Recent Developments in OVERGRID, OVERFLOW-2, and Chimera Grid Tools Scripts

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OVERVIEW

> Easy-to-use multiple-body dynamics in OVERGRID and OVERFLOW-2

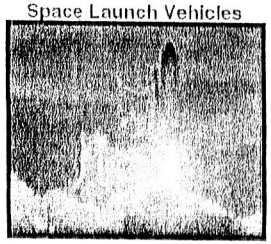
> OVERGRID new features
- preliminary chemistry interface
- standard atmosphere and mass properties calculators
- simple unsteady solution viewer
- debris tracing interface

> Script library development in Chimera Grid Tools and applications in turbopump grid generation

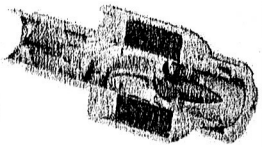
> Future work

A SAMPLE OF APPLICATIONS WITH MULTIPLE COMPONENTS IN RELATIVE MOTION

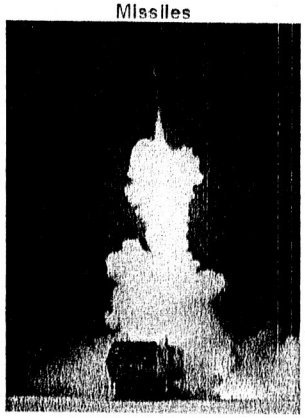
Space Launch Vehicles



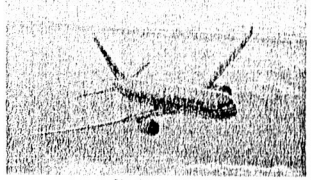
Heart Assist Devices



Missiles

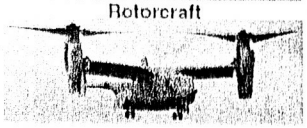


Aircraft Control Surfaces

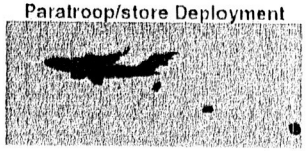


Turbomachinery

Rotorcraft



Paratroop/store Deployment



MULTIPLE COMPONENT DYNAMICS

Collaborators: Scott Murman, William Chan, Mike Aftosmis, Bob Meakin

Motivation - Problem setup is difficult and not standardized

Objective - Develop solver-independent standard protocol
Make it easy to use

Approach
> Develop protocols for describing
- hierarchical relationship between static/moving components, grids, geometry, etc.
- prescribed motion
- 6-dof motion with external loads and constraints
> Develop easy-to-use graphical interface in OVERGRID
> Use XML files to communicate with flow solvers (FLOWCART and OVERFLOW-2)

PROCEDURE FOR PREPARING DYNAMICS PROBLEMS

Previous

> Write special code for dynamics of each component
> Determine how to interface with flow solver by
  - reading complicated documentation (if any)
  - talking to flow solver authors (if available)
> Recompile flow solver
> Verify and debug by running flow solver

Current

> Set up problem interactively using OVERGRID
> Verify/debug with animation in OVERGRID before running flow solver
> Write XML interface files from OVERGRID
> Read XML interface files from flow solver
> Rcompilation/knowledge of flow solver coding not needed

CONFIGURATIONS AND SCENARIOS

Configuration

Each component may
- have one immediate parent or no parent
- move relative to the parent
- be linked to geometry or grids (structured/unstructured)
- have an initial transform (rotate/translate/mirror)

Scenario

Motion of each component may be

Prescribed - specified by
- sequence of rotate and translate commands

Aero6dof - specified by
- mass properties (mass, principal moments of inertia, and principal axes orientation)
- initial location of center of mass
- external loads and constraints (gravity,app. load, etc.)

