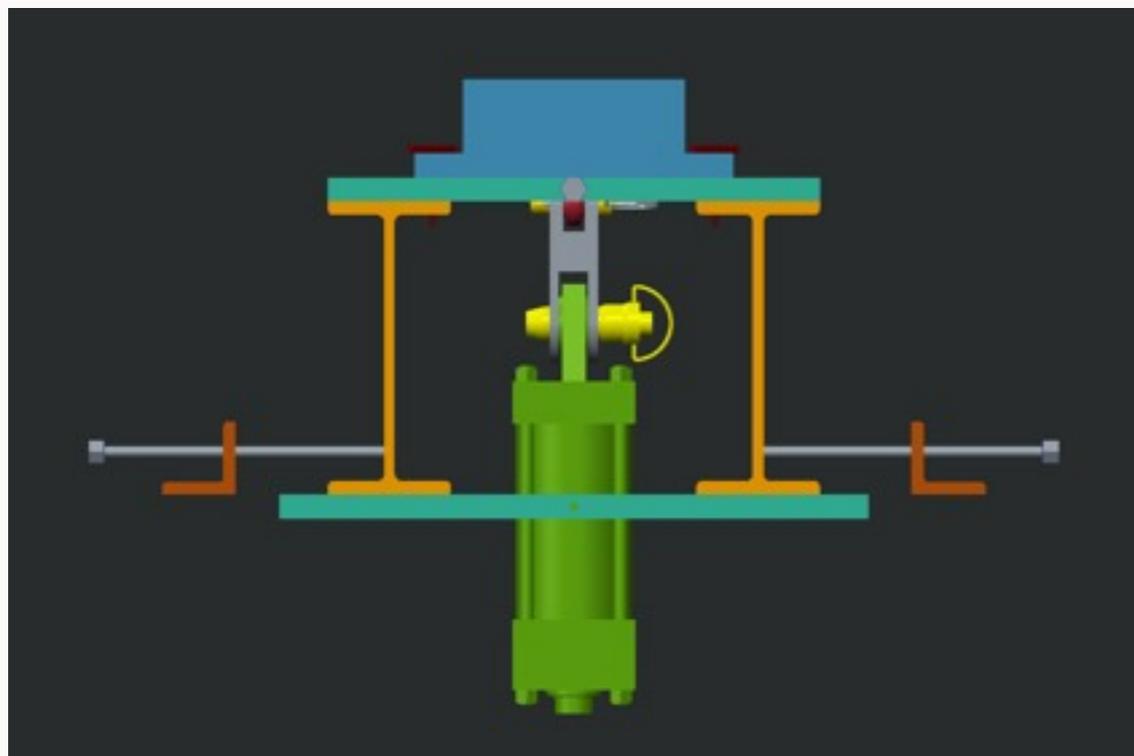
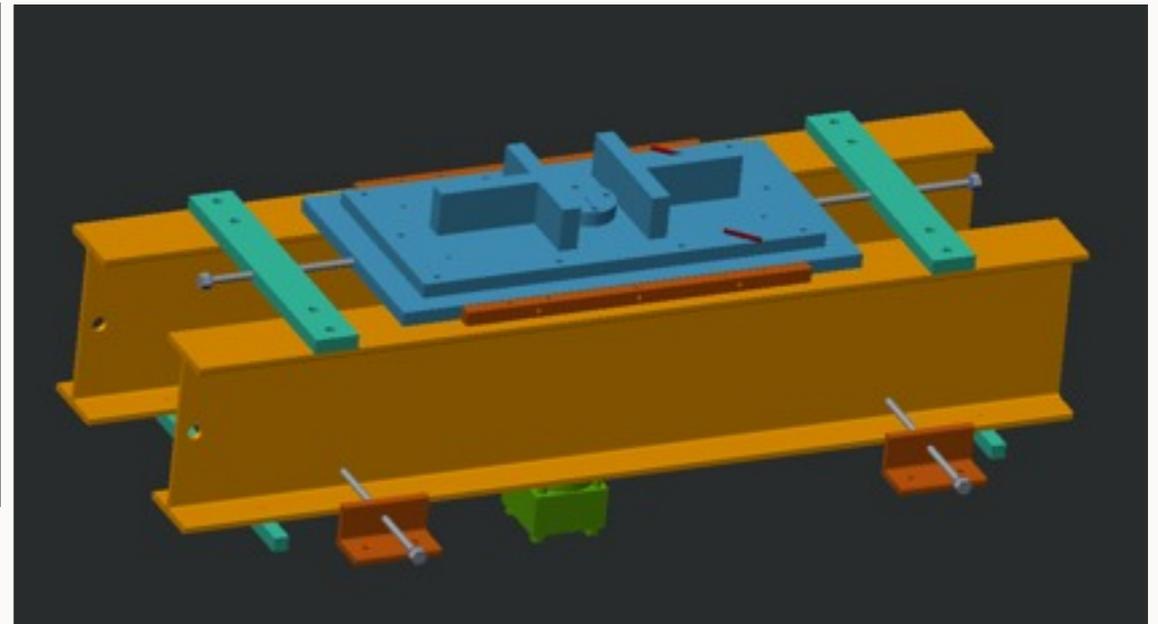
