TEMPO$^3$

First step to the Fourth Planet
Overview

• Humans to Mars
• Humans in Space
• Artificial Gravity
• Tethers
• TEMPO³
Humans to Mars – How?

- Not “one huge ship”
  - W. von Braun
- Send return craft first
- Human crew, next opportunity
- Leaves infrastructure behind
- Live off the land
  - Return propellant
  - Water
  - Oxygen
- Reduce costs to tens of $B

Source: *The Case for Mars* by Zubrin/Wagner, 1996
Humans in Space
Lack of Gravity

• Most known-about difference in space life
• Effects
  – Muscle atrophy
  – Bone deterioration
  – Blood changes
• Exercise helps, but…
• Crew arriving on Mars must be physically ready
Artificial Gravity

• Take gravity along!
• Possible with smaller mission architecture
• Upper stage as a counterweight
• Spin end-over-end
• Simple in concept, but
  – Tether dynamics
  – Velocity changes
Tethers
Previous Artificial Gravity Efforts

• NASA experimented in the 1960s
• Gemini 11 + 12 used target vehicle (Agena) as counterweight
• Small amount of gravity generated
• Apollo and shuttle/station eras were not conducive
Tethers
Other Efforts

• Multiple potential uses in space
• Many tried with varying success
  – Power generation
  – Orbit change
  – Payload de-orbit
• No recent efforts for artificial gravity
TEMPO³

Goals

• “Build and test a CubeSat satellite to demonstrate artificial gravity”
• Inform the public
• Bring artificial gravity back into architectures
• Build knowledge base for future, more complex missions
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Mission Sequence

• Launch as secondary payload with other CubeSats
• Spin up  
  – Method under review
• Deploy tether
• Transmit generated gravity measurement to receiver stations on Earth
• Other actions possible, but limited
PR/Fundraising/Science Submission

- “Join the mission” PR Effort
- Recommended Donation
- Originally Planned for mini SD Ram Chip
- Name Entered on a List for Transmission from TEMPO3
- Transmitter Functions in 10m band
  - Susceptible to Ionospheric Interference
  - Allows Exploration of Space Weather
Sub-Mission Technical Details

- Rotating Spacecraft
  - Constantly Changing Antenna Angle
- Network of Listening Stations
  - Timing Possibilities?
  - Contest?
- Multi-part Signal Helps Strength Estimation
  - Names
  - Tones
  - Beeps
- Orbit Unimportant
  - All Provide Varying Angles
Technical Considerations

• Spin-up method
  – Thruster (cold-gas)
  – Momentum wheel
  – Magnetic coil

• Transmission Signals
  – Likely 70cm Band. Possibly two Frequencies
  – Additional 10m PR/Science Signal Possible

• Spacecraft Software Development
  – Coding relatively simple, considering competition

• Spacecraft Integrator
  – Common bus designs include many required features
Development Timeline

• Kickoff in Aug ’08
• Concept developed, initial design work
• High-altitude balloon flight test planned late 09
• Use experience with balloon flight to plan next steps
• Launch in ’11
• Follow-on satellite
Outreach

• Split into at least three areas
  – Education – Lesson plans, student contests
  – Popular media – “Name in space”, museums
  – Focused organizations – Amateur radio, pilots

• Internet-involved
  – Video updates
  – YouTube ‘shorts’ describing key concepts
Future Plans

• TEMPO³ demonstrates some very basic aspects of artificial gravity generation
• Many other challenges exist
  – Realistic spin-up
  – Velocity change while spinning
  – Attitude change while spinning
  – High speed communications while spinning
  – Separation at Mars approach
• A future, larger, experiment can test these
Thank you for your time!

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The Mars Society

- Founded in 1998
- Annual conferences
- Non-profit
- International
- Formation spark caused by interest in Robert Zubrin’s book *The Case for Mars*
Mars Society’s Other Projects

• Three Mars Research Stations Built
  – FMARS – Canadian Arctic
  – MDRS – Utah Desert
  – Additional – Built, but in storage

• Spaceflight plans
  – Archimedes - hitchhiker payload on Mars mission
  – Mars Gravity Biosatellite – expose mice to Mars gravity