CURRENT STATUS

OVERGRID

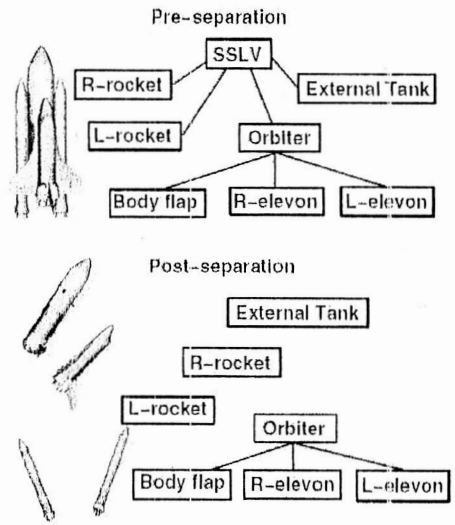
> Define components and specify prescribed and 6-dof motion with gravity and external loads
> Read/write XML files for input to flow solver
> Animate
  - prescribed motion
  - 6-dof motion with gravity and external loads before running flow solver (assume zero aero loads)
  - 6-dof motion after running flow solver from history log

OVERFLOW-2

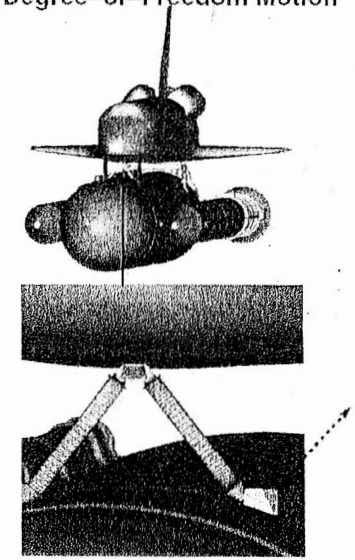
> XML interface implemented (activated by I6DOF=2)
> Validated for simple prescribed and 6-dof motion
> Validated for more complex motions with mixed prescribed and 6-dof commands with time-varying external loads

EXAMPLES OF PRESCRIBED AND 6-DOF MOTION

Prescribed Motion



6-Degree-of-Freedom Motion



VALIDATION TEST CASES

> Sphere (6dof with aero loads turned off)
- initially at rest, dropping under gravity with time varying resistive force
- dropping under gravity with initial upward velocity

> Cylinder (6-dof with aero loads turned off)
- prescribed initial angular velocity with no external load
- prescribed initial angular velocity with initial impulsive couple for small finite time

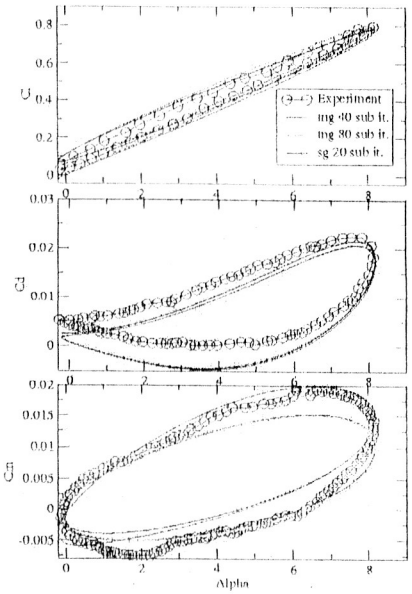
> Oscillating airfoil (prescribed motion, dual time step)
-0.2 <= alpha <= 8.2 (case 1)
6.8 <= alpha <= 15.2 (case 2)
10.8 <= alpha <= 19.2 (case 3)

OSCILLATING AIRFOIL TEST CASE 1
-0.2 <= alpha <= 8.2, DTPHYS=0.157, 200 steps/cycle

