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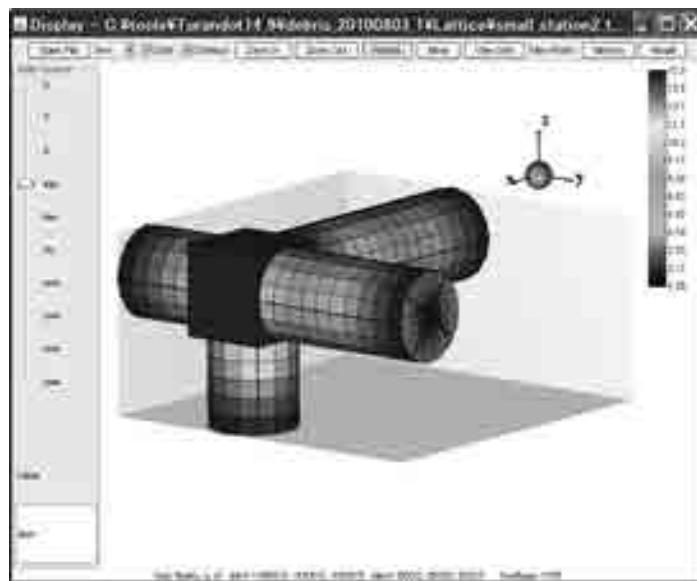
デブリ衝突損傷リスク解析ツール(TURANDOT)の機能拡張 Expansion of Tactical Utilities for Rapid ANalysis of Debris on Orbit Terrestrial

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デブリ衝突損傷リスク解析ツール(TURANDOT)は、2008年に開発を開始した宇宙機設計支援ソフトウェアである。本ツールは宇宙機表面を詳細な格子に分割し、衛星各部の遮蔽効果を考慮した上で、各部のデブリ衝突による損傷発生確率を推定する。軌道上デブリフラックスのデータベースとしては、当初、MASTER2005とORDEM2000を利用したが、現在ではMASTER2009も利用可能なように機能拡張を実施した。本ツールの概要を報告する。

Development of Tactical Utilities for Rapid Analysis of Debris on Orbit Terrestrial (TURANDOT) is started on 2008. The software is capable of prediction of spacecraft damage probability by collisional debris including shielding effect of the spacecraft itself. The tool initially makes use of MASTER-2005 and ORDEM2000 as database of debris flux. We conducted the expansion so that the tool can reference MASTER-2009 also. The report is of the schematic of the tool.



TURANDOT

Expansion of Tactical Utility for Rapid Analysis of Debris on Orbit Terrestrial

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@ Chofu Aerospace Center

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1

Contents

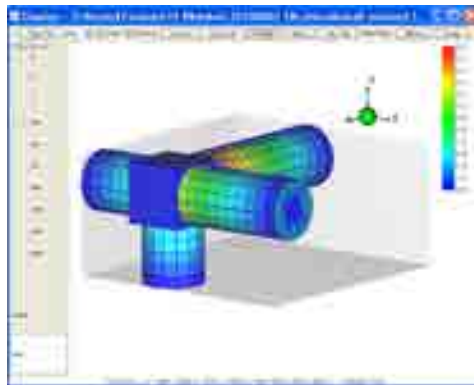
- What is TURANDOT ?
- History
- Functions
 - Own GUI
 - Database Inclusion
 - Damage Probability
- Analytical Technic
- Validation
- Conclusion

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2

What is TURANDOT ?

- JAXA's Debris collision risk analysis tool
 - For each part of spacecraft system
 - Orbit, Attitude, Shape & Shielding Effect
 - Users' defined Damage Mode & Ballistic Limit Eq.