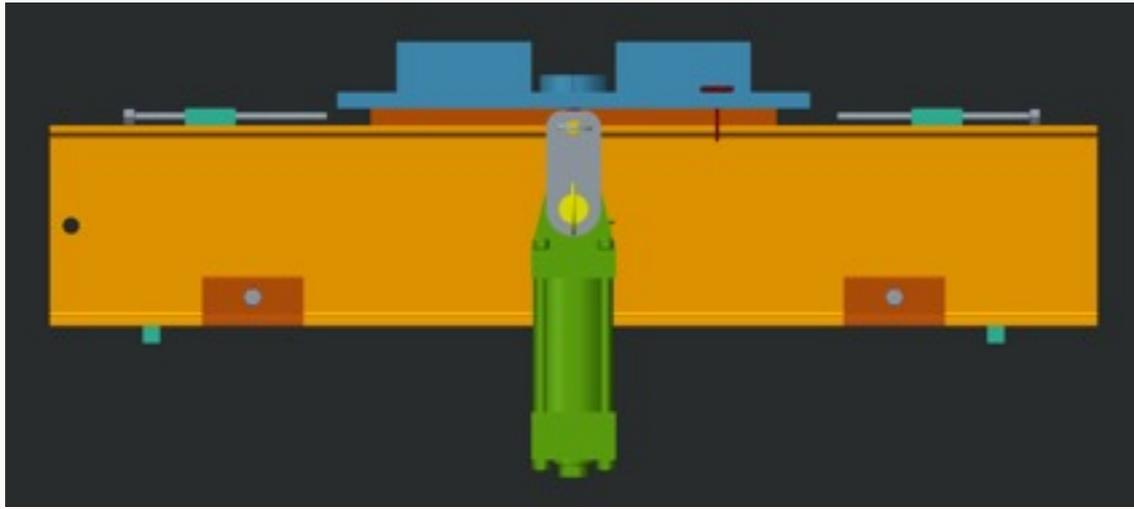


