



Space Missions

Remote On-Ground Ice Detection System for NASA Space Shuttle External Tank Inspection

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September 25, 2007

- The need for ice detection
- Description of MDA multispectral Ice Camera
- Test results
- Shuttle External Tank ice inspection results



Photo courtesy of NASA

- Shuttle External Tank (ET) houses liquid hydrogen and oxygen fuel in a tank externally insulated with foam
- Fuel cold soaks insulation and water condensation can freeze to produce thin layers of acreage ice and ice balls
- The need for ice detection
 - The Space Shuttle Columbia was lost caused by foam debris falling from the ET
 - Recent STS-118 mission had tile damage caused by ice covered foam
- Ice debris detection is the one of the highest priorities for NASA pre-launch inspection

STS-118 Tile Damage

August 8, 2007



Photos courtesy of NASA

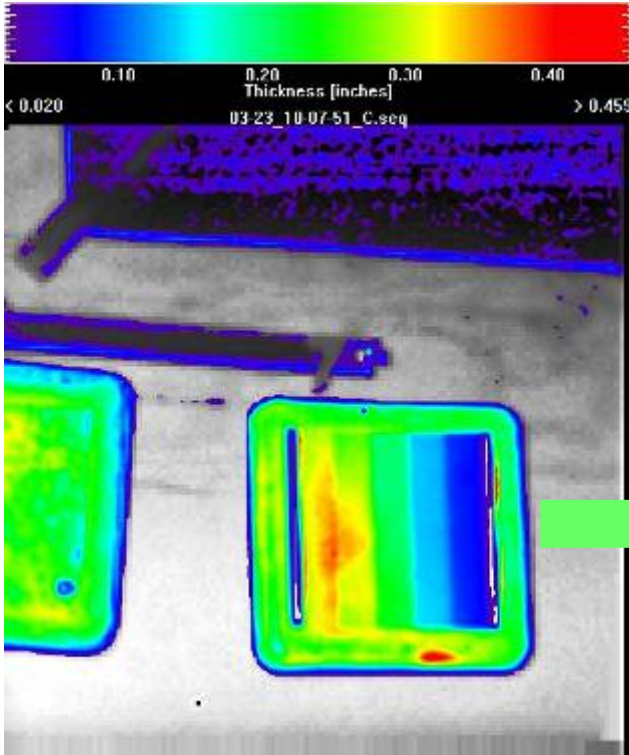
- Portable system to inspect the shuttle ET and engines prior to launch from the launch tower and launch platform
- Determine if ice exceeds Launch Commit Criteria (LCC)
 - >1.6 mm for ice layers on ET insulation
 - Detect ice balls >58 mm diameter
- Safe for use in hazardous areas