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3

History

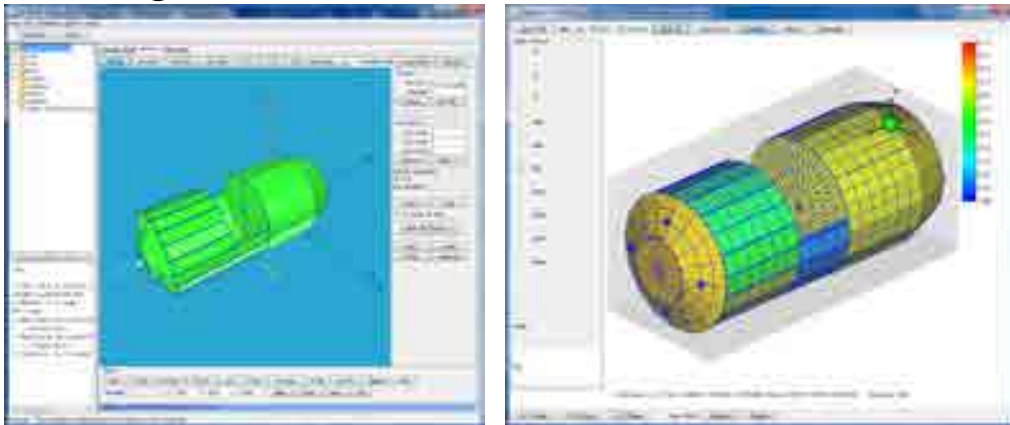
- April, 2007~Feb., 2009
 - “Collision Probability” Analysis Tool
- April, 2009~Feb., 2011
 - “Collisional Damage” Probability Analysis Tool
- April, 2011~Feb., 2012
 - Including “MASTER-2009”

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4

Functions I

- GUI
 - Integrated Analysis Environment
 - Satellite modeling
 - Grid generation

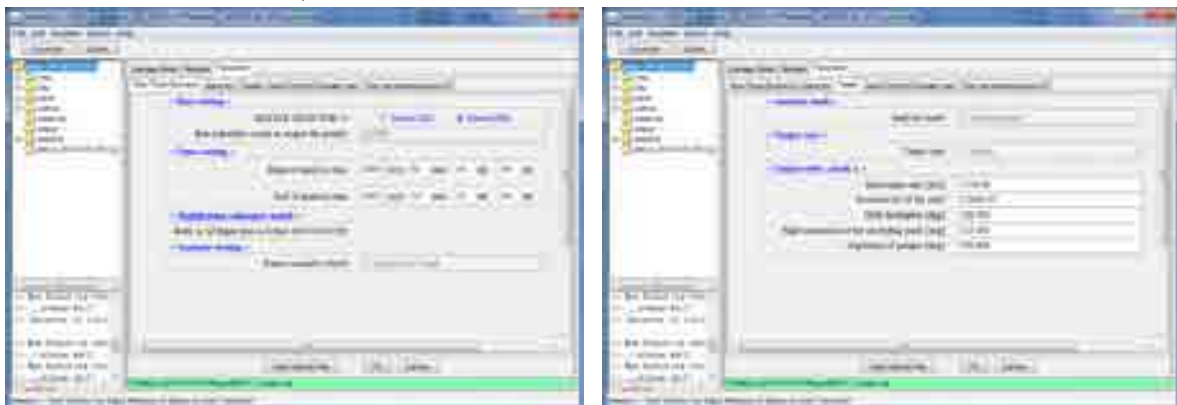


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5

Functions I

- GUI
 - Computation condition setting
 - Requirement from Databases (MASTER & ORDEM)