PITCH & ROLL ANCHOR DESIGN

- Determine the requirements for the actuator to resist all the loads during the test.

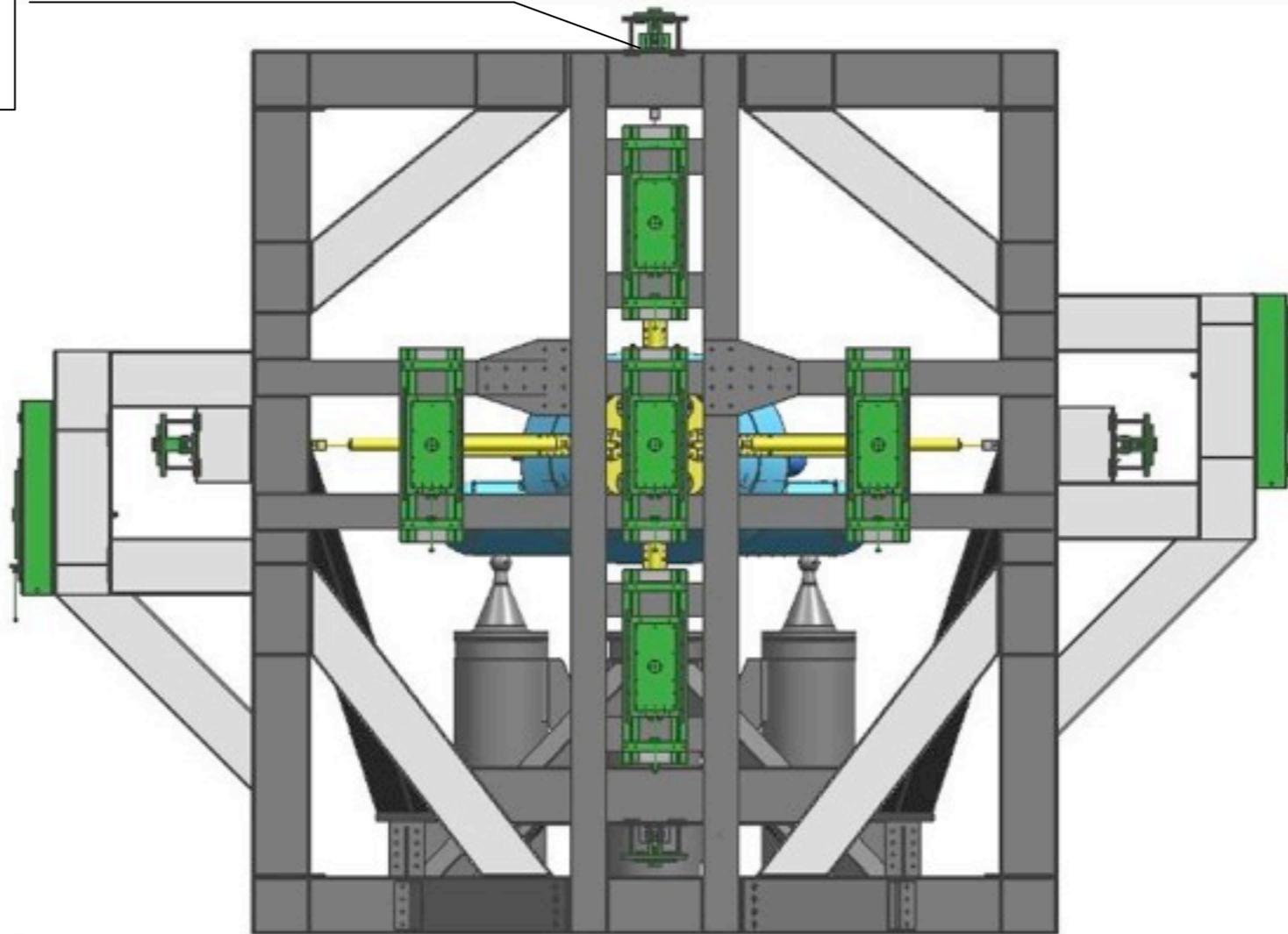


