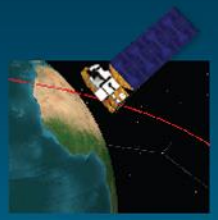
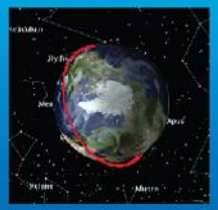
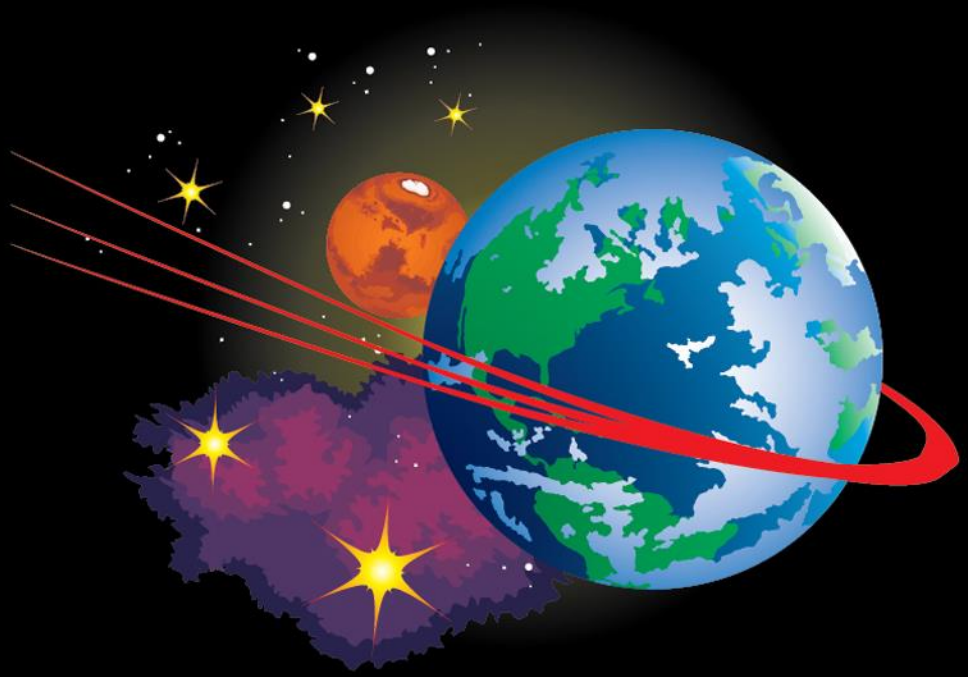
National Aeronautics and Space Administration