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6

Functions II

- No Domestic Database!
 - MASTER-2005 & ORDEM2000
 - MASTER-2009 & ORDEM2000

$$flux_{ORDEM} = flux_{MASTER} \cdot K \quad \text{if } 1 < K$$

$$flux_{ORDEM} = flux_{MASTER} \quad \text{if } K < 1$$

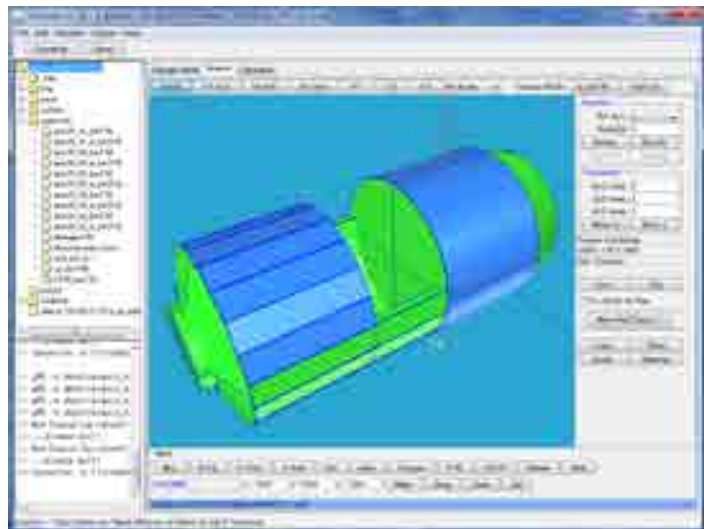
$$K = \frac{F_{ORDEM}}{\int_{4\pi} f_{MASTER} \cdot d\Omega}$$

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7

Functions III

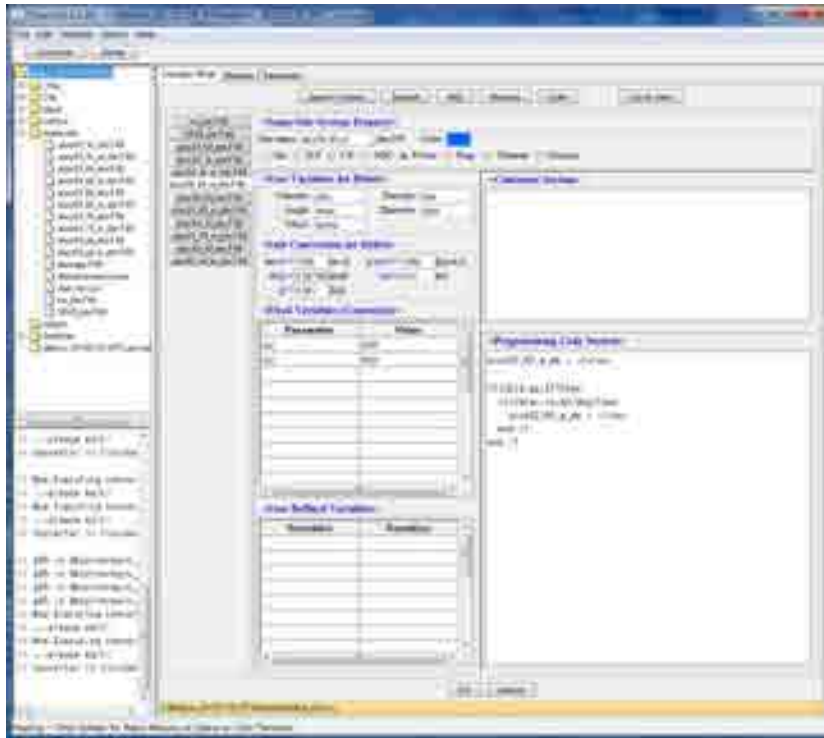
- Damage Probability
 - Users' Definition
 - Fortran 95 like



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8

Functions III



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9

Analytical Technic I

- Computation Cost
 - If an spacecraft has 1000 surface elements,

Shielding Elements

1000 x 1000 x 1000000 Shielding Effect Check !!

Surface Elements

MASTER Fluxes

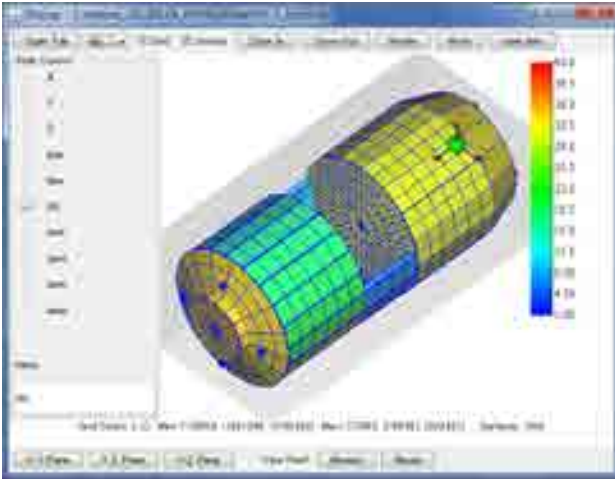
- Long computation time.
- Huge memories to Windows PC.
- HD is too slow.