Lift

Drag

Pitching moment



Multiple-grid
- 40 sub-iterations
- 80 sub-iterations

Single-grid
- 20 sub-iterations

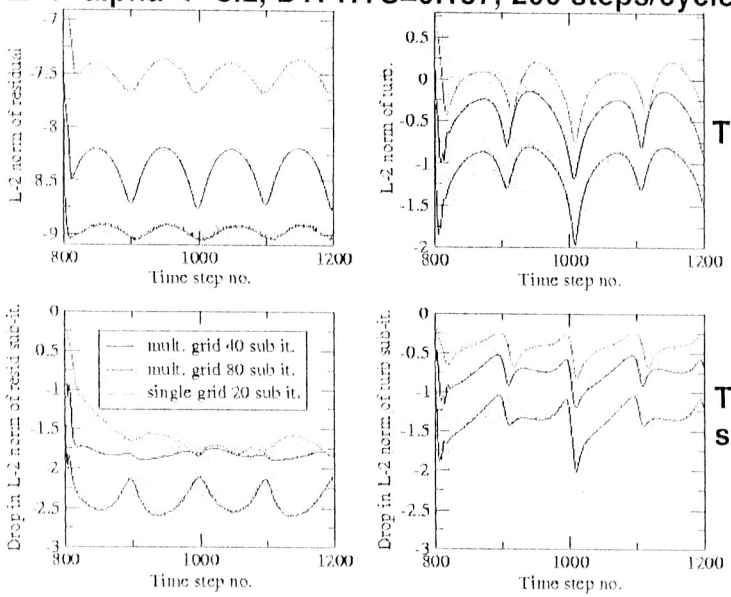
OSCILLATING AIRFOIL TEST CASE 1 (residuals)
-0.2 <= alpha <= 8.2, DTPHYS=0.157, 200 steps/cycle

Flow

Turb.

Flow sub-it.

Turb. sub-it.

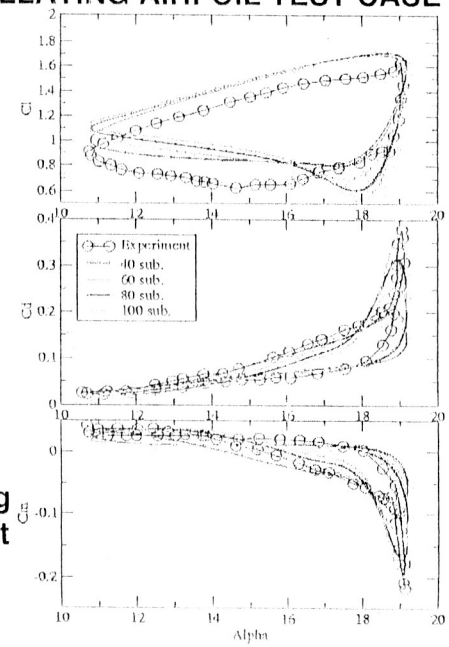


OSCILLATING AIRFOIL TEST CASE 3 (force/moment)