www.nasa.gov



Introduction to the GMAT Project

GMAT Fundamentals
Joel Parker
June 30, 2014

NASA Goddard Space Flight Center

general mission analysis tool

Presentation Overview

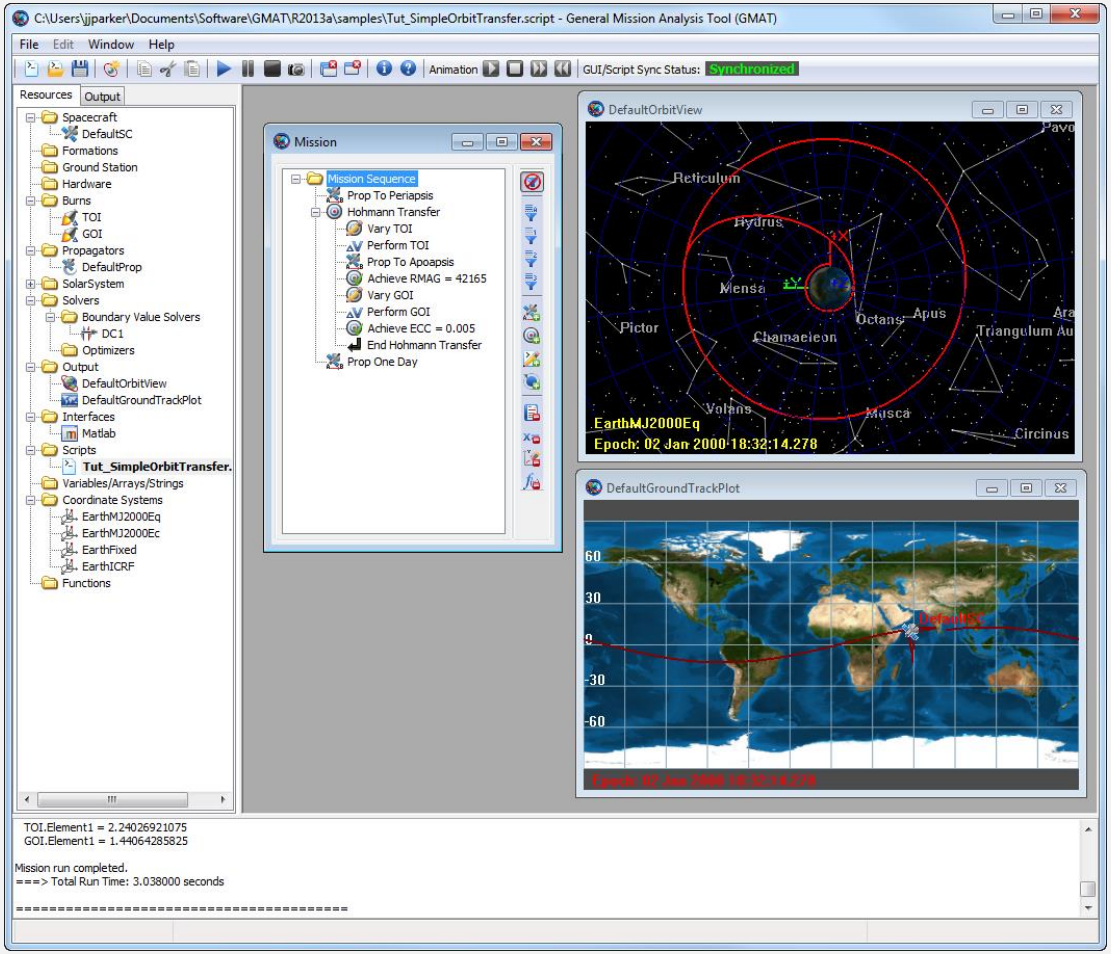
1. What is GMAT?
2. System Overview
3. Key Features
4. Project History
5. Participants & Contributors
6. Development Metrics
7. Recent Activities
8. Near-Term Activities
9. Project Resources
10. Getting Involved

What is GMAT?

GMAT is a **g**eneral **m**ission design and **a**nalysis **t**ool.

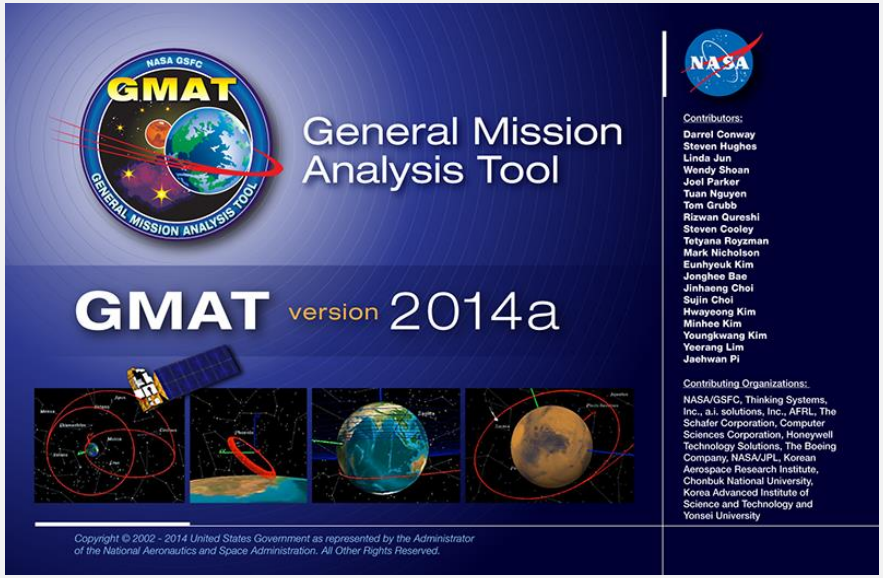
Key characteristics:

- open source
- high fidelity
- feature rich
- publicly developed
- desktop oriented



System Overview

- Applications
  - Mission analysis/optimization
  - All orbital regimes
- Comparable to
  - AGI STK/Astrogator
  - A.I. Solutions FreeFlyer
- Functionality
  - Full-featured GUI
  - Custom script infrastructure
  - Cross-platform core
  - Precision orbit propagation
  - Built-in targeting & optimization
- Status: Fully tested and certified for operational use



