After nearly 26 years of development and assembly, the ISS is nearly complete

- 35 US and Russian assembly flights
  - 4 to go
- 140 EVA’s
- 90% complete by mass
- 90% complete by volume
- 370 km altitude
- 16 Earth orbits each day
- 51.6° inclination covers 90% of world’s population

* note: all figures approximate

In orbit since November 1998 with the launch of the first ISS element FGB from Baikonur, Kazakhstan

Permanently crewed since November 2000 with Expedition 1

6 crew members for nearly one year
No one expected it to take this long
No one expected it to be accomplished
No one expected it to go so well

- **Space Station assembly has evolved over the years**
  - External assembly was more complex and required orders of magnitude more EVA’s than the final version
  - If we were to have lost an ISS element, it would have to be replaced or the ISS would have had to be re-designed
  - Dependence on a single launch vehicle significantly set back the program

- **From a top level, if we were again to ever craft a complex mission that required assembly, we should**
  - Limit the number of assembly missions; less than 10
  - Require EVA’s only when absolutely necessary
ISS Assembly

- Human vs. robotic operations require tradeoffs
  - Safety
  - Amount of planning and training
  - Failure scenarios
  - Cost and schedule

- For ISS, the investments made in EVA over many years made EVA assembly tasks the preferred mode of operation
  - SSRMS and SRMS operations were critical to assembly of the large elements – however – nearly 1000 EVA hours to-date were needed to complement robotic assembly operations

- Most external maintenance tasks were designed to be robotically compatible – but this has not been demonstrated
  - Dextre to demo soon, SSRMS-JEM RMS used for payload transfers – robot to robot handoffs
ISS Assembly Lessons Learned

- Human operations are very compatible with robotic operations
  - Demonstrated by many simultaneous EVA and robotic assembly operations
- Robotic operations can successfully be accomplished remotely without on-board crew
- We have performed maintenance tasks on-orbit that were never planned
  - Maintenance of many ORU’s were assumed to be performed on the ground during the design phase

- Design system and components to be accessible and maintained on-orbit
  - Even for systems that “don’t require” service when originally conceived
- System design should be paralleled by maintenance and service design activities
For More Information

ISS Reference Guide
Cumulative Results Reports:
NASA/TP-2006-213146
NASA/TP–2009–213146–REVISION A

Education on ISS 2000-2006:
NASA/TP-2006-213721

Space Station Science Webpages

Facilities Webpages