Preliminary Debris Transport Assessment of Debris Impacting Orbiter Lower Surface in STS-107 Mission

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Subcontract 1970483303

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Debris Impacts Orbiter Lower Surface

- **Issue** – At about 82 seconds into the flight, a large piece of debris was seen emanating from the ET bipod area and later seen impacting the Orbiter lower surface tiles

- **Background**
  - Preliminary assessment of debris impact conditions predicted an impact to the Orbiter lower surface at location XO1049, YO185 (results provided on January 17, 2003)
    - Impact Velocity estimated to be 750 ft/sec.
    - Impact Angle estimated to be less than 20 degrees
  - Refinement of the results show reduction of impact angle and impact velocity
  - Analysis methodology and results were presented to the Aero Panel on January 21, 2003
    - Aero Panel concurrence was obtained
    - Aero Panel recommended sending results to Orbiter Program for damage assessment

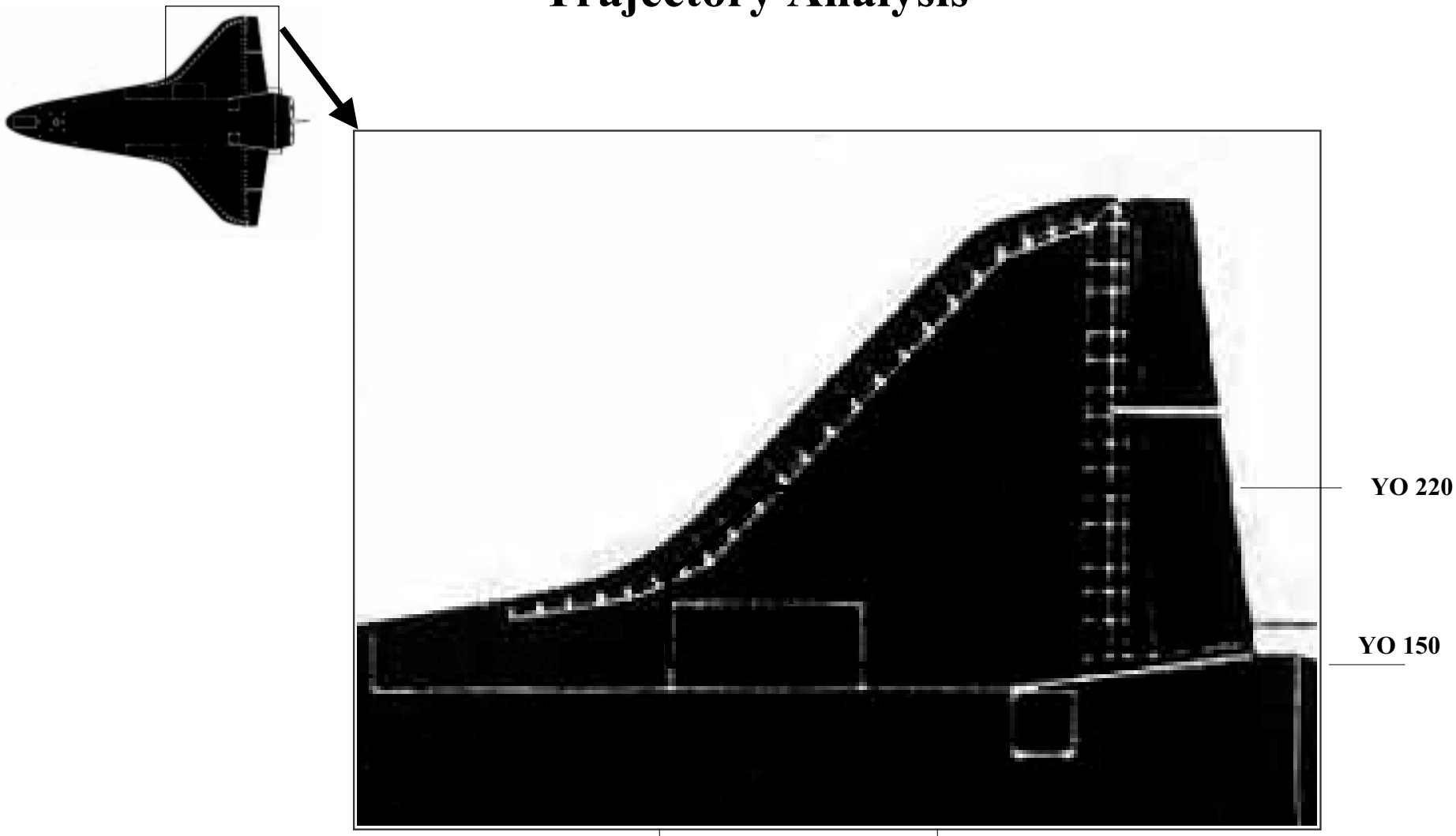
Debris Impact Conditions to Be Evaluated for Area on Orbiter Lower Surface