Lift

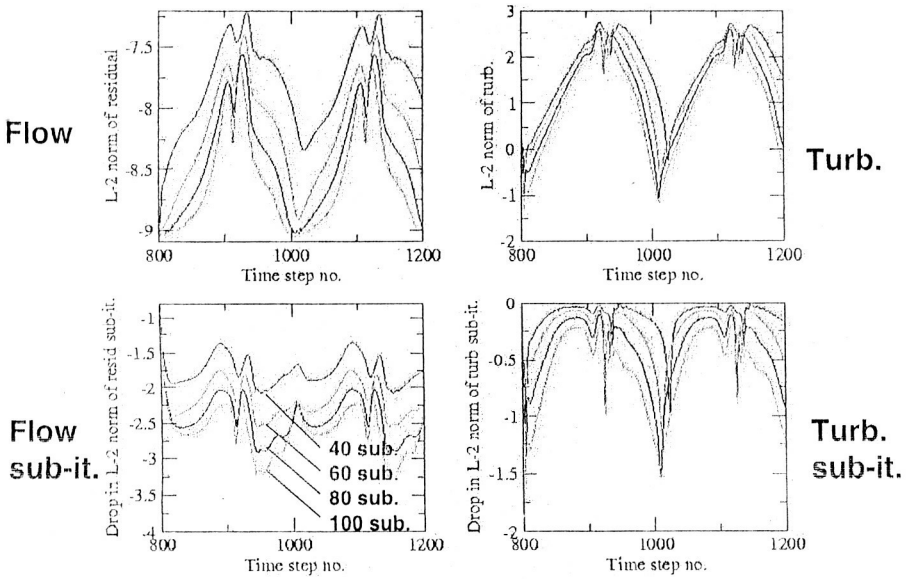
Drag

Pitching moment

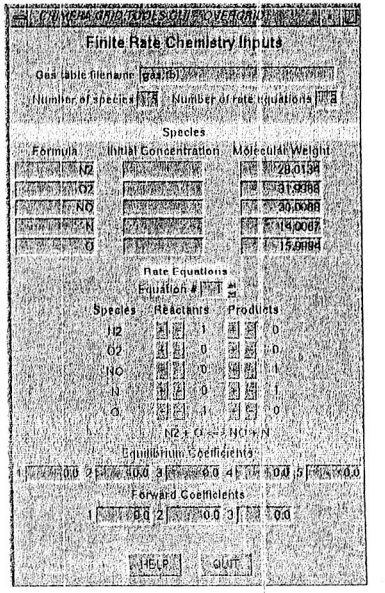


10.8 <= alpha <= 19.2
DTPHYS = 0.157
200 steps/cycle

OSCILLATING AIRFOIL TEST CASE 3 (residuals)



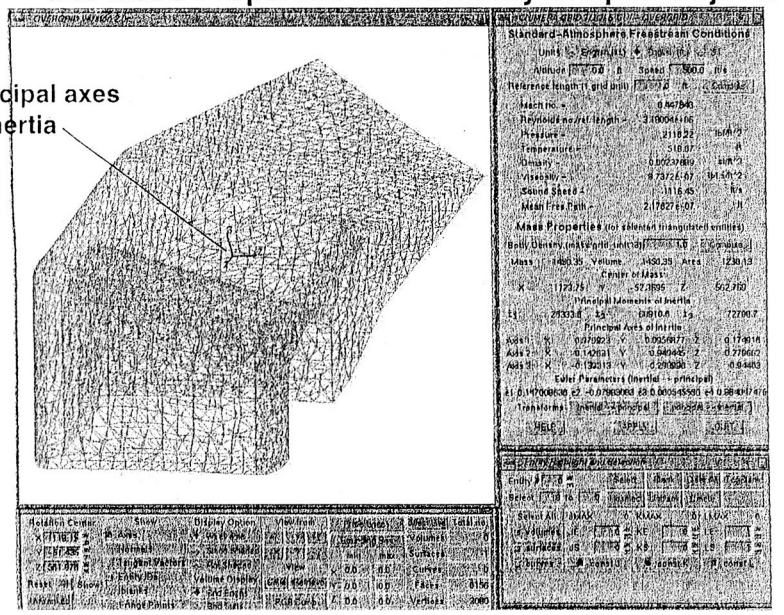
EQUILIBRIUM AND FINITE RATE CHEMISTRY INTERFACE FOR OVERFLOW (preliminary version)



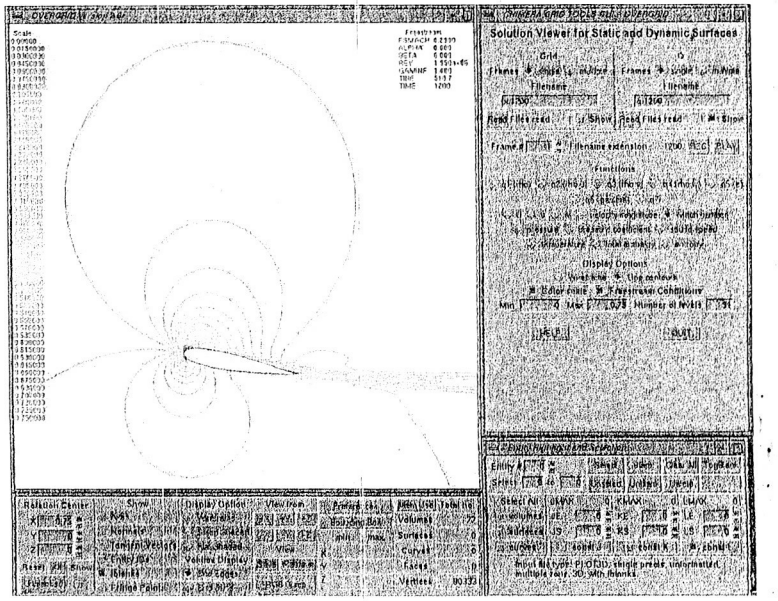
Species formula and concentration specification