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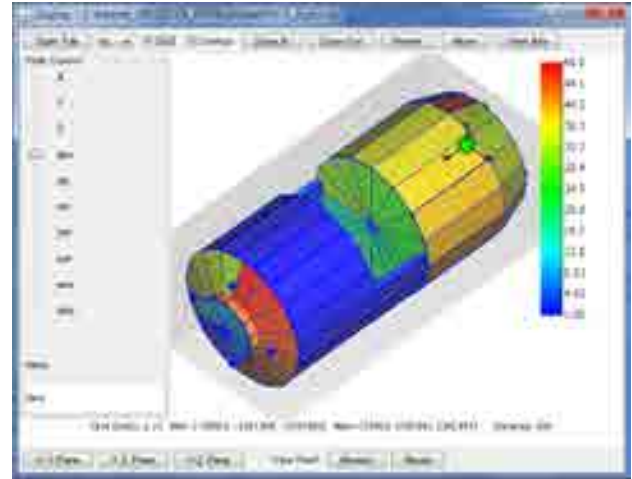
10

Analytical Technic II

- Reduce Shielding Elements



Shielded Element



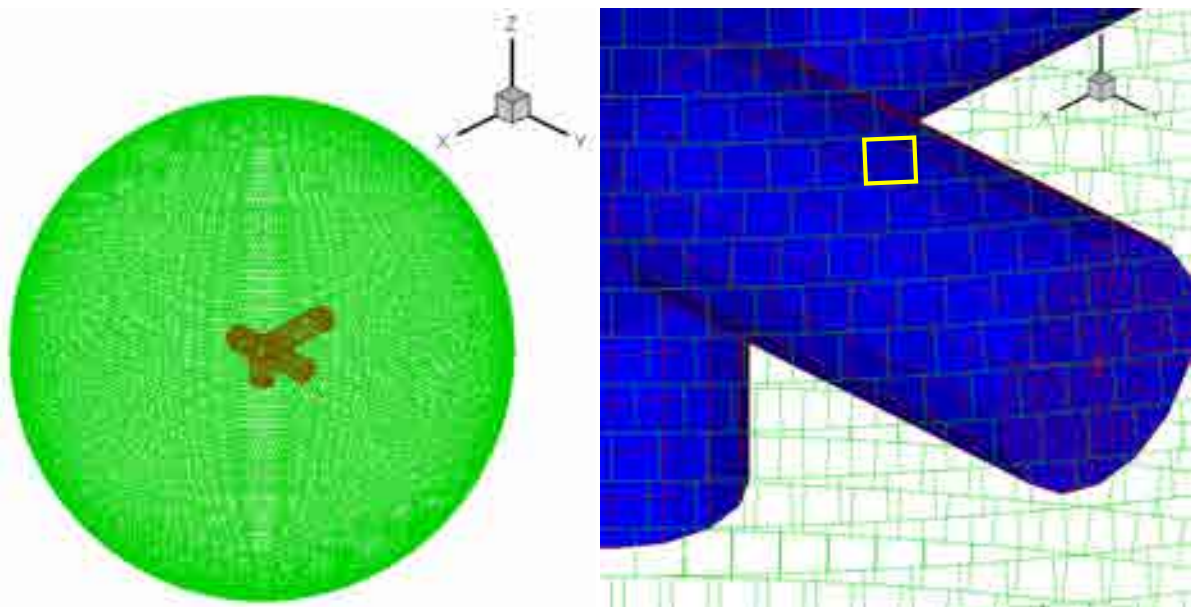
Shielding Element

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11

Analytical Technic III

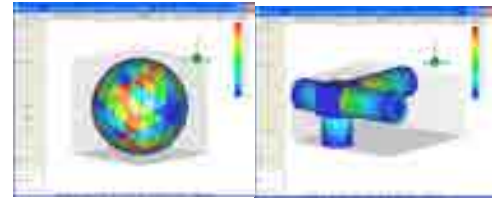
- Reduce MASTER fluxes into solid angle