KSC Prototype Ice Camera Description

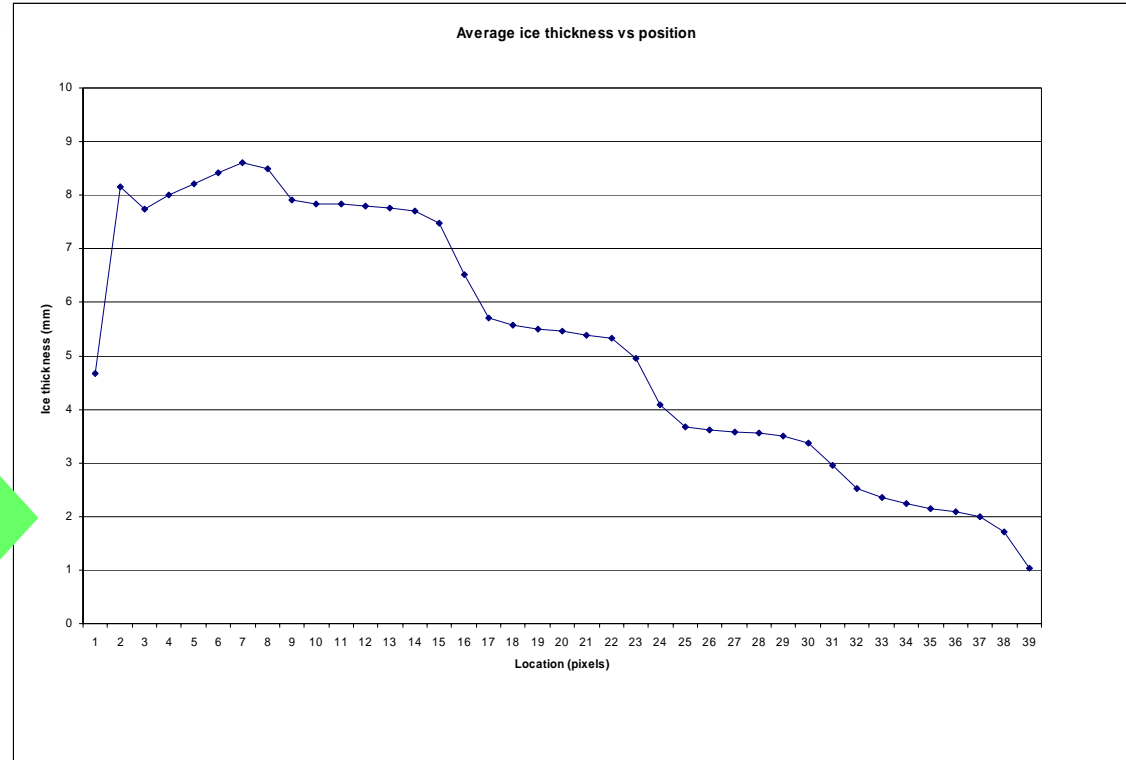


Prototype Ice Camera for Shuttle ET Inspection

- Remote On-Ground Ice Detection system that distinguishes between ice and water on most surfaces
- Explosion proof packaging
- Ice thickness measurement range 0.5-12.5 mm (0.01-0.5 inches)
- Thickness accuracy $< \pm 0.25$ mm (0.01 inches)
- Operating range 7.6-37m (25-120 ft)
- 1 sec update rate
- Day/night operation
- Easy to operate and interpret

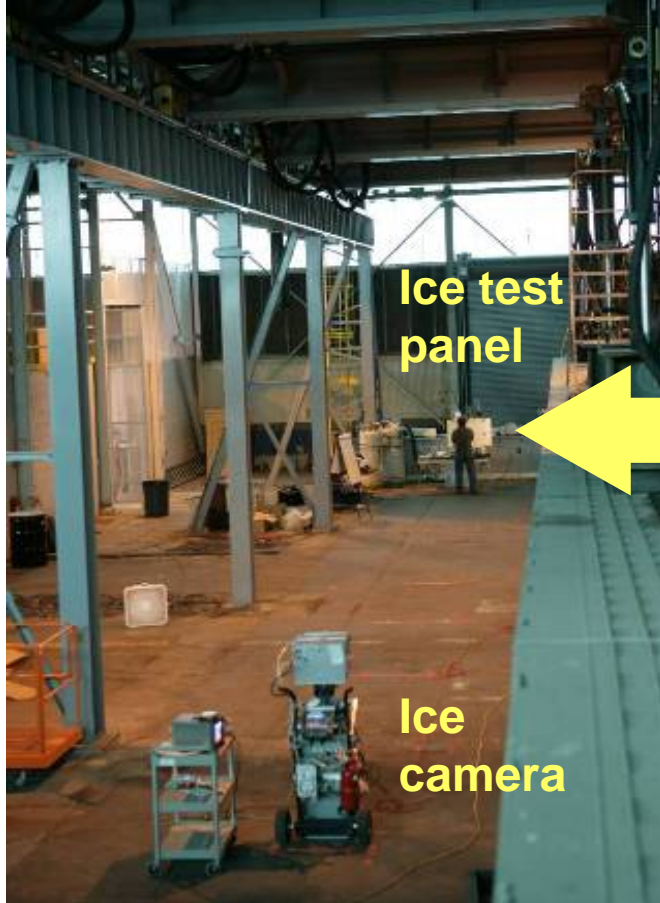


Ice Camera Image of Stepped Ice Thicknesses on Milled ET insulation
(Blue to red = Thin to thick)