VERTICAL FORCE ANCHOR DESIGN

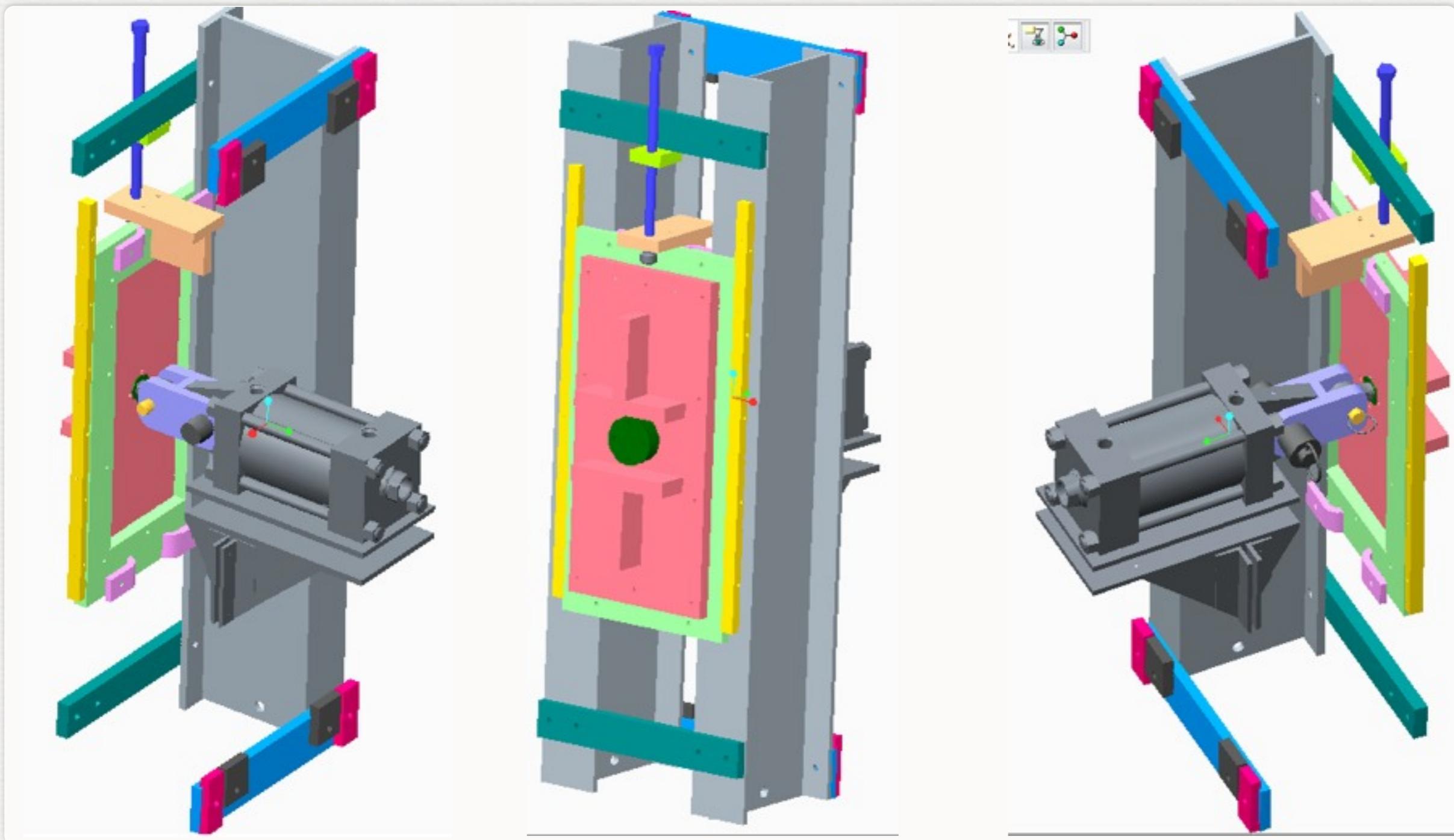


VERTICAL FORCE ANCHOR DESIGN

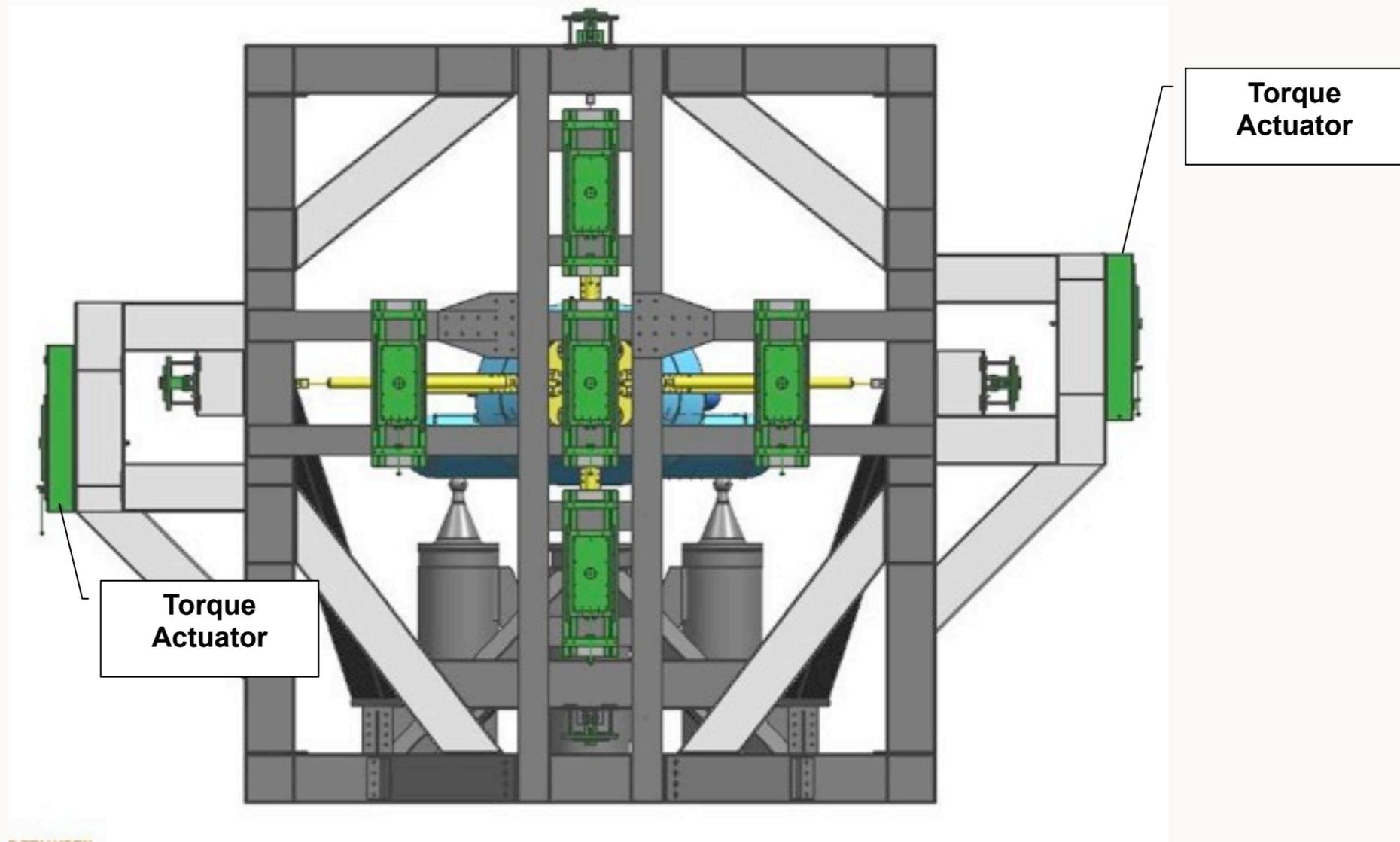
Vertical
Force
Actuator



TORQUE ANCHOR DESIGN