- **Actions Taken**
  - Defined impacts area based on film observations and debris trajectory modeling
    - Large uncertainty in trajectory computation does not allow a good prediction of the impact area
  - Performed debris trajectory computations to define impact conditions inside impact area.
    - Debris particle emanates from bipod ramp area (XO 389, YO 50)
    - Two debris sizes analyzed:
      - 20” x 10” x 6” (representing flange foam)
      - 20” x 16” x 6” (representing bipod ramp)
    - Debris material considered to be foam (density = 2.4 lb/ft3)
    - Particle subjected to initial lateral motion to simulate lateral loading of bipod ramp
  - Impact conditions inside predicted impact area was derived as follows:
    - Actual Impacts: Particle impact information as computed by the debris trajectory program
    - Near Impacts: Particle velocity obtained for specific points in particle trajectory
    - Debris Database: to define particle impact angles at locations in the landing gear wheel well

Results Show Low Impact Angles on the Orbiter Lower Surface

- **Results -**
  - Completed evaluating results for trajectory analysis of foam debris of size = 20”x10”x6”
    - Impact velocity inside predicted impact area range between 650 and 730 ft/sec.
      - Impact velocity at wing RCC may vary between 700 and 720 ft/sec.
      - Impact velocity at Landing wheel well varies between 650 and 730 ft/sec.
    - Impact angles can be expected to be larger near wing leading edges because of wing curvature
      - RCC impacts can be as high as 22 degrees in some regions
    - Impact angles at the landing wheel well are expected to be less than 10 degrees
  - Results for trajectory analysis of foam debris of size = 20”x16”x6” are currently under evaluation

Predicted Impact Area Derived from Film Observations and Trajectory Analysis

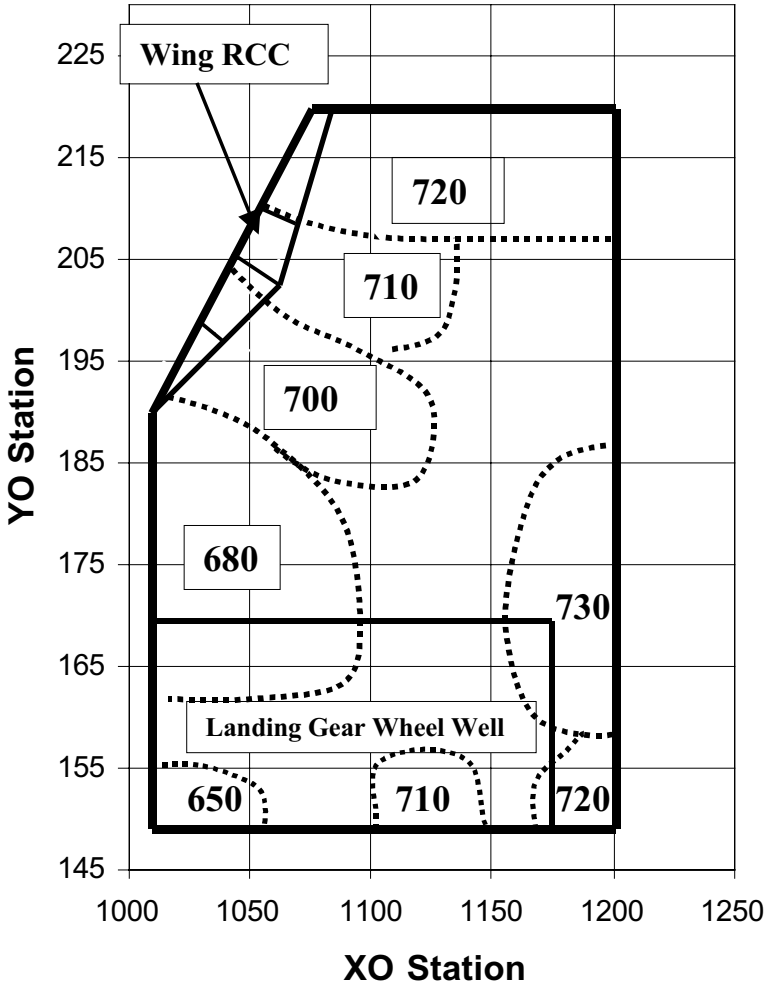


Velocity and Impact Angle Distribution Inside Impact Area

(Debris Size = 20” x 10” x 6”, Density = 2.4 lb/ft3)

