Computational Fluid Dynamics Simulation of Moving Bodies using Overset Grid Method

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Presenter Background

Ernesto Camarena

- Born and Raised in El Paso, Texas
- Undergraduate Senior at Purdue University
- Majoring in Aeronautics & Astronautics Engineering
  - Concentrating on Aerodynamics and Structures
- Interned at
  - Penn State University, Applied Research Lab (Summer 2010)
  - Glenn Research Center (Spring of 2011)
  - Kennedy Space Center (current)
- Interested in applying to a Master's degree program in Aerospace or Mechanical Engineering at:
  - Purdue Univ., Penn State Univ. , FIT, Univ. of New Mexico, MIT.

Recognition

- Mentors: Bruce Vu and Doug Willard
- Lennie Duncil and Amy Duffy from LSP

- The contents of this presentation were gathered from the work of
  - William Chan (Ames Research Center)
  - Peter Bunning (Langley Research Center)
  - Reynaldo Gomez (Johnson Space Center)
  - Stuart Rovers (Ames Research Center)

Presentation Outline

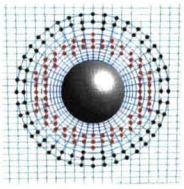
1. Overset Methodology and Nomenclature
2. Overset Grid Generation (Might not be included)
3. Utilizing Grid Movement in OVERFLOW
4. Launch Vehicle Description
5. Launch Pad Vehicle Drift Exercise
6. Booster Separation Exercise
7. Conclusion

1. Overset Methodology and Nomenclature

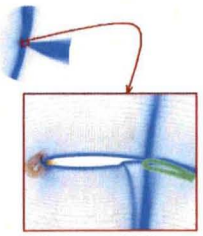
Overset Grids

- Overset grids also known as Chimera grids
- **Zone:** a single structured grid composed of ordered grid points
- Types of zones that decompose a spatial domain
  - Near-body zones
    - Defined near surface geometry
    - Useful for resolving near-body features while maintaining control of cell-size
  - Off body zone (optional)
    - Discritize space that extends to the far-field
    - In some cases the near-body grids may be extended (or "grown") to the far-field.

Near- and Off-body Grid Examples



Cartesian "box-gird" surrounding near-body grid for sphere



Multi-element airfoil
- Near-body grid for main element extends to far field
- Near-body grids for slat and flap are overlaid.

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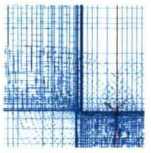
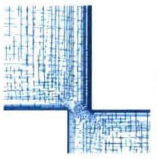
Hole-cutting

- Grid points that are defined inside or near solid geometry must be removed from computational domain
- Removing points from a grid is referred to as **hole-cutting**
- **Hole point:** a grid point which has been "**blanked out**" and whose data will not be used by the flow solver



Before hole-cutting



After hole-cutting

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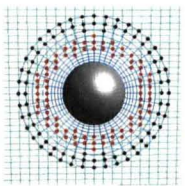
Interpolation

- Multiple overlapping grids requires:
  - Inner-grid communication of flow variables
  - Interpolation data must be provided for flow-slover
- **Fringe point**: a grid point which will be updated in the flow-solver via interpolation of data from a neighboring zone
- **Orphan point:** a fringe point for which a valid donor cell cannot be found



The small red and black circles represent fringe points.

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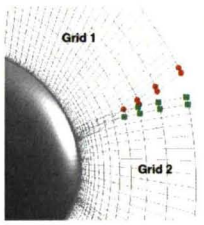
Interpolation (cont.)

- **Orphan point:** a fringe point for which a valid donor cell cannot be found
- Orphan points occur mainly when
  - The difference in cell size of the donor cell and recipient cell are too large
  - In insufficient overlap between adjacent grids



Two adjacent volume grids with a region that has insufficient overlap.

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2. Overset Grid Generation Process (tentative)

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3. Utilizing Grid Movement in OVERFLOW

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OVERFLOW-D Mode

- OVERFLOW 2.0 (flow-solver) has moving body capability
  - Mode-D (called OVERFLOW-D)
    - Given near-body grids, off-body Cartesian grids are automatically generated.
    - Domain-Connectivity is internal to OVERFLOW

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OVERFLOW Inputs

- OVERFLOW inputs –
  - grid.in: PLOT3D file with all near-body grids
  - Output from mixsur
    - mixsur is a force and moment coefficient pre-processor
    - External to OVERFLOW
  - X-rays:
  - Two XML files
  - overflow.inp
    - Main namelist

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Work Flow in OVERFLOW for Moving Body Problems

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4. Launch Vehicle Description

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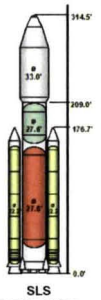
Launch Vehicle Description

Inertial Properties for SRB (ea.)	
Ixx, Slugs ft^2	217,308.00
Iyy, Slugs ft^2	11,405,920.00
Izz, Slugs ft^2	11,408,799.00
Mass, Slugs	5,730.90

*Derived from AIAA 2006-8033



SLS Configuration

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Major Assumptions

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5. Booster Separation Exercises

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6. Launch Pad Vehicle Drift Exercises

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7. Conclusion

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Conclusion

- NE-M1 has not had the capability of performing moving body simulations with any flow-solver
- The exercises in this project:
  - Utilize generic geometry from an SLS concept
  - Demonstrate the possibility of using OVERFLOW-D to perform CFD and dynamics analyses
  - Time step and applied loads need to be tweaked

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