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12

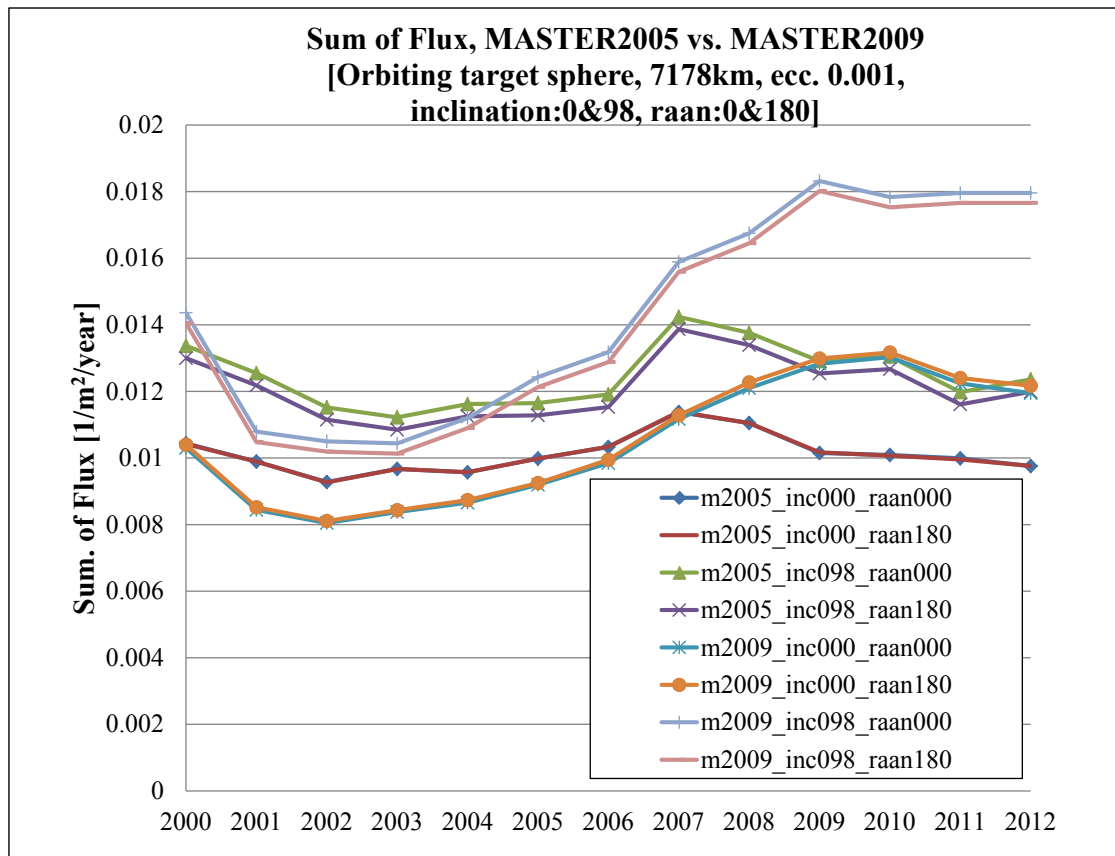
Validation



		Cube		Sphere		Small Station
		ORDEM2000/ MASTER2005	Turandot	Ordem2000/M ASTER2005	Turandot	Turandot
ORDEM2000 (+MASTER2005)	D>0.1mm	-	2.25E+01	1.77E+01	1.60E+01	9.32E+01
	D>1.0cm	-	1.35E-05	2.16E-06	9.51E-06	5.44E-05
Master2005	D>0.1mm	6.14E+00	6.15E+00	4.65E+00	4.37E+00	2.55E+01
	D>1.0cm	1.36E-05	1.36E-05	1.04E-05	9.53E-06	5.45E-05