Reaction equation builder and auto balance check

Calculators for Standard Atmosphere Freestream Properties and Mass Properties of Arbitrarily-Shaped Objects



SOLUTION VIEWER FOR SINGLE OR MULTIPLE FRAMES IN TIME



DEBRIS ANALYSIS INPUT PREPARATION AUTOMATION

OVERGRID/DPREP → DEBRIS → DPROX

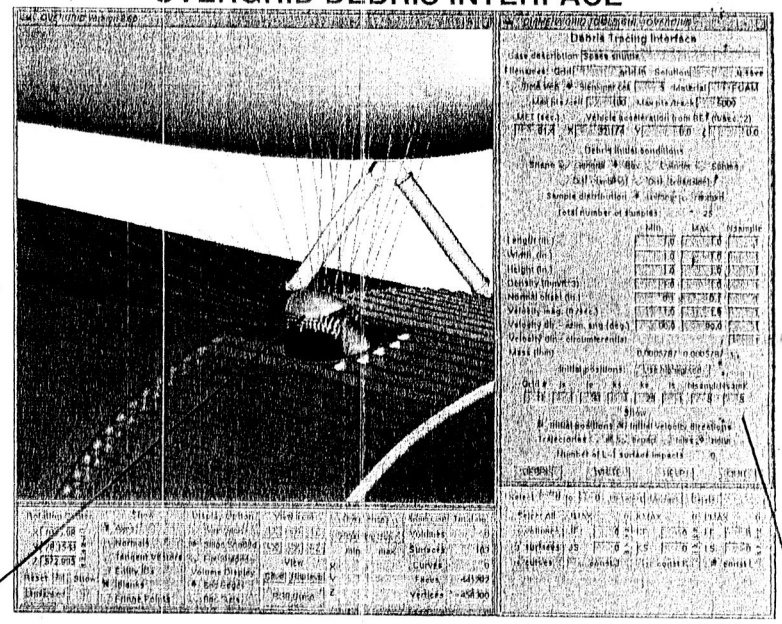
OVERGRID - graphical interface

- specify uniform or random sample distribution
- specify shape (general / box / cylinder / sphere / tumbling disk / broadside disk)
- specify attribute range(min and max) density, length/width/height/diameter, normal offset distance, velocity magnitude and direction (elevation, azimuthal)
- auto-generate and view initial positions and velocity vectors
- auto-generate input file for DEBRIS code
- option to execute DEBRIS code and view trajectories, impact points and impact speed

DPREP - batch code

- batch mode equivalent of OVERGRID interface suitable for incorporation into a script for executing different steps in a complete debris trajectory analysis