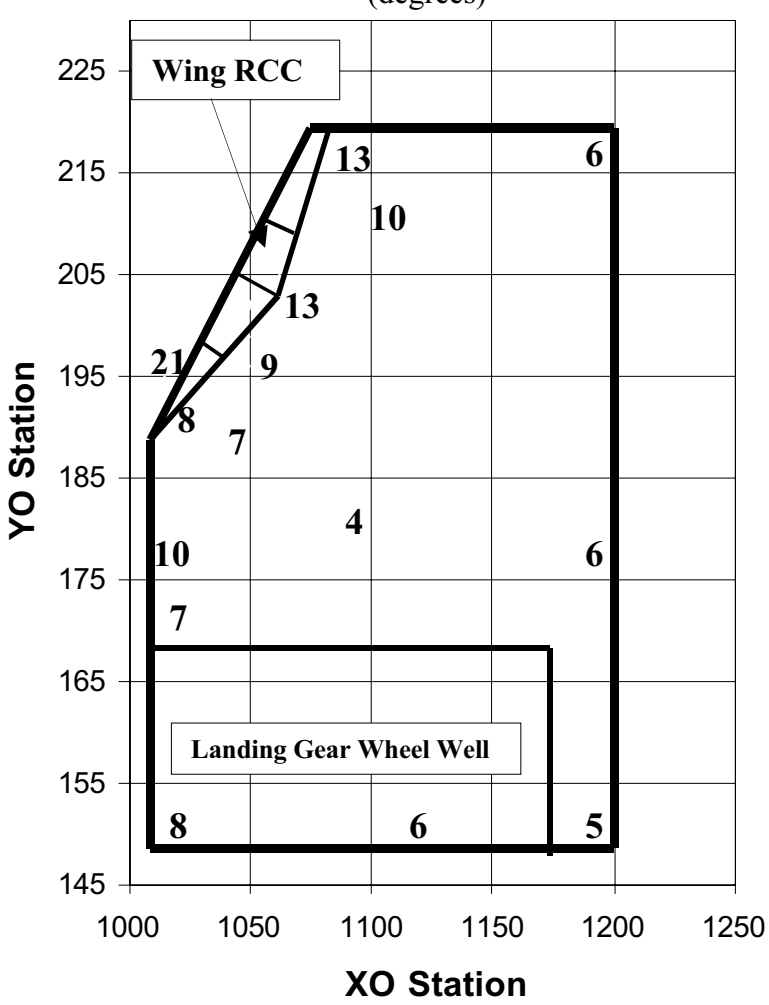
Impact Velocity

(ft/sec.)



Impact Angle

(degrees)



STS-107 Debris Impacting Orbiter Wing

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More Results Underway

- **Conclusions -**
  - Impact conditions were presented for a debris of size = 20”x10”x6”
    - Impact velocity inside predicted impact area range between 650 and 730 ft/sec.
    - Impact angles can be expected to be larger near wing leading edges because of wing curvature
    - Impact angles at the landing wheel well are expected to be less than 10 degrees
  - Results for trajectory analysis of foam debris of size = 20”x16”x6” are currently under evaluation
    - Preliminary assessment of the data shows impact velocity range between 558 and 700 ft/sec.
    - Impact angles generally low (in same order as those presented for particle size = 20”x10”x6”)
    - Expected completion of task is 1/22/03.

Back-Up

Results of Impact Analysis for particle size = 20” x 10” x 6”

XT	YT	ZT	VMAX (ft/sec.)	VX (ft/sec.)	VY (ft/sec.)	VZ (ft/sec.)	IMPANG (degrees)
1755	193	625	690	682	104	20	9.0
1759	194	630	689	680	107	25	9.4
1744	190	637	693	683	107	36	8.7
1755	191	641	698	689	107	41	7.8
1800	197	648	702	693	105	46	8.8
1747	190	626	686	677	104	21	7.0
1769	192	629	682	674	105	23	7.1
1751	188	637	685	676	105	35	10.4
1754	188	641	690	681	104	40	7.8
1754	187	644	694	684	103	44	6.6
1755	197	627	693	684	107	23	11.9
1748	195	630	691	682	107	27	13.3
1756	194	638	699	689	109	37	8.9
1806	202	645	712	703	109	42	11.3
1788	199	647	711	701	109	46	10.4
1762	200	627	700	691	109	24	21.5
1833	211	633	707	698	110	28	9.6
1802	204	641	713	703	110	38	12.8
1790	202	644	711	702	110	42	11.3
1781	200	647	712	703	108	46	11.1
1744	186	625	683	675	102	18	6.5
1718	181	627	673	665	101	22	6.0
1742	184	636	653	645	98	30	2.0
1652	169	635	635	627	96	32	0.4
1593	159	634	611	603	92	34	2.0
1786	198	621	705	697	104	15	7.5
1799	201	624	702	694	105	18	7.7
1758	194	624	691	683	104	20	9.1
1830	210	617	723	715	106	12	5.4
1799	205	620	710	702	106	15	7.9
1790	202	623	707	699	106	17	8.1
1762	198	625	694	686	107	21	11.8
1788	196	620	705	697	102	14	7.0
1798	198	623	698	691	103	17	7.2
1755	191	624	687	679	103	19	6.8
2023	238	615	762	755	103	7	1.1
1830	210	617	723	715	106	12	5.4