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13

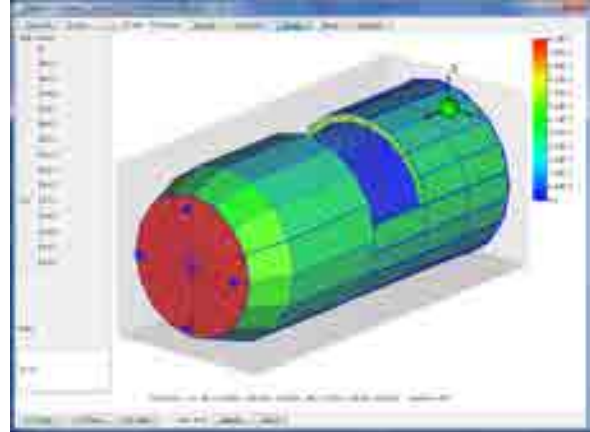
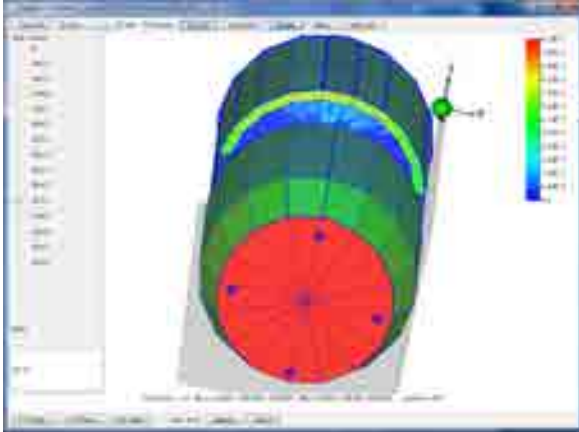


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14

Example

- Collision Probability

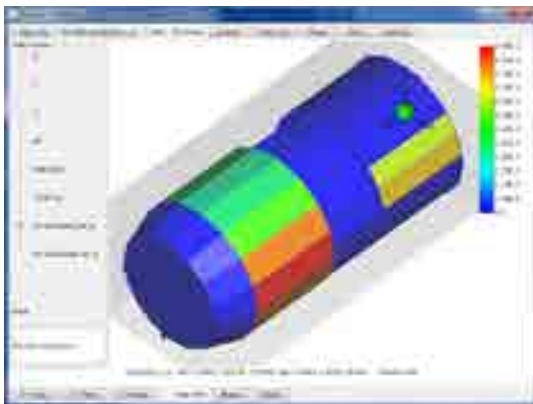


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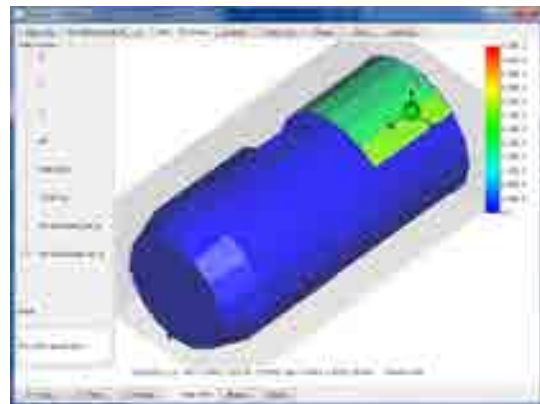
15

Example

- Damage Frequency



User defined SAP-1



User defined SAP-2

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16

Conclusion

- Development April 2007~Feb.2012
- GUI
- Solver
- MASTER-2005/2009 & ORDEM2000
- Users' damage mode definition
- Tri-direction Spacecraft (Geo , Inertia & Helio)

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17

References

- MASTER-2005/2009 Manuals
- ORDEM2000 Manual
- IADC Protection Manual
- Hastings & Garrett "Spacecraft Environment Interaction," Cambridge

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18

FAQ “TURANDOT”

- Japanese E.T. legend “Kaguya” /”Takatori”
 - No “D” of debris, damage
 - No “C” of collision
- Oriental similar legend “Turandot”
 - François Péti de la Croix, ”Les Mille et un Jours”



“Takatori”

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“Turandot”

19