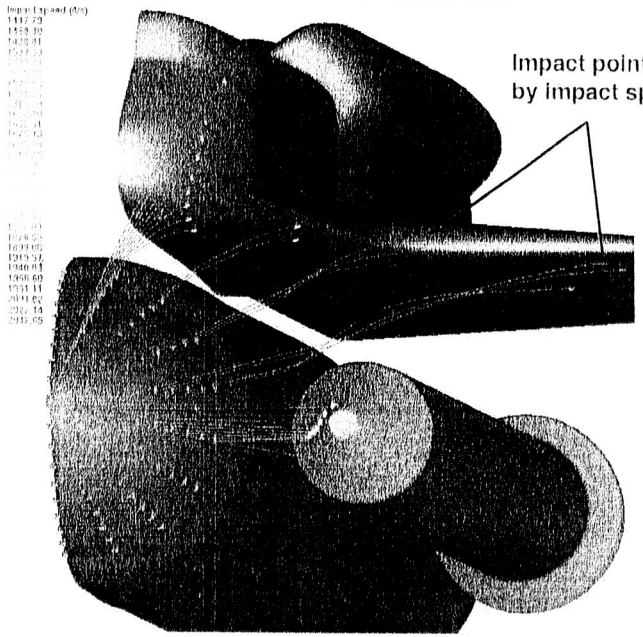
OVERGRID DEBRIS INTERFACE



Initial positions and velocity directions display

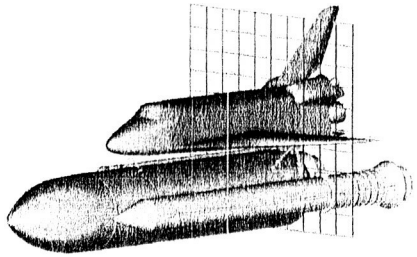
Input parameters specification panel

DISPLAY OF TRAJECTORIES, IMPACT POINTS AND SPEEDS IN OVERGRID'S DEBRIS INTERFACE

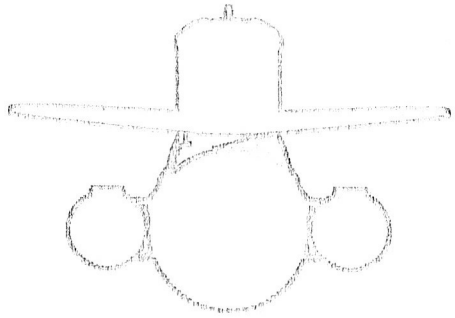


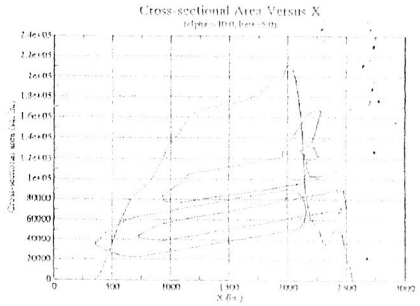
Impact points colored by impact speed

CAT SCAN UTILITY - Tscan



- Compute cross-sectional area versus X/Y/Z of a triangulated object at specified angle of attack and yaw
- Estimate wind tunnel blockage
- Proper treatment of non-simply-connected regions





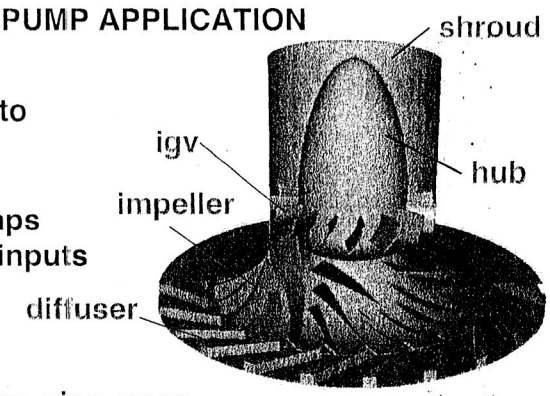
CGT SCRIPT DEVELOPMENT

> Introduce macro Tcl procedures for rapid script creation
- File manipulation
- Grid information
- Grid editing
- Grid redistribution
- Grid generation (surface and volume)
- Math functions
- OVERFLOW namelist i/o
- Program execution and error checking

E.g., one-line Tcl command for rotating a set of grids versus 10-15 lines of script for generating GRIDED input file and executing GRIDED

> Documentation of procedures

TURBOPUMP APPLICATION



Objectives
Develop script system to automatically generate
- grids
- hole-cutting X-ray maps
- domain connectivity inputs
- flow solver inputs

Capabilities
- modules for blade, ring, pipe, nose
- blade module
  - N sections with M blades per section
  - with or without tip clearance
  - 1 or 2 leading edge and trailing edge break points
  - 1 or 2 viscous directions
- typical 34 million point system created in about 10 min.

FUTURE WORK

> Surface grid generation on CAD models directly via CAPRI interface (SURGRD, PROGRD, OVERGRID)

> OVERPLOT improvements - rapid viewing of various history files in a single frame

> Scripting improvements
- Macro Tcl procs - one-line commands for various functions in GRIDED,SRAP,SURGRD, file manipulation, grid info interrogation, etc.
- Script generation and execution from GUI

> Multi-component turbopump grid generation script

> Automatic hybrid overset grids
...