Key Features

Basic Models	
Spacecraft model	• Orbit state • Kinematic attitude • Mass properties • Viz properties • Attached hardware
Solar system	• User-defined bodies • Libration points • Barycenters • SPK & DE ephemerides
Coordinate systems	• Inertial • Body-fixed • Relative • Rotating

Propagation	
Numerical integrators	• Runge-Kutta (several) • Prince-Dormand (several) • Adams-Bashforth-Moulton • Prince-Dormand
Force models	• Third-body point-mass gravity • Central-body non-spherical gravity • Atmospheric drag • Solar radiation pressure • Earth tides • Relativistic corrections
SPK ephemeris propagator	

Key Features

Powered Flight
Fuel tank w/ mass depletion
Thruster model
Impulsive burn
Finite burn

Solvers	
Targeting w/ differential correction	
Optimization	• VF13 optimizer • Interface to MATLAB `fmincon` optimizer • Nonlinear constraints

Programming Infrastructure	
User-defined variables	• Numeric • Array • String
Control flow	• If/Else • While • For
External interfaces	• Call MATLAB functions
Built-in math	
Calculated parameters	

Project History

- 2001: Requirements gathering
- 2002: Architectural design
- 2003: Implementation of system core
- *…feature development…*
- 2010: Decision to prepare for operational use
- *…feature development…*
- 2013: First production release (R2013a)
- 2013: Operationally certified (ACE mission)

- Public releases:
  - 2007-08-23
  - 2007-12-10
  - 2008-09-30
  - R2011a (April 2011)
  - R2012a (May 2012)
  - R2013a (April 2013)
  - R2013b (Aug. 2013)
  - R2014a (May 2014)

Participants/Contributors/Users

- Government
  - NASA Goddard
  - AFRL
  - JPL
  - ESA
  - KARI
- Industry
  - Thinking Systems, Inc.
  - Schafer Corporation
  - a.i. solutions
  - Numerica
  - Boeing
  - CSC
  - Honeywell
  - Decisive Analytics Corporation

- GSFC Flight Projects
  - LCROSS (backup tool)
  - ARTEMIS
  - LRO
  - OSIRIS
  - MMS
  - ACE
  - MAVEN
  - TESS (primary)
  - Future mission studies
- R2013a public release: ~400 downloads/mo.
- >30 published papers using GMAT results

Development Metrics

- 14 active team members
  - 6 engineers (GSFC Code 595, A.I. Solutions)
  - 7 developers (Code 582/583, Thinking Systems)
  - 1 tester (A.I. Solutions)
- 450k lines of C++ code
- 12k public commits
- 11k automated script tests
- 4k automated GUI tests
- Nightly automated build/test process

Recent Activities

- GMAT R2013a
  - First production (non-beta) release
  - Focused entirely on QA and documentation
  - Very few new features—but many improved
  - New support for ICRF coordinate systems
- GMAT R2013b (internal)
  - First operationally-certified release
  - Focused on ACE mission requirements
    - Initial state file reader
    - Binary-format ephemeris generator
    - New aligned-constrained coordinate system
    - New parameter types
- GMAT R2014a
  - Public release of all R2013b features
  - New KARI-developed features
    - State representations
    - Attitude models
  - Customizable orbit segment colors
  - Mars-GRAM 2005 atmosphere model
  - LHS parameter dependencies
  - New solver algorithms

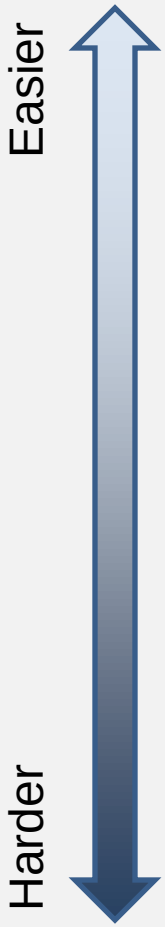
Near-Term Activities

- Large-scale features
  - Event location utility (w/ KARI)
  - GMAT functions
  - Low-thrust development (w/ KARI)
- Mission-specific development
  - TESS
  - MAVEN
  - JWST
- Navigation subsystem revitalization

Project Resources

- Homepage & Wiki: http://gmatcentral.org/
- User Forums: http://forums.gmatcentral.org/
- Documentation: http://gmat.sf.net/docs
- Issue tracker: http://bugs.gmatcentral.org/

Getting Involved



- Community support (forums, lists)
- Submit bugs, feature requests to JIRA
- Improve documentation
- Fix bugs, contribute to “starter” feature requests
- Contribute to new features