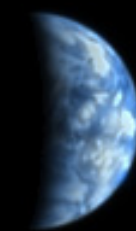




Using NASA Life Support Technology to Reduce Cement Industry CO₂ Emissions While Improving Cement and Concrete Products



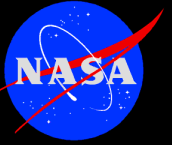
Morgan B. Abney
Environmental Control and Life Support Systems
NASA Marshall Space Flight Center

March 2013 ACI Strategic Development Council #33

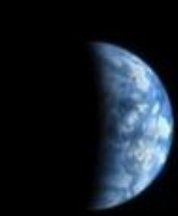
March 13, 2013



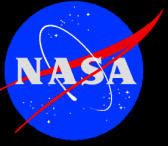
Agenda



- Introduction
- Background of NASA Technology
- Technology Transfer to Cement Industry
- Current Progress
- FY13 Ongoing Work
- Future Work and Planning



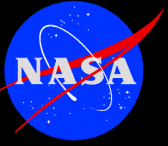
Introduction



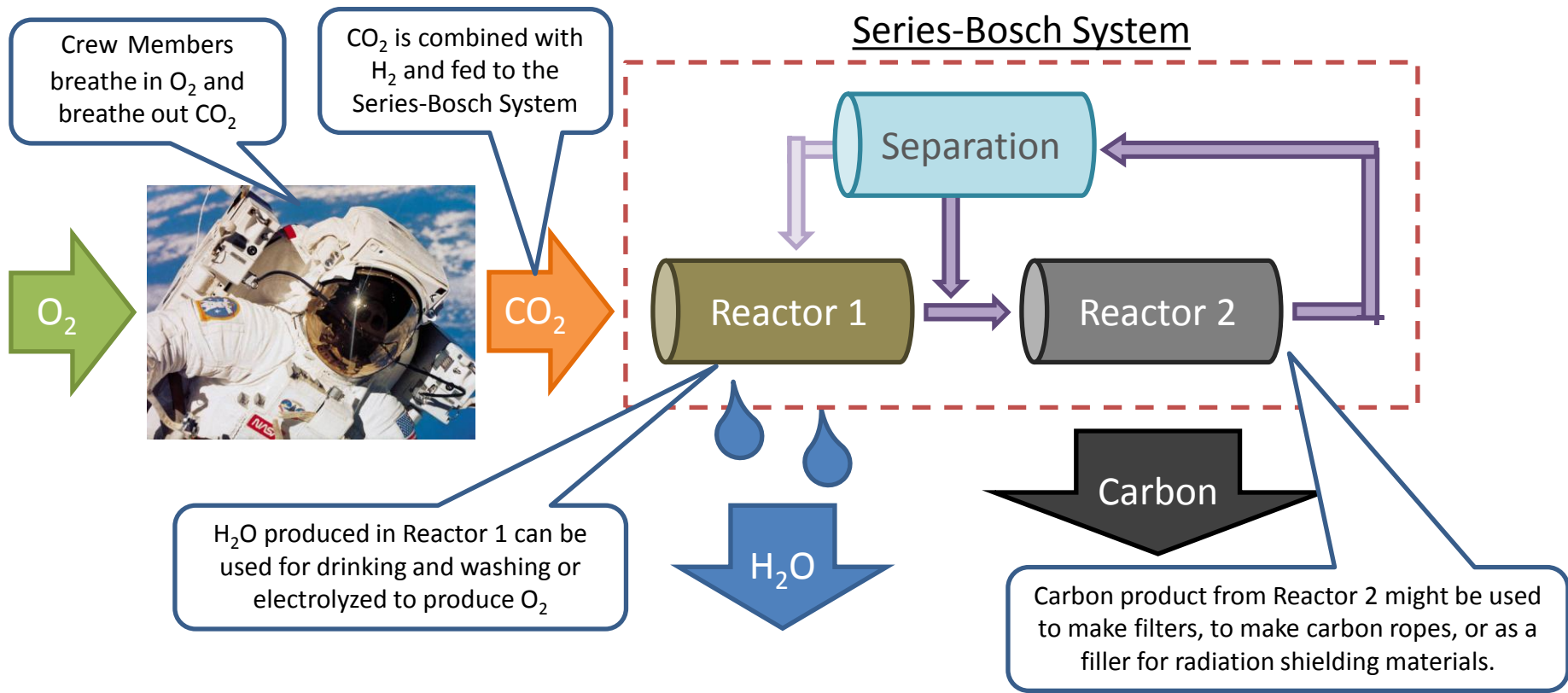
- Environmental Control and Life Support Systems (ECLSS) - Goal is to keep astronauts healthy and happy in space
- Long Duration Missions
 - Lunar or Mars Surface
 - Mars Transit
- Atmosphere Revitalization Resource Recovery
 - Oxygen recovery
 - Hydrogen recovery
 - Carbon recovery?



Background of NASA Technology

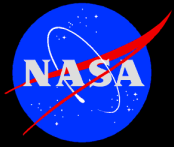


- **Bosch Process**

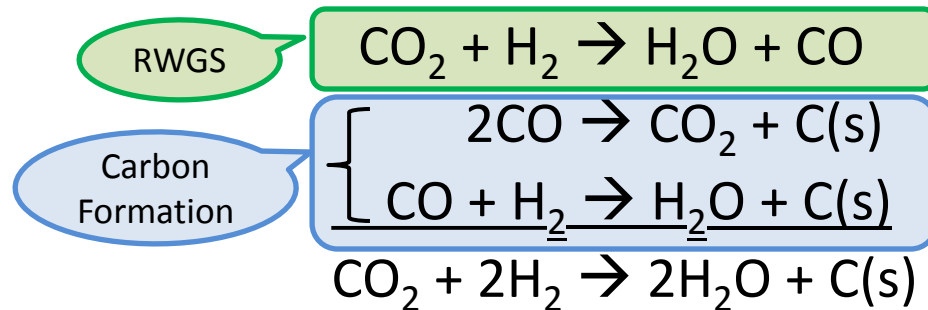




Background of NASA Technology



- Chemistry



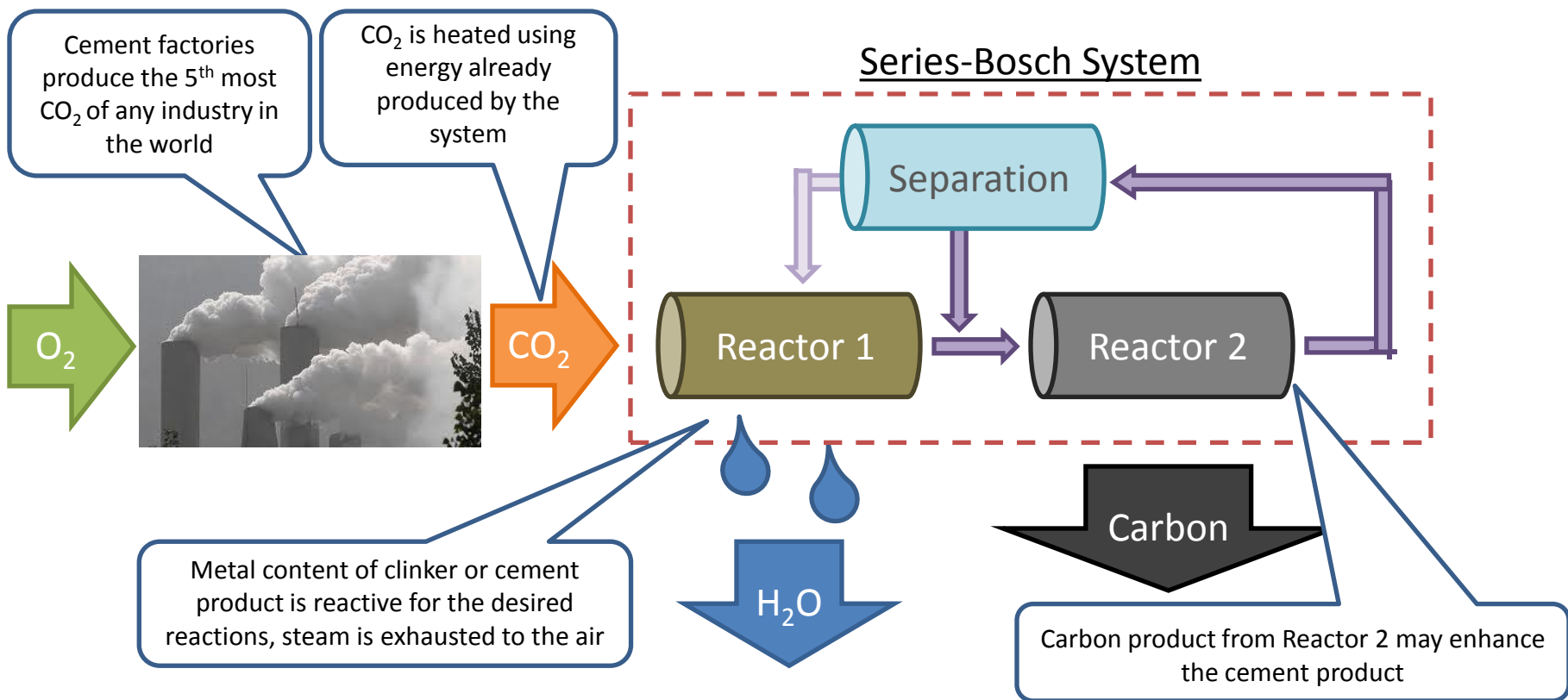
- Challenges for Space Application

- Power Consumption
 - High Temperature Reactions
- Catalyst Resupply
- Volume/Mass



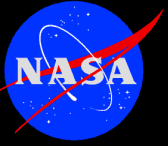
1980's Bosch System

- 2010 Iowa State University approached NASA about using Bosch technology to reduce CO₂ emissions in the cement industry

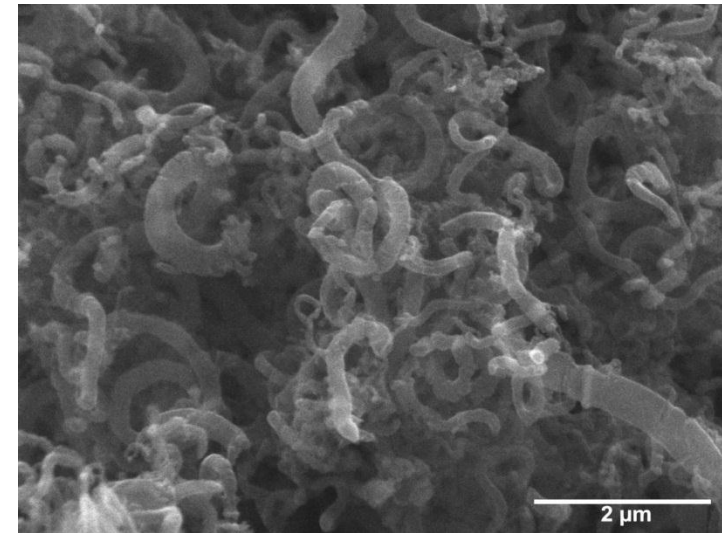




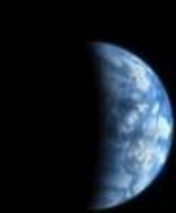
Technology Transfer



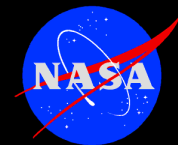
- Added benefit – carbon product in cement may improve the concrete product
 - Dr. Surendra Shah (formerly of Northwestern University)
 - Showed that well-dispersed nanofibers in cement dramatically improved the mechanical properties of the resulting concrete (e.g. 4x longer life for roads)



SEM of Carbon fibers from Space
Bosch Testing



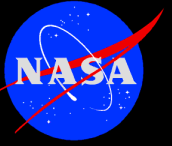
FY13 Plan



1. Test cement and/or clinker for reactivity
 - RWGS Reaction
 - Carbon Formation Reactions
2. Evaluate carbon produced
 - Type (nanotube, nanofiber, amorphous, etc)
 - Dispersion
3. Test concrete blocks from cement+carbon
 - Compressive strength
 - Tensile strength
 - Modulus of elasticity
 - Freeze/thaw cycles



Current Progress



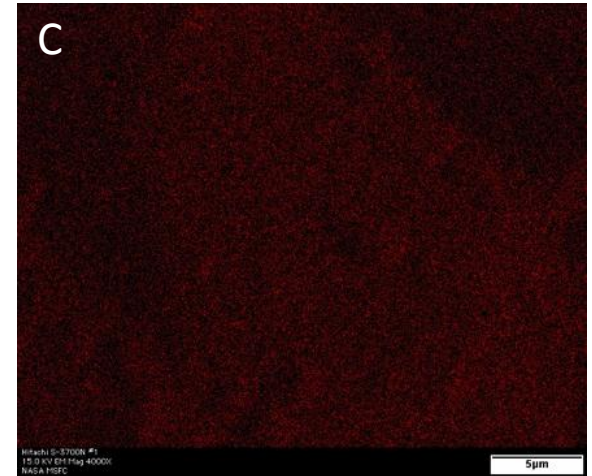
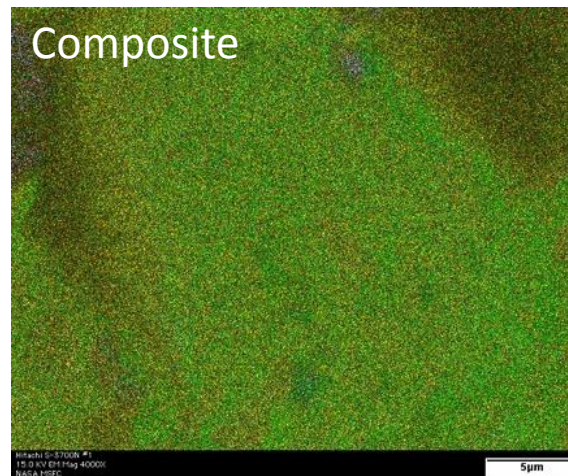
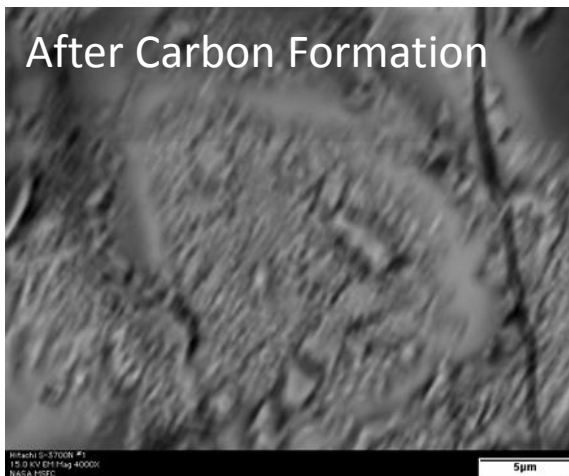
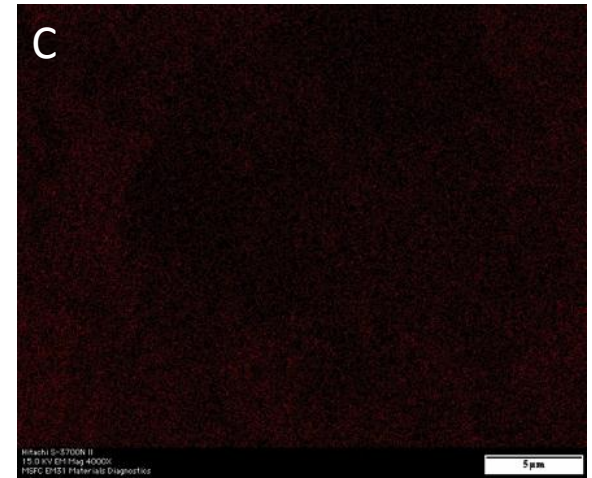
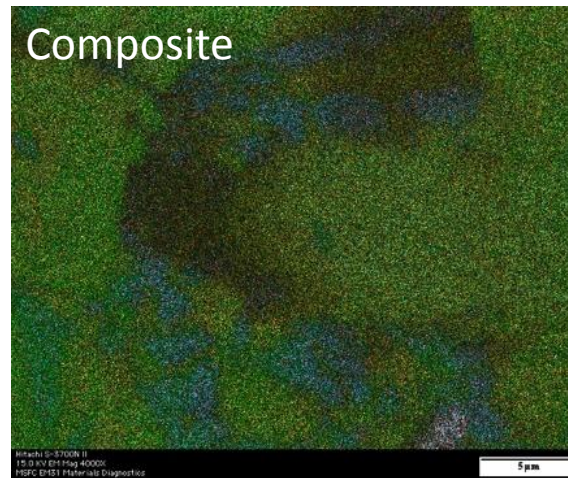
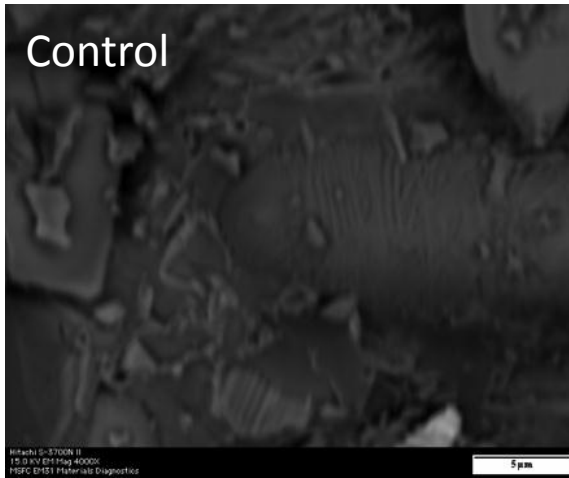
1. Test cement and/or clinker for reactivity
 - RWGS Reaction - 44% CO₂ Conversion (50% theoretical max)
 - Carbon Formation Reactions – slower than RWGS, but obvious formation



Carbon formation in increasing time increments (left to right).

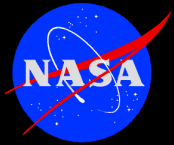


Current Progress

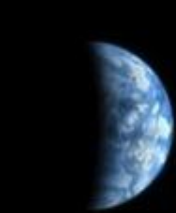




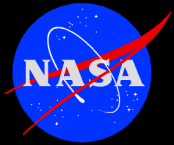
FY13 Ongoing Work



- ~~1. Test cement and/or clinker for reactivity~~
 - ~~— RWGS Reaction~~
 - ~~— Carbon Formation Reactions~~
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Future Work and Planning



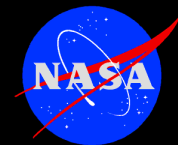
- Develop Bosch Integration Plan
- Complete Logistical Feasibility Study
- Complete Economic Feasibility Study
- Find Appropriate Partners for Technology Transfer
- Pursue Sub-Scale Development Effort
- Pursue Full-Scale Development Effort

Questions?





Contact Information



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