

# Orbital Servicing Models and Technologies

NASA International Workshop on On-Orbit Satellite Servicing

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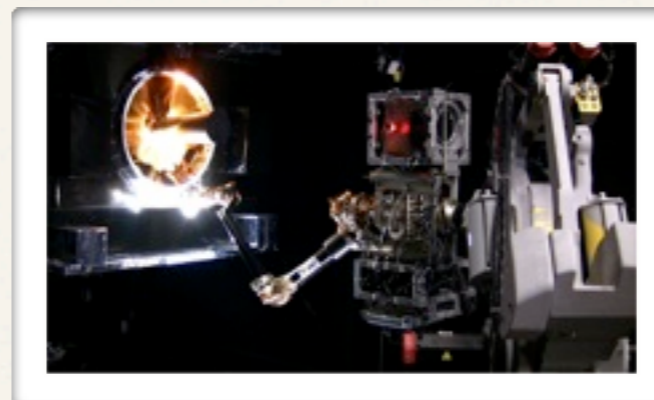
*25 March 2010*



# How did we get here?

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- ♦ Big ideas
- ♦ Great technology
- ♦ Stunning good looks

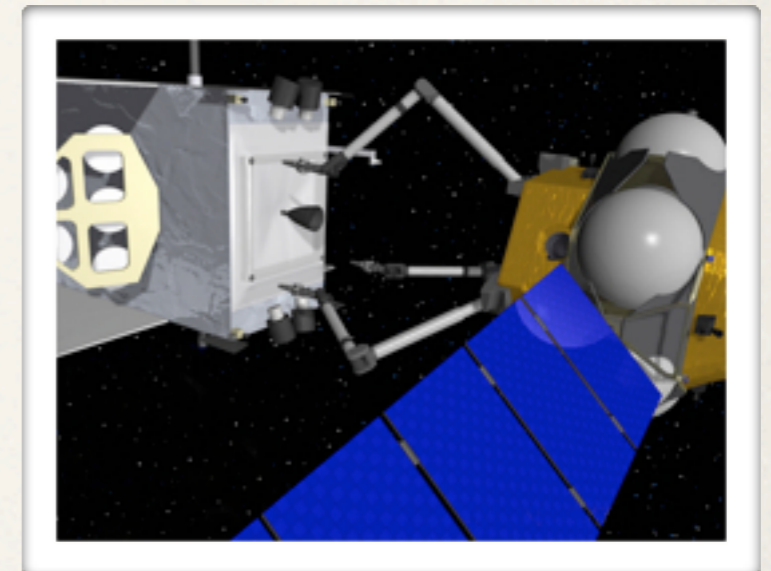


- ♦ But very few transitioned systems



# Robots I have known

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# Why didn't they sell?

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It's the economics, stupid.



# Spacecraft business models

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# Commercial Spacecraft Fleet

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- ♦ Commercial operators “own” bandwidth
- ♦ Assume regular replacement
- ♦ Loss of spacecraft born by insurer
- ♦ Residual value of end-of-spacecraft is low
- ♦ Modifications to host unlikely to make economic sense
- ♦ Viable servicing model requires high volume



# Government Spacecraft Fleet

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- ♦ Government “owns” service
- ♦ Assume intermittent replacement
- ♦ Loss of spacecraft borne by government
- ♦ Residual value of end-of-life spacecraft is high(er)
- ♦ Modifications to host may make economic sense, require buy-in
- ♦ Viable servicing model requires low initial servicer cost



# NASA Spacecraft Fleet

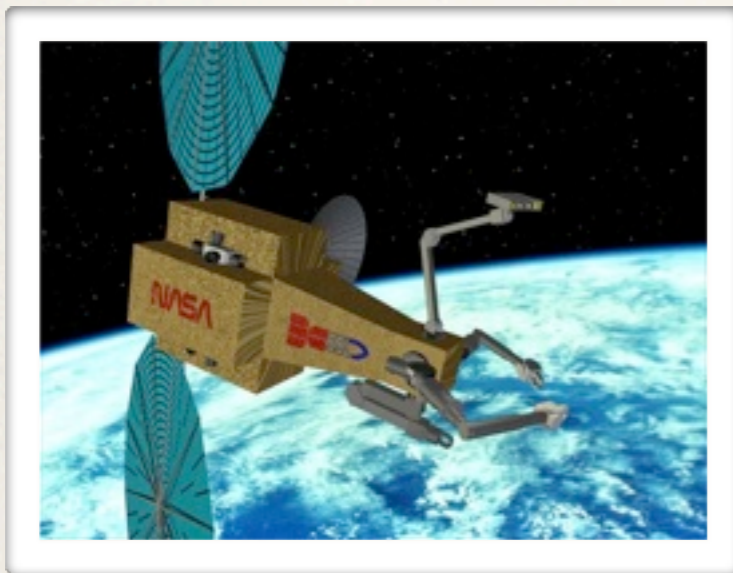
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- ♦ NASA owns spacecraft!
- ♦ Assume periodic technology refresh, not replacement
- ♦ Loss of spacecraft borne by NASA; generally intolerable
- ♦ No definable end-of-life
- ♦ Modifications to host make economic sense, but require buy-in
- ♦ Viable servicing model requires high capability, safety



# Robots I have known, redux

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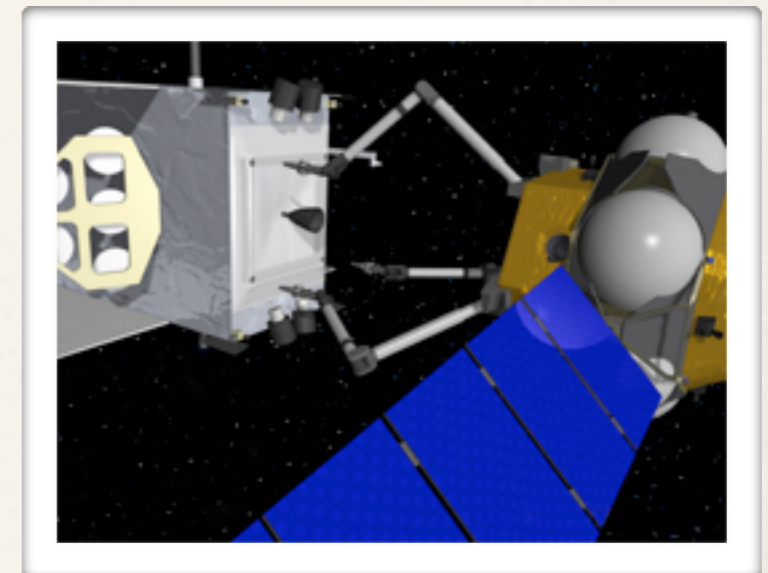
Maserati model

- ♦ Maintenance \$\$\$ ~ initial \$\$\$
- ♦ Difficult to justify and plan for
- ♦ Perceived risk



Accord model

- ♦ “Chicken and egg” problem
- ♦ Haven’t found the knee in the repair/replace curve
- ♦ Need to bring cost of servicer down



Taurus model

- ♦ No repair market
- ♦ Possible refueling market
- ♦ No central government decision-maker



# Commercial Tech

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- ♦ **Keys: amortize cost of servicer over multiple customers**
- ♦ High- $I_{sp}$  propulsion (or stay in GEO)
- ♦ Rendezvous and grapple to unmodified host
- ♦ Refueling capability without specialized ports
- ♦ Minor servicing



# Government Tech

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- ♦ **Keys: mind share; low cost**
- ♦ High- $I_{sp}$  propulsion
- ♦ Lightweight mechanisms; smaller, faster flight processors
- ♦ Improved reliability
  - ♦ More, better sensors
  - ♦ Improved automation
  - ♦ Improved supervisory control



# NASA Tech

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- ♦ **Keys: capability, flexibility, safety without astronomical cost**
- ♦ Dexterous manipulation
- ♦ Machine cognition
- ♦ Better supervisory control



# Conclusion

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- ♦ Basic technologies to establish orbital servicing already exist
- ♦ Focus on developing systems that address viable business models
- ♦ Focus on gaining mind share with decision makers
- ♦ Improved technologies make our case much stronger