IPS Virtual Paint - Spray

**Capability**
- Accurate simulation of spray painting
- Seamless integration of multi-physics solver
- Extremely robust, accurate and fast algorithms with immediate visualization
- Requires no expertise on computational tools

**Benefits**
- Power (Detailed physical models)
- Speed (Full car simulation overnight)
- Easy to use (one day crash course)

**Results**
- First software on the market
- Successful validation campaigns
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Physics-based simulation

- Automatically generated adaptive octree grids and immersed boundary techniques
- Fast solvers using GPU acceleration running on standard computers (full car simulation overnight)
- Internally and externally charged rotary bells supported

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Advantages
- Includes all relevant physics
- Excellent accuracy proven in numerous benchmark campaigns
- Isolate critical areas
- Minimize the need for physical testing
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Projection Method

- Paint a plate with one stroke and measure the thickness
- Reconstruct a static brush that corresponds well with the measurements when projected on the plate
- Takes object curvature, robot speed and TCP distance into account

### Input
- Geometry: CAD
- Process cond.: Applicator motions, Paint flow, Shape & purge air, Downdraft, Rotation speed, High voltage

### Simulation
- Painted flat plate profile
- Project profile
- Note: No physics taken into account

### Results
- Paint thickness

### Advantages
- Close to real time simulations
- Reasonable accuracy on large flat surfaces
- Gives rough initial estimate of paint coverage
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Simulation Procedure

1. Import geometry
   - CAD description

2. Process conditions:
   - Brush definition
   - Applicator motion
   - Spray-box: Downdraft

3. Perform Simulation
   - Physics-based
   - Projection

4. Evaluate results
   - Paint distribution
   - Thickness profile
   - Impact histogram
   - Transfer efficiency
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Selected validation campaigns

- **Volvo Cars 2011**
  - V60 car fender, plates
  - Dürr Ecobell 2 atomizer, internally charged
  - Clear coat
  - Measurements performed at Fraunhofer IPA, Stuttgart

- **General Motors NA 2012**
  - Car hood, car door
  - Dürr Ecobell 2, internally charged
  - Clear coat

- **Volvo Cars 2013**
  - Full car
  - Atomizers ABB G1, ABB RB1000, internally charged
  - Clear coat, base coat, filler

- **General Motors NA 2013**
  - Full car
  - Atomizer Fanuc, internally charged
  - Base coat

- **Volvo Trucks 2014**
  - Cab side
  - Dürr Ecobell 2, internally charged
  - Top coat
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Painting a Volvo Truck Cab

- Number of robot programs: 3
  - TFH_S.TID (21.3 s)
  - TFH_SD.TID (30.8 s)
  - TFH_5SU.TID (22.3 s)

- Number of brushes: 16
  - Measurements on plates for 4 brushes

- Paint applicator: Dürr Ecobell 2

- Select validation areas that are not affected by overspray from interior painting

- Physics-based simulation overnight

- Projection method simulation in a few minutes
Physics-based simulation shows excellent agreement
Projection method shows good agreement
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Technical advantages
- Extremely robust, accurate and fast method with immediate visualization
- Running on standard computer
- E-field, airflow and particles in one environment
- Many brushes at the same time, tested up to 20 brushes
- Opening doors during simulation does not cost additional time
- Contamination of applicators can be investigated and minimized
- No mesh generation
- No special know-how of FEM, solvers, meshing necessary. Training in one-day

Benefits
- Saves days of simulation time and time for correcting wrong setup
- Saves money for HW-resources
- No co-simulation of different complex SW-tools
- Realistic setup of the paint shop over night.
- One continuous simulation instead of splitting into sections
- Tremendously reduced time and cost for cleaning
- Saves man days of preparation
- Ready for productive use in short time frame