Tools and Processes for Robotic Outfitting of Buildings
Terrestrial And Space Construction Examples
Overview

Terrestrial Vs Extraterrestrial Construction

Multi System Assemblies

Traditional Construction

Systems Integration

NREL ICI – Robotics for Systems Integration
Terrestrial Vs Extraterrestrial Construction

Building on Earth
a system of systems that are functional
-structurally stable
-energy efficient
-thermally efficient
-habitable**
-rapidly constructable

Building in orbital space
a system of systems that are functional
-structurally stable
-energy efficient
-thermally efficient
-habitable**
-easily deployable (or assembly)
-remotely controllable

Building on extra-terrestrial bodies
a system of systems that are functional
-structurally stable
-energy efficient
-thermally efficient
-habitable**
-remotely constructable
-easily deployable
-remotely controllable
Multi System Assemblies

Source: https://www.autogreeknews.gr/antallaktika-autokinwn/2655-metageirisomena-antallaktika-autokinwn-lagios-k-gewrgios
Multi System Assemblies

Source: https://imageio.forbes.com/specials-images/imageserve/6123fd7c33703c8ccc0e9ba6/Automotive-production-line–Welding-car-body–Modern-car-Assembly-plant/960x0.jpg?format=jpg&width=960
Multi System Assemblies

**STRUCTURES**
1. Fuselage
2. Cockpit

**AVIONICS**
3. Winglet
4. Flaps
5. Slats
6. Spoiler
7. Aileron
8. Stabilizers

**MECHANICAL**
10. Landing Gear
11. Aileron Control System
12. Spoiler Control System
13. Wheels
14. Wheels

**CONTROL SYSTEMS**
10. Flap Control System
11. Aileron Control System
12. Spoiler Control System

**ENGINES**
9. Turbine
Multi System Assemblies

**MECHANICAL**
- 12. Boiler Plant
- 11. Chiller Plant
- 10. Air valves
- 9. Ducts

**ELECTRICAL**
- 16. Main board
- 15. Power supply
- 14. Conduits
- 13. Artificial Lighting

**PLUMBING**
- 21. Water storage tank
- 20. Water supply pipes
- 19. Grey water return pipes
- 17. Drainpipes

**STRUCTURAL**
- 8. Footing
- 7. Foundation
- 6. Slabs
- 5. Beams
- 4. Columns

**ARCHITECTURAL**
- 3. Windows
- 2. Interior walls
- 1. Envelope assembly

~1000+ Components
Multi System Assemblies

~10000+ Components
Trends in Robotic Construction – Timber Construction

Source: ETH, Zurich
Trends in Robotic Construction – Wall Assembly

Source: AIST, Japan
Trends in Robotic Construction – Brick Laying

Source: Semi Automated Mason (SAM)
Trends in Robotic Construction – Brick Laying

Source: Semi Automated Mason (SAM)
Trends in Robotic Construction – Wall Finishing

Source: Canvas Drywall Robot
NREL ICI Focus Areas – Robotics for Systems Integration in Buildings

- Industrial Robotic Arms
- Rovers
- Quadrupedals
- Drones
NREL ICI Focus Areas – Robotics for Systems Integration in Buildings

- Robotic Outfitting
- Virtual Simulation
- Semi-Autonomous Robotics
- Computer Vision Based Sensing
- Autonomous Robotics
- Digital Twin Visualization
Past Projects from Penn State – NASA 3D Printed Mars Habitat Challenge

PRINTING PROCESS: WALLS
4D Simulations of robotic construction is computational graphics intensive
Past Projects from Penn State – NASA 3D Printed Mars Habitat Challenge

Detailed 4D Simulation

Robotic Box Collision metamodel (faster computation)

Metamodels for faster constructability analysis (Toolpath Clash Detection)
NREL ICI Focus Areas – Additive Concrete Construction + Energy Systems
NREL ICI – Robotic Programming for Environmental Control Systems Integration
Thank you!