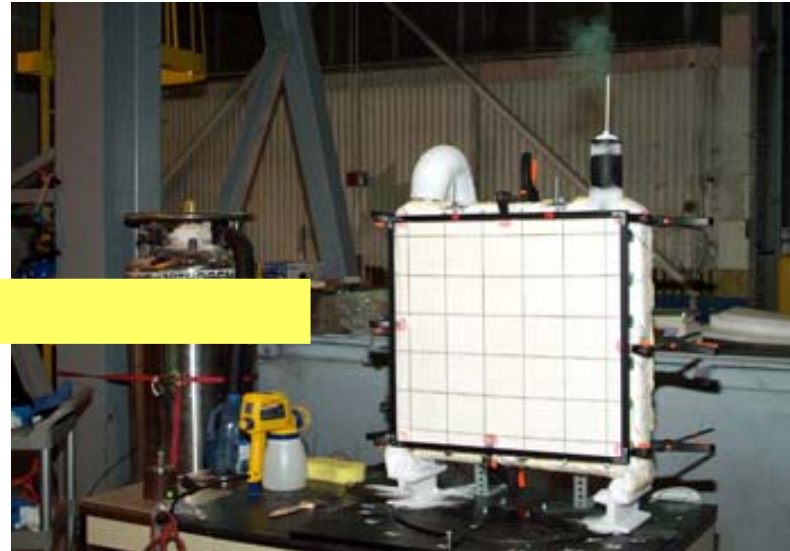


Measured ice thickness across milled insulation panel

- NASA and the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) entered into a Space Act Agreement (SAA)
- Under the SAA, the TARDEC Visual Perception Lab serves as an independent test and evaluation organization for NASA
 - Research different ice detection technologies for ET inspection
 - Test and evaluate prototype Ice camera characteristics including:
 - Ice detection and thickness accuracy
 - Measurement range
 - Ambient lighting effects
 - Ice ball detection



Test facility



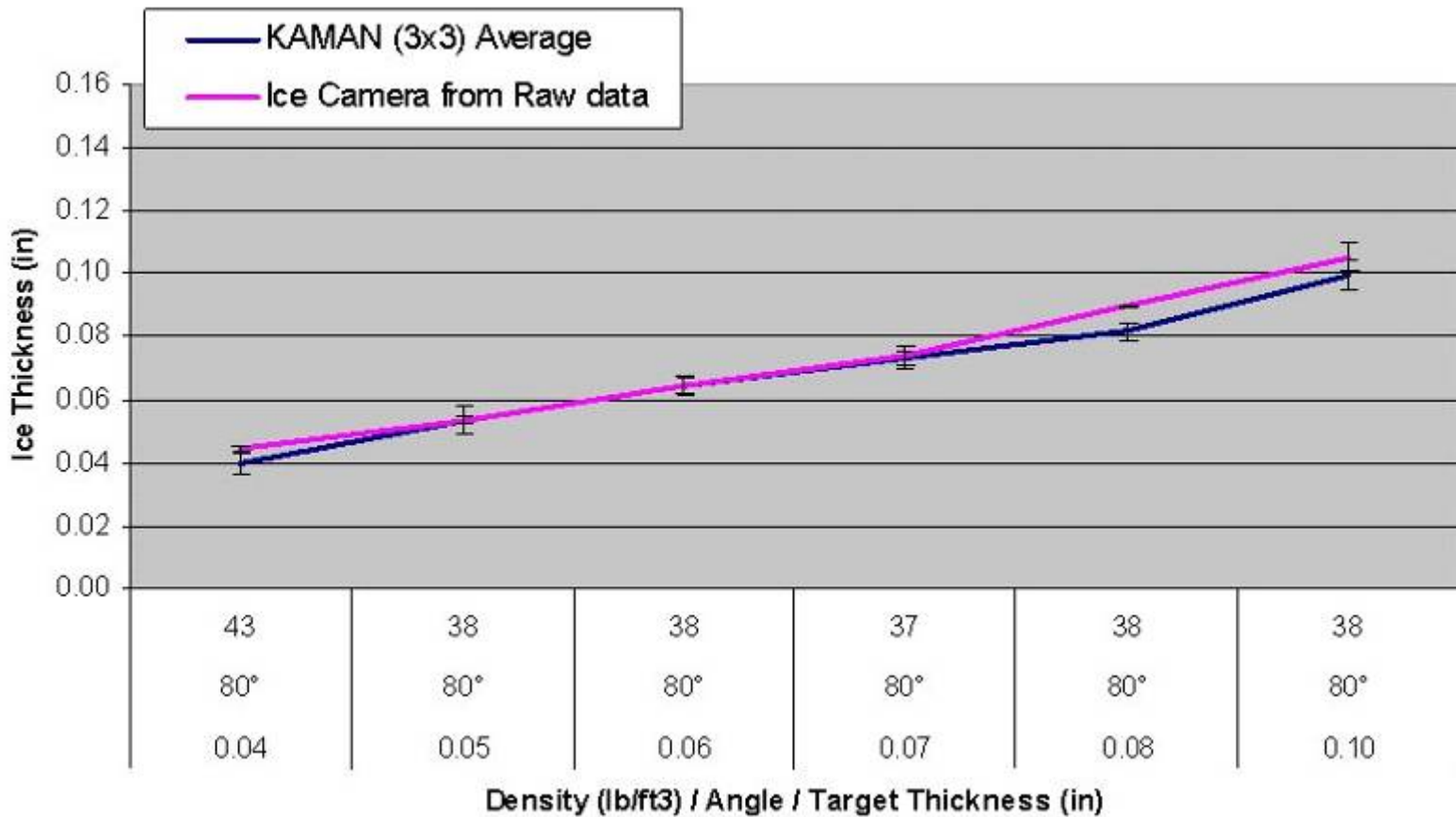
Cryogenic ET foam ice test panel



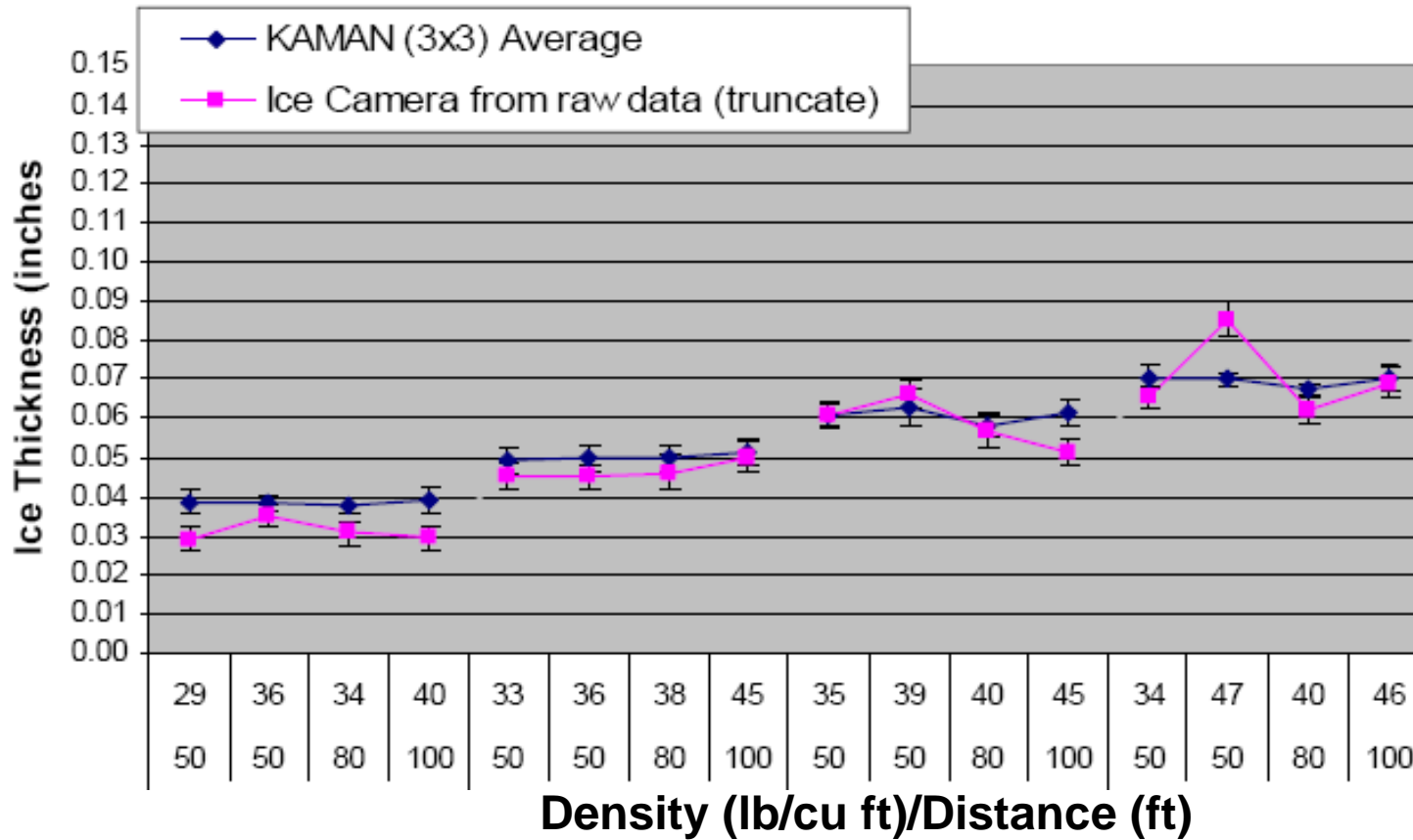
Kaman ice thickness gauge

Photos courtesy of TARDEC

- Comparison of ice thickness measurements by Kaman and Ice camera @ 50 ft range for different ice densities



- Comparison of ice thickness measurements by Kaman and Ice camera for different ranges and ice densities



- System can distinguish between ice and water
- Ice with thickness $<0.5\text{mm}$ to $>25\text{ mm}$ can be detected on ET foam insulation
- ET ice thickness measurement accuracy is within $\pm 0.25\text{ mm}$ at distances up to 33 m
- Ambient lighting has no effect on performance

- **After series of successful laboratory tests by TARDEC, the prototype Ice camera was used for engineering measurements in three shuttle launches**
 - **STS-116 December 6, 2006**
 - **STS-117 June 24, 2007**
 - **STS-118 August 8, 2007**

Inspection from the launch tower



Photos courtesy of NASA

Acreeage ice inspection



Photos courtesy of NASA

LO2 feedline bracket inspection





LH2 Umbilical



Photos courtesy of NASA

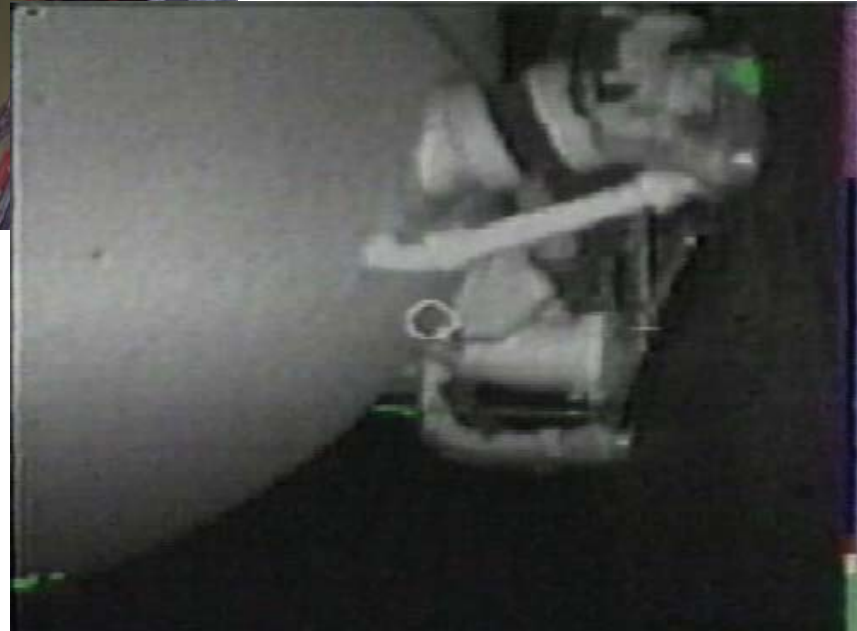
Inspection from the Mobile Launch Platform



Photos courtesy of NASA

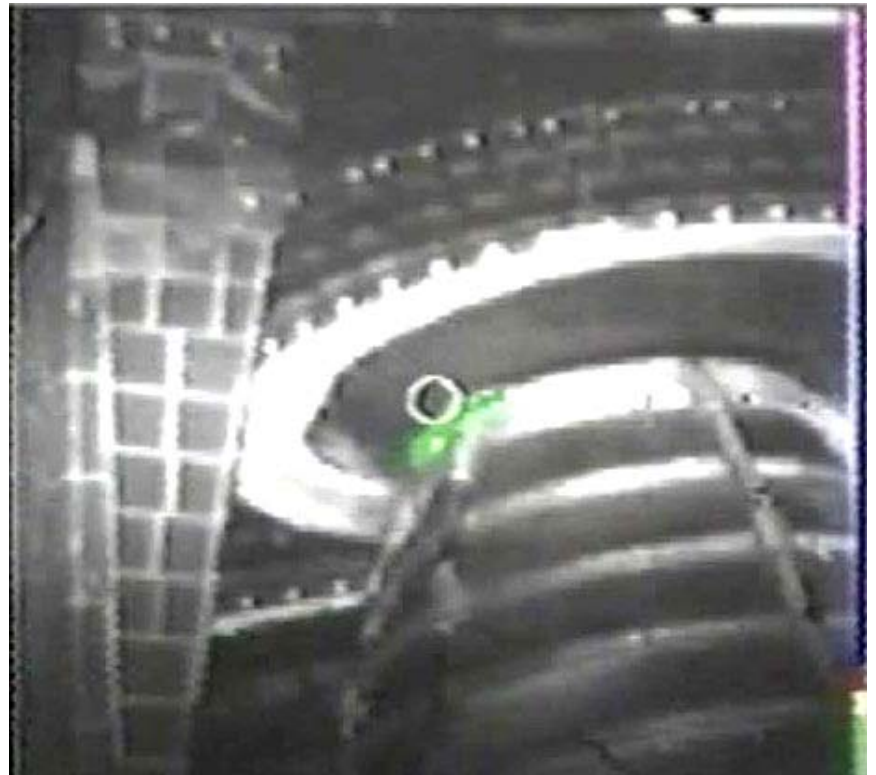


ET/Orbiter LH2 Feedline



Photos courtesy of NASA

Shuttle Main Engine







“The SAA team has developed an ice detection and measurement system in less than three years, that has the potential to solve a problem that NASA has struggled with for more than 25 years—SOFI acreage ice detection and measurement, and more recently ice ball detection.”

- Charles Stevenson (Technical Assistant to the Shuttle Processing Chief Engineer)

- Next step is to develop an operational Ice camera as a primary means of detecting and measuring ice contamination

Questions?