TORQUE ANCHOR DESIGN

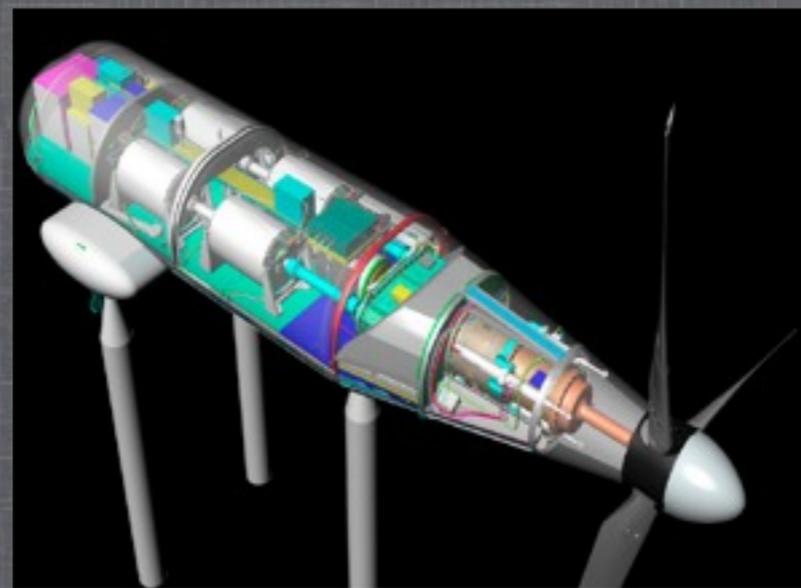


FUTURE WORK

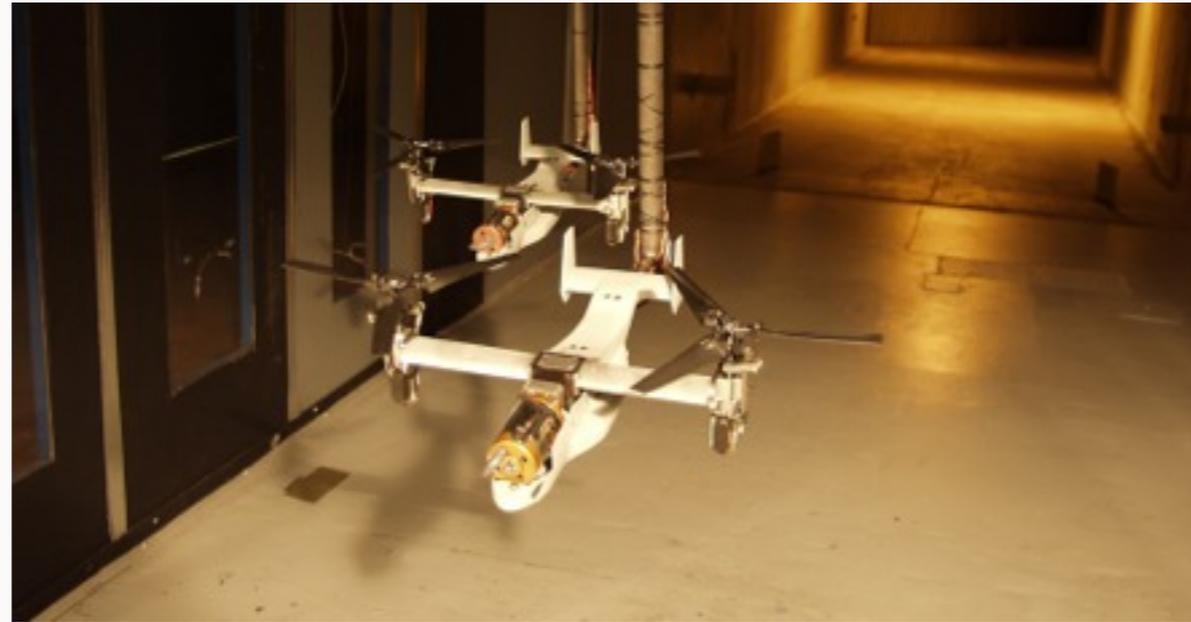
- Design review
- Disassembly / Assembly plan
- Linkage design
- Hydraulic System review
- Installation of the anchors in Forward Frame



TILTROTOR & TTR SCALE MODELS



V-22 OSPREY SCALE MODEL



Main advantages:

- Efficient and effective tests
- Ease to improve configurations

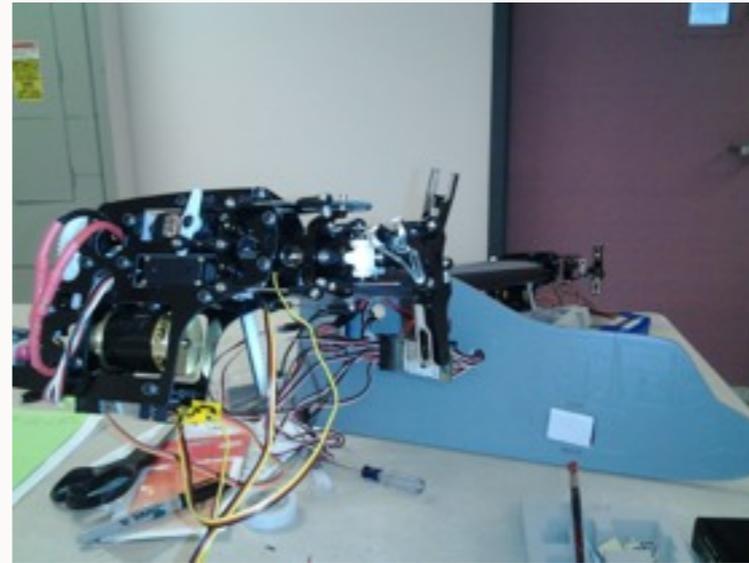
V-22 OSPREY SCALE MODEL

Differences with the real V-22

- Shaft connecting both nacelles
- Control surfaces
- Landing gear
- Degrees of freedom on swash plate



V-22 OSPREY SCALE MODEL FOR WIND TUNNEL



V-22 OSPREY RC MODEL SETUP FOR FLIGHT

- Electronic components programming
- Hardware update
- Nacelle conversion alignment
- Blade tracking
- Motor spool test

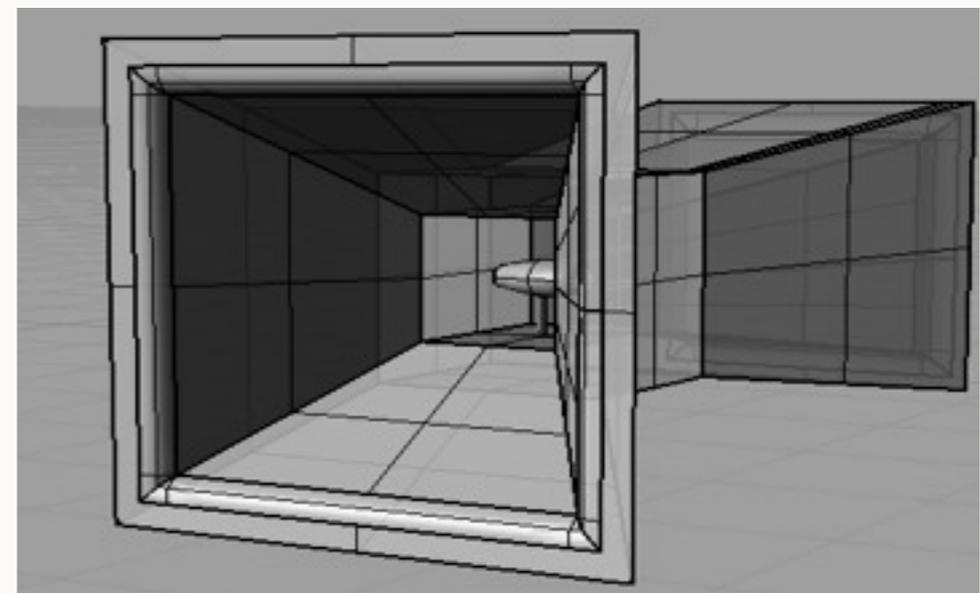
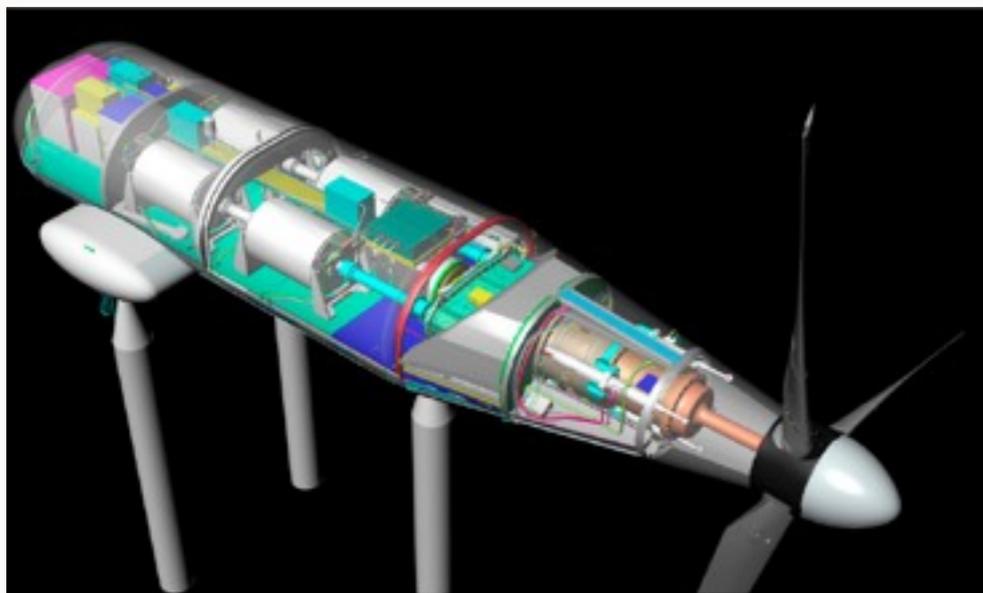
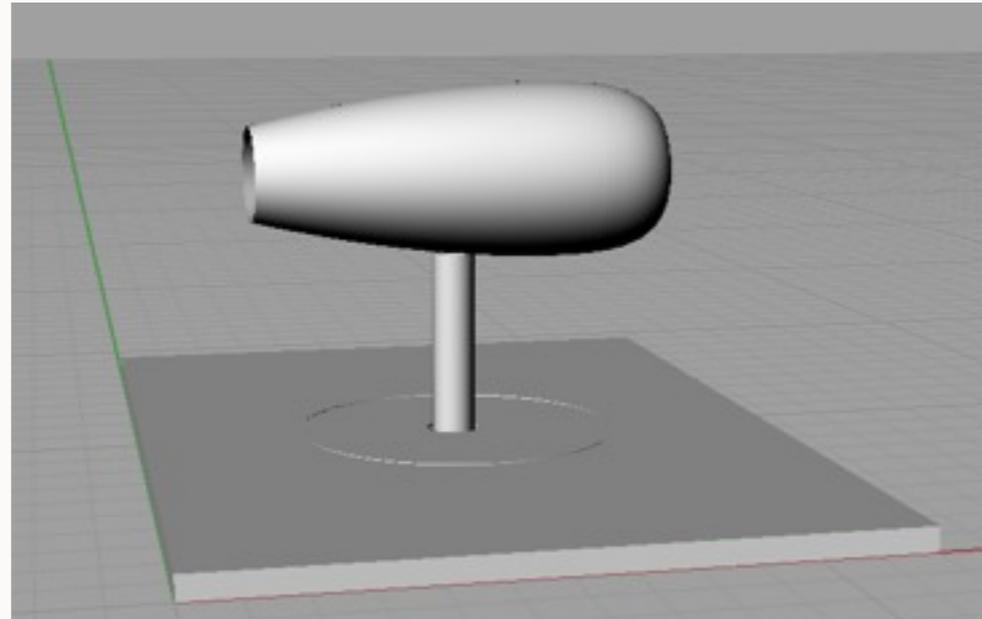
V-22 OSPREY MODEL SETUP FOR FLIGHT



TTR SCALE MODEL

- Display tool for didactical purposes
- Visualization and ability to apply real wind tunnel test in scale models
- Obtaining meaningful and real data
- Encouraging students to the research field.
- Understanding wind tunnel tests projects

TTR SCALE MODEL



FUTURE WORK

- Flight Tests
- Software / Hardware update
- Structural Analysis of RC models for wind tunnel testing
- Testing different configurations

Acknowledgements:

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QUESTIONS

