The CENKI Space Economic Simulator: Analytical Verification of an Agent-Based Modeling Engine

Track 10. Software and Computing

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The Committee for Expansion into Key Space Industries

- Formed in 2016 out of a CU special topics project with ULA
- Space is complex
- Need for community consensus

Mission Statement: CENKI will assemble the community and technical resources to stimulate the development of a thriving space economy

- There is a need to model economic interactions between actors in space industries
- Existing solutions can optimize logistics or behaviors; existing approaches can model specific scenarios
- What's missing is a general framework to model diverse, decentralized actors across sectors

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Such a framework could answer questions like:

- What types of competition are likely in space industries?
- How will technical or economic decisions impact inter-industry linkages?
- How might regulations interact with industry profitability and Gross Space Product?

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- What's missing is a general framework to model diverse, decentralized actors across sectors

Such a framework would

1. allow flexibility in defining player logic and importing custom data/models as inputs
2. perform consistent aggregation of choices and outcomes
3. solve for market prices and reflect policy constraints

Agent-Based Modeling

Agent-Based Models

Agent-Based Models (ABM) are computational models in which rule-based objects ("agents") interact independent of central control.

Our Solution: the CENKI SES

Use ABM to build up individual decisions and interactions. Agents interact in the marketplace, which tracks transactions and aggregates outcomes.

- *Players* are collections of *Agents*
- Agents may be *Customers* or *Providers*
- Customers issue *Contracts*, and Providers submit *Bids*
- When a Customer's best interest is fulfilled by a particular Bid and a Provider's best interest is fulfilled by a particular Contract, the two agents complete a *Deal*

SES Overview

Study layout
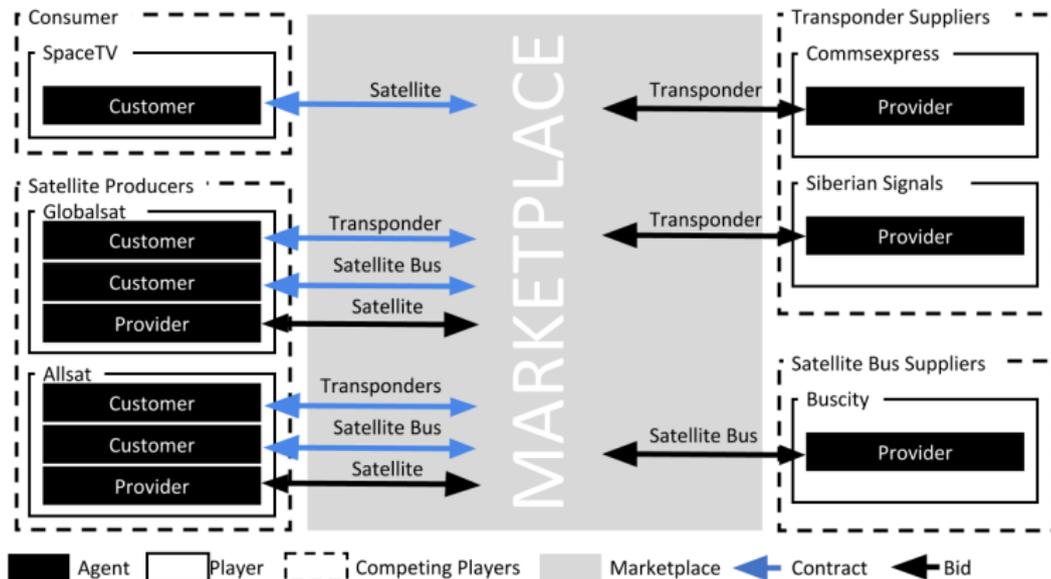
This study

We verify that the SES reproduces analytical solutions to economic models.
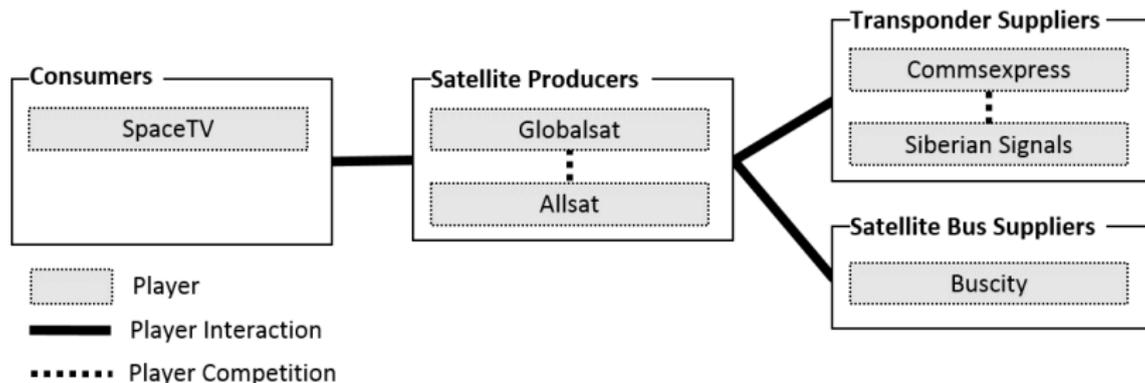
We study three models, progressively increasing in complexity.

1. *Model A1*: Competition between two providers
2. *Model A2*: Competition with production from reserves
3. *Model A3*: Competition with production and supply chain

In all of these models, providers supply undifferentiated goods and customers select the lowest-cost providers (Bertrand competition).

A1 and A2 layout
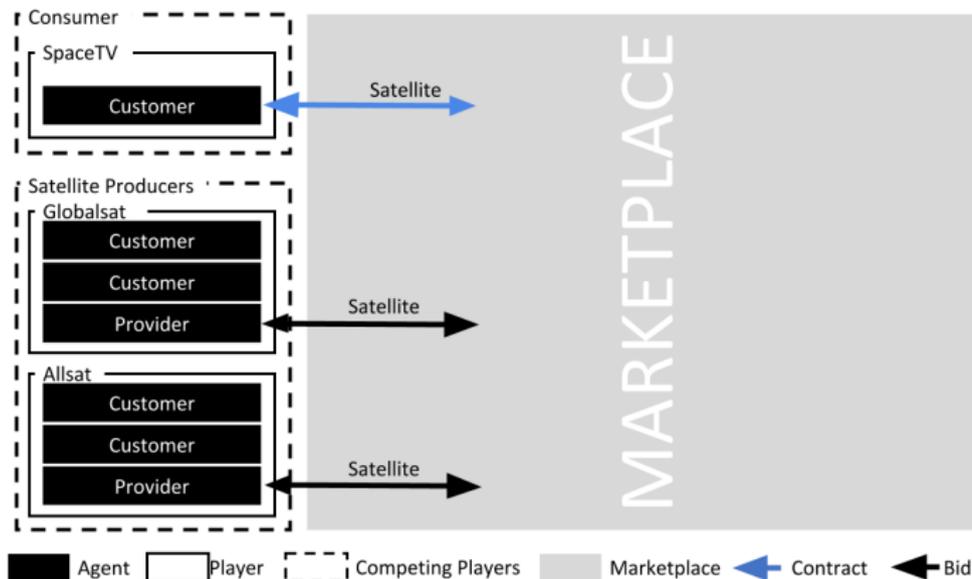
Model A1
