Trash to Supply Gas (TtSG) Project Overview

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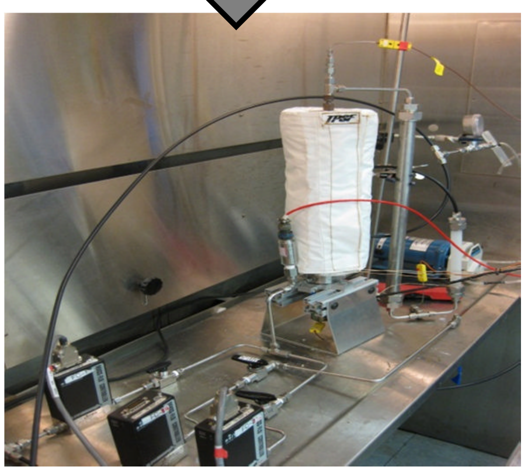
Agenda

- Logistics, Reduction and Repurposing (LRR) Project Overview
- TtSG overview, schedule, and processes
- Waste model

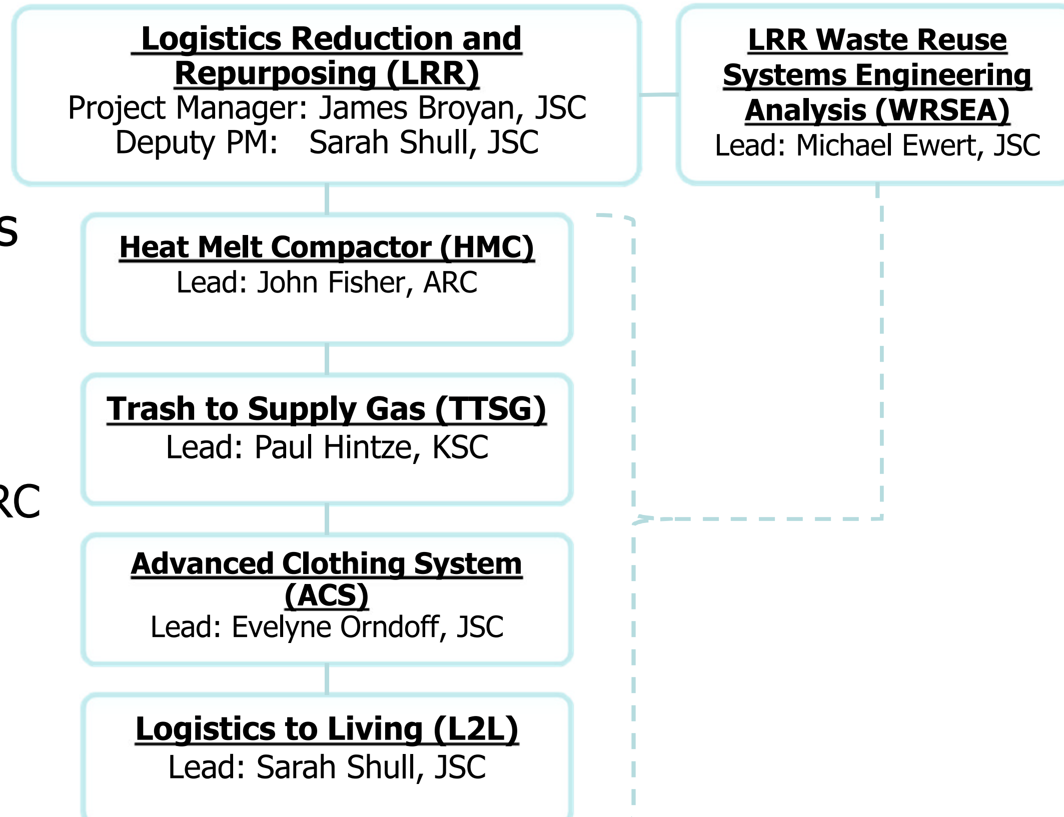


LRR Overview

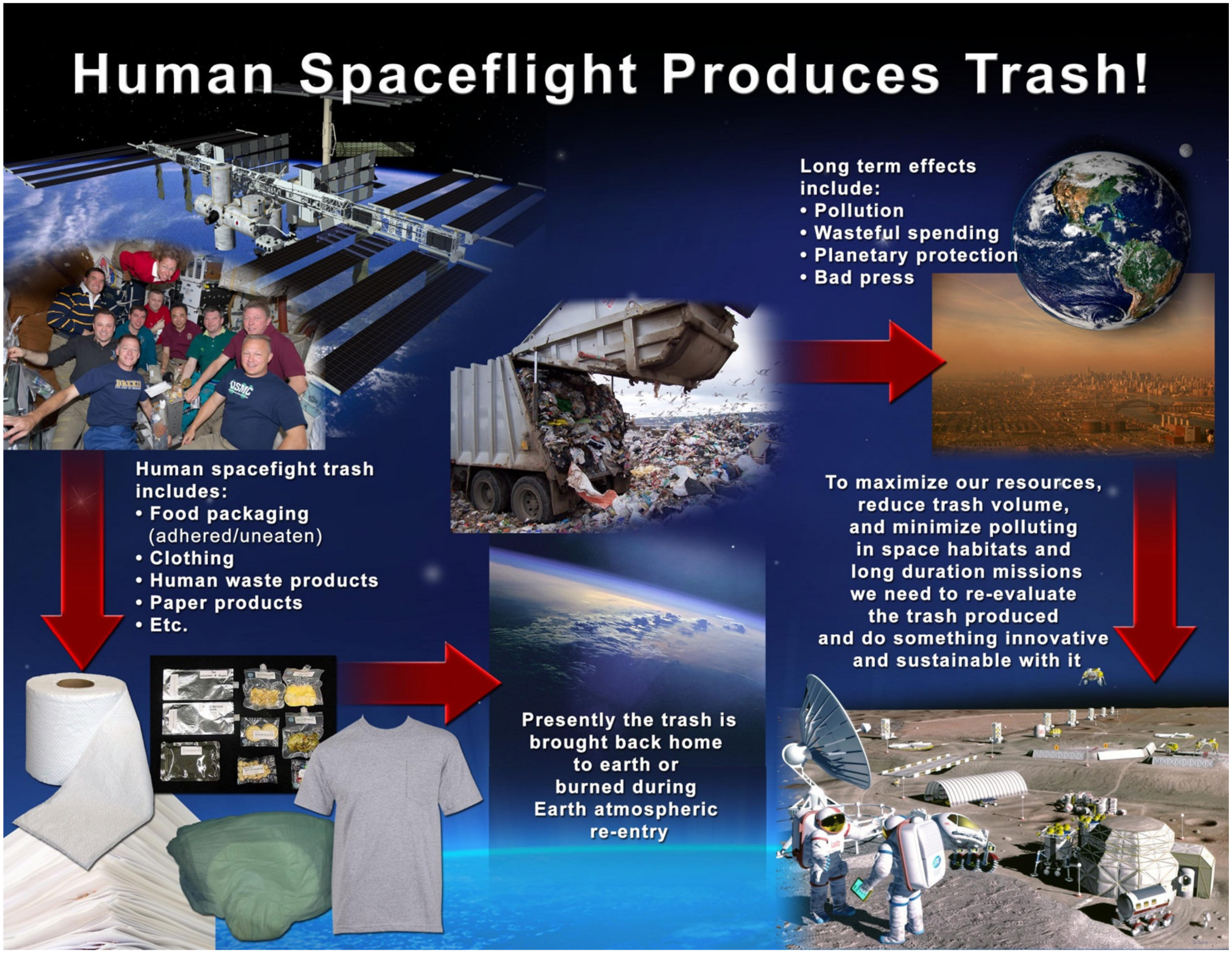
- Summary
  - Logistics Reduction and Repurposing (LRR) will utilize a cradle-to-grave approach to logistics to reduce total mission logistical up mass.
  - LRR will demonstrate efficient methods to repurpose hardware originally designed for other uses, reduce packaging volume, and using common system elements for multiple mission applications.
    - Minimize intrinsic logistics mass.
    - Direct logistics component repurposing for on-orbit outfitting.
    - Compact and process logistics to useful components and products.
    - Enable long term stable storage and disposal
    - Enable logistics sharing between vehicles in different mission phases
- Goals: new capabilities and exploration affordability
  - Reuse and repurposing will reduce initial up mass and volume because it will reduce the number of dedicated crew outfitting items.
  - Compacted/processed logistical material available for radiation shielding, water, or propellant.
  - Enable more hygienic crew environments through waste stabilization.
  - Increase habitable volume over mission duration through compaction.
  - Reduced mass will reduce vehicle cost.

LRR Overview

- LRR has four hardware oriented tasks and a systems engineering task
- Six NASA centers are participating
  - HMC: ARC/JSC/MSFC/KSC/GRC
  - TTSG: KSC/GRC/ARC/JSC
  - ACS: JSC/WSTF
  - LTL: JSC/JPL/ARC



TtSG Overview



TtSG Overview

TtSG Overview

- Why TtSG?
  - Reduce volume of trash - Current human spaceflight missions either carry trash during the entire round-trip mission or discard trash inside a logistic module which is de-orbited into Earth's atmosphere for destruction.
  - Produce something useful from a waste product
- Challenges
  - Miniaturization
  - Operation with minimal human interaction
  - Do not produce hazards
  - Gas cleaning and purification

KSC-01PP-0726: Workers in the Space Station Processing Facility are removing contents from the Multi-Purpose Logistics Module (MPLM) Leonardo to begin removing the contents after STS-102. The MPLM brought back nearly a ton of trash and excess equipment from the Space Station.

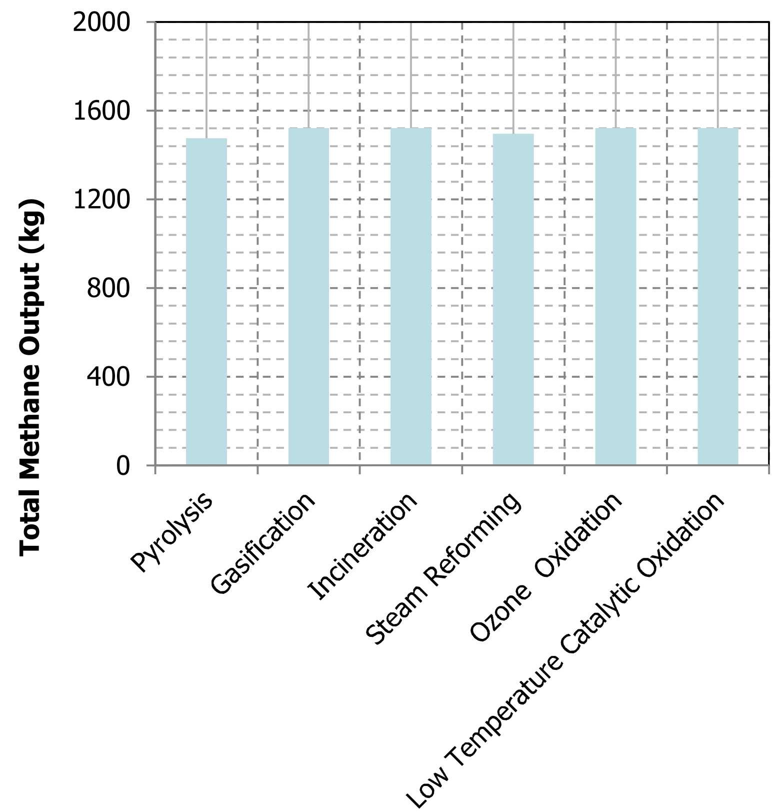
TtSG Processes

- Wood gas car, Biofuel power generation

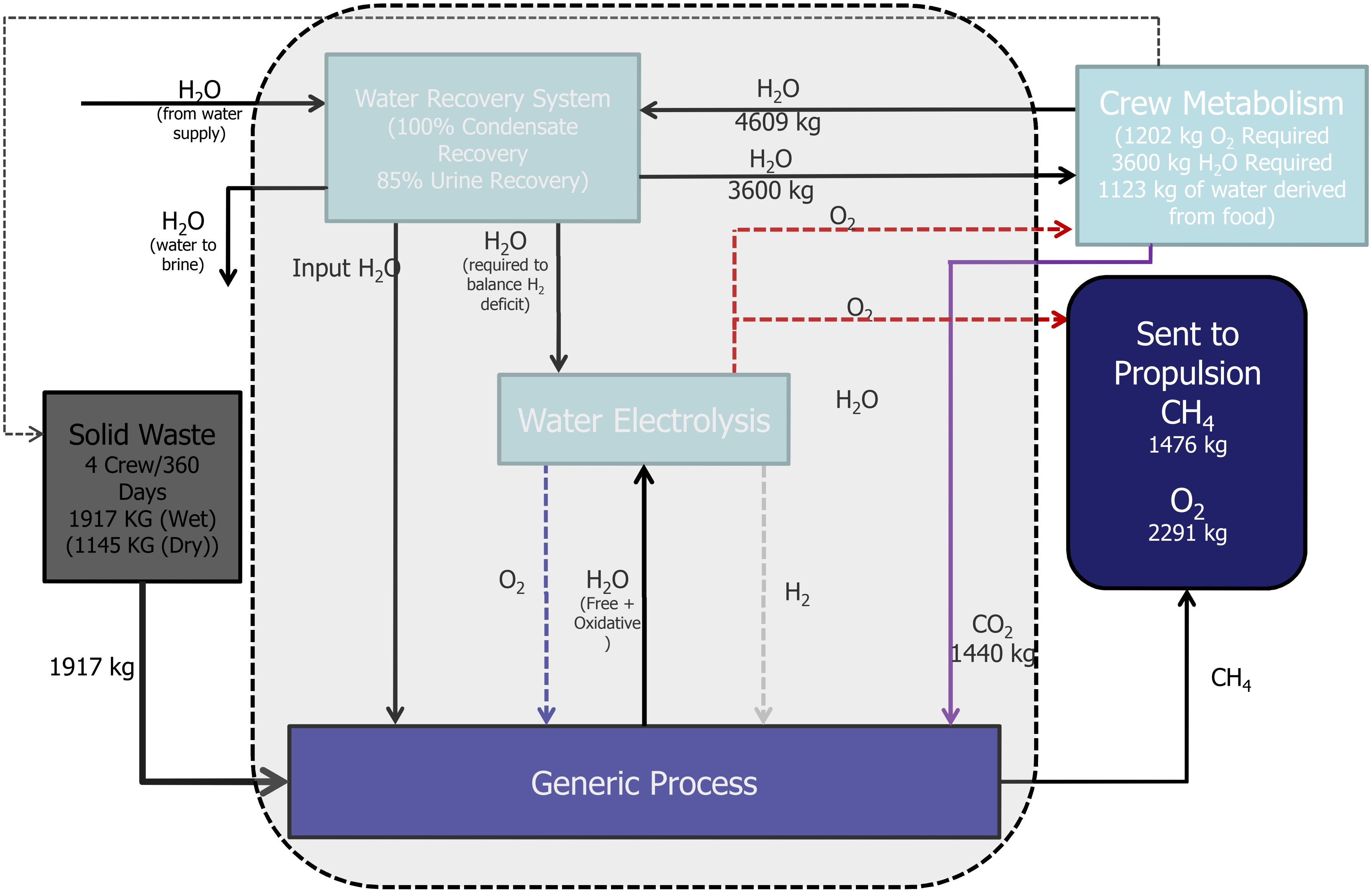
- Challenges
  - Miniaturization
  - Operation with minimal human interaction
  - Do not produce hazards/Gas cleaning and purification
  - Many processes use only one feedstock

TtSG General Systems Analysis

- Comparing six technologies
- No power or volume trades completed
- Assumptions
  - Crew of 4 for 360 days
  - Waste types: Human Waste, Packaging, Adhered Food, Uneaten Food, MAGS, Gray Tape, Paper, Clothing, Towels, Washcloths
  - Waste quantity:1144.8 kg dry mass, 771.8 kg water; Crew metabolism 4200 kg
  - Additional O2 and H2O added to processes in analysis to equate CH4 output – On a dry mass basis, complete conversion is hydrogen limited
    - Technologies produce ~ 1500 kg of methane
    - Technologies produce 1900 - 2300 kg of oxygen
    - Integrated systems require 500 – 1000 kg of water as extra payload

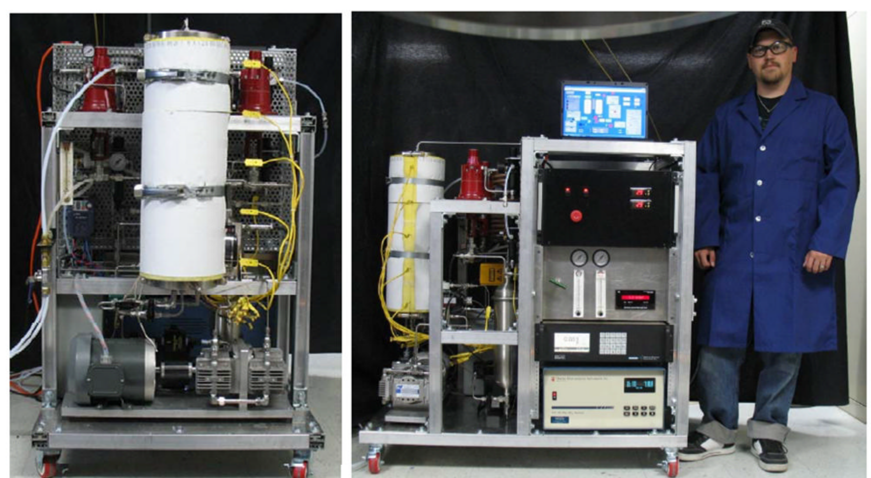


TtSG General Systems Analysis



TtSG Processes

- KSC, GRC, ARC have hardware that they are testing
- All processes have a 3-4 TRL
  - Pyrolysis
    - Decomposition of waste materials with heat in the absence of oxygen
  - Gasification
    - Decomposition of waste materials with heat in the presence of oxygen and/or steam
  - Incineration
    - Decomposition of waste materials with combustion
  - Steam Reforming
    - Decomposition of waste materials with heat in the presence of steam
  - Catalytic Decomposition- Low Temperature Decomposition of waste materials in the presence of a catalyst
    - Wet air oxidation
    - Photocatalytic oxidation
  - Ozone Oxidation
    - Decomposition of waste materials with heat in the presence of ozone

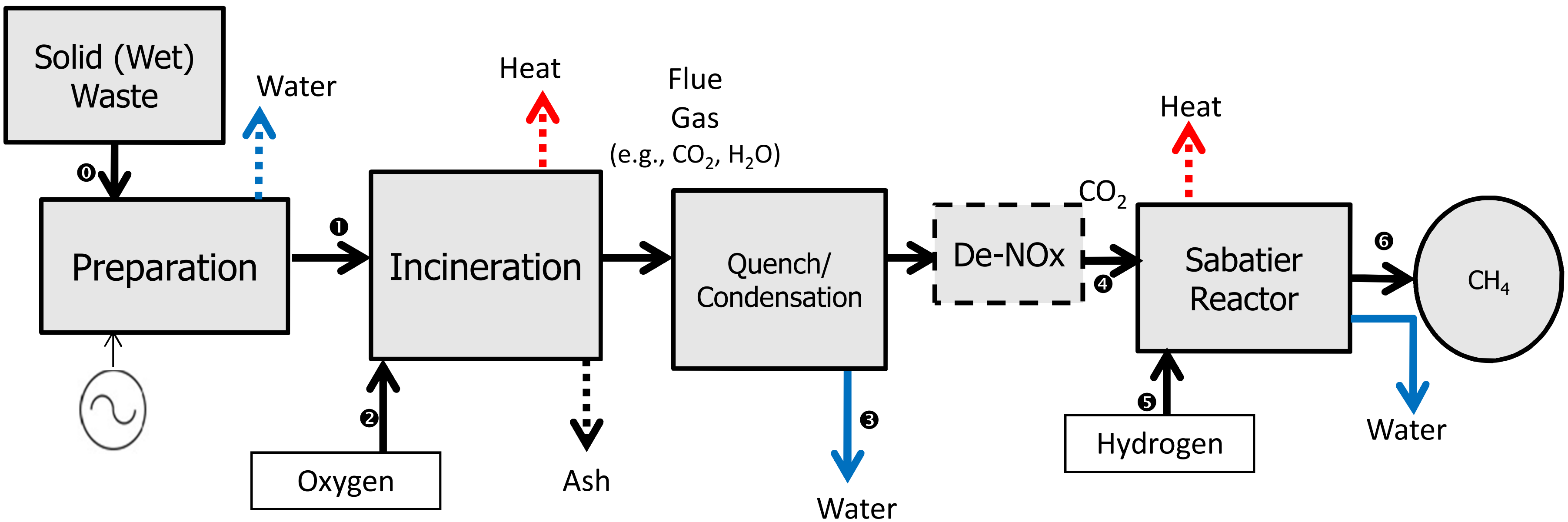


Ozone Oxidation System (ARC)

TtSG Processes

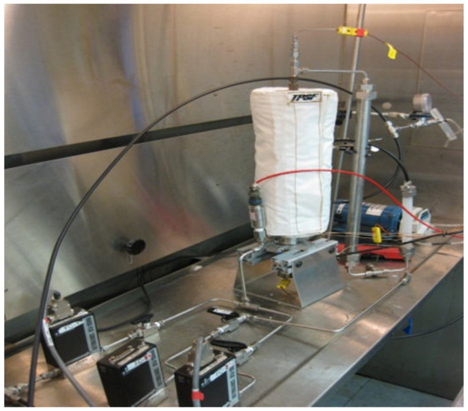
General Technology	Subtypes	Process Options	Temp. (˚C)	Pressure (atm)	End Products/ By-products	Past Work
THERMAL TREATMENT	Pyrolysis (Thermal decomposition)	Fast pyrolysis	400-650	~1	Liquids, tars, char, gases	ARC; KSC
	Gasification	Direct/ Partial oxidation	400-800	~1	Synthesis gas (CO, CO_2, H_2, CH_4, H_2O)	KSC
	Incineration	Incineration mass burn/auger feed	300-1000	~1	CO_2, H_2O, ash	KSC; ARC
CHEMICAL OXIDATION	Ozone Oxidation	Wet ozonation	125	4-5	CO_2, H_2O	ARC
	Steam Reforming	Steam Reforming	400-600	~4	CO, CO_2, H_2	GRC
CATALYTIC DECOMPOSITION	Low Temperature Catalytic Decomposition	Photocatalytic oxidation	<100	~1	CO_2, H_2O	GRC
		Wet air oxidation	150-325	20-200	CH_4, CO_2, CO, H_2	GRC

TtSG General Systems Analysis



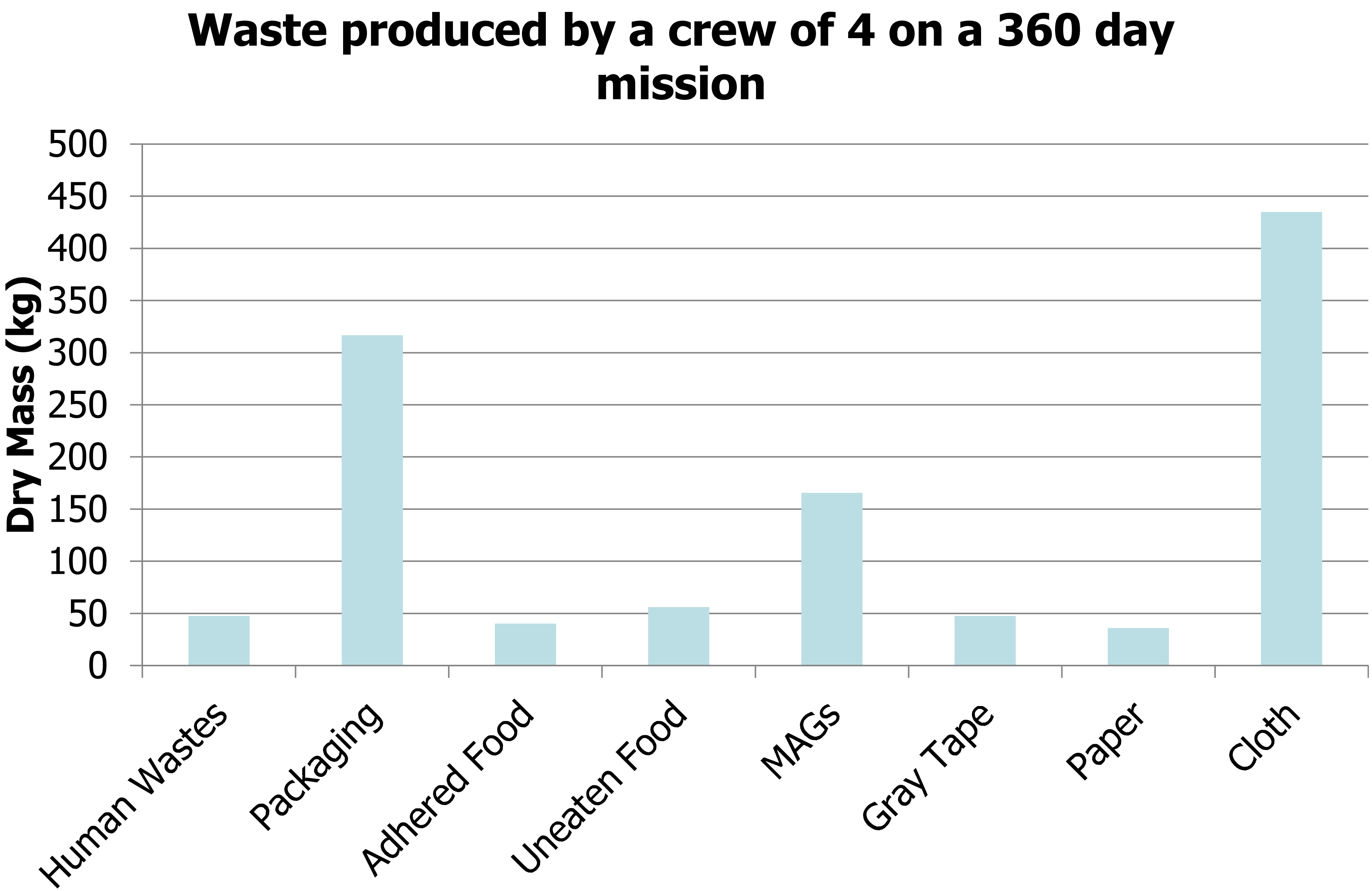
TtSG Schedule

- FY12:
  - Testing existing prototypes
  - Efficiency analysis
  - Waste characterization analysis
- FY13:
  - Mixed trash testing
  - Down-selection to two processes for breadboard design
- FY14:
  - Complete breadboard design testing
  - Upgrade analysis
- FY15:
  - Build upgraded prototype
  - Provide mission architecture recommendations
- FY17:
  - ISS flight project design complete



Thermal oxidation reactor at KSC

TtSG Waste Model



TtSG Overview

- Strayer et al. AIAA-2011-5126; Characterization of Volume F trash from four recent STS missions: weights, categorization, water content

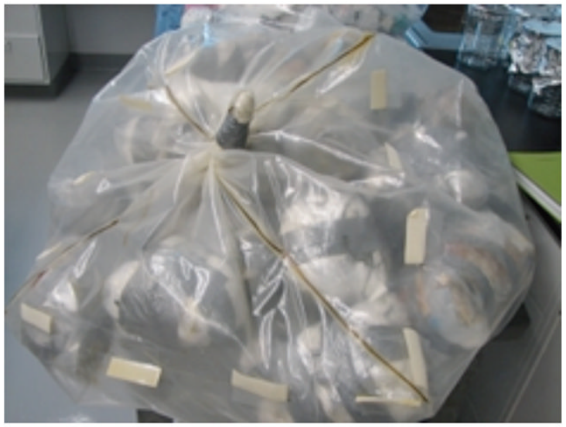


Photo 1. Shuttle Volume F trash.

Photo 2. Shuttle trash, not Volume F trash, contained in a large ziplock plastic film bag.

Photo 5. A food 'football' from the Shuttle Volume F trash.

Photo 6. A Maximum Adsorption Garment (MAG, EVA diaper) 'football' from the Shuttle Volume F trash.

TtSG Waste Model

- Waste Simulants
  - Cloth, food packaging and MAGs (Maximum Absorbent Garments) were selected as initial simulants to test technologies
  - Future simulants will include food and simulated human wastes
- Washcloth
  - Cotton is predominantly cellulose; 44% Carbon, 6% Hydrogen, 50% Oxygen by mass
- Diaper
  - Diaper contains multiple polymers and materials including the sorbent, Velcro and elastic. No elemental estimation made at this point

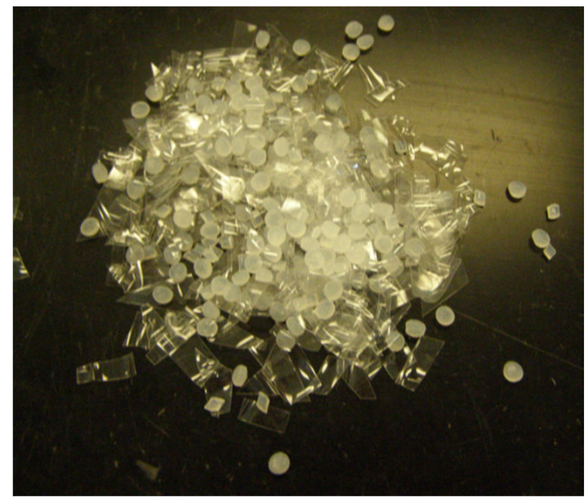
Washcloth

Diaper

TtSG Waste Model

- Food Packaging Simulant (FPS)
    - 22% aluminum foil
    - 14% Polyethylene terephthalate (from water bottle) 63% Carbon, 4% Hydrogen, 33% Oxygen by mass
    - 13% Nylon 69% Carbon, 6% Hydrogen, 13% Oxygen, 12% Nitrogen by mass
    - 51% PE; 86% Carbon, 14% Hydrogen by mass

Food Packaging



Food Packaging Simulant

TtSG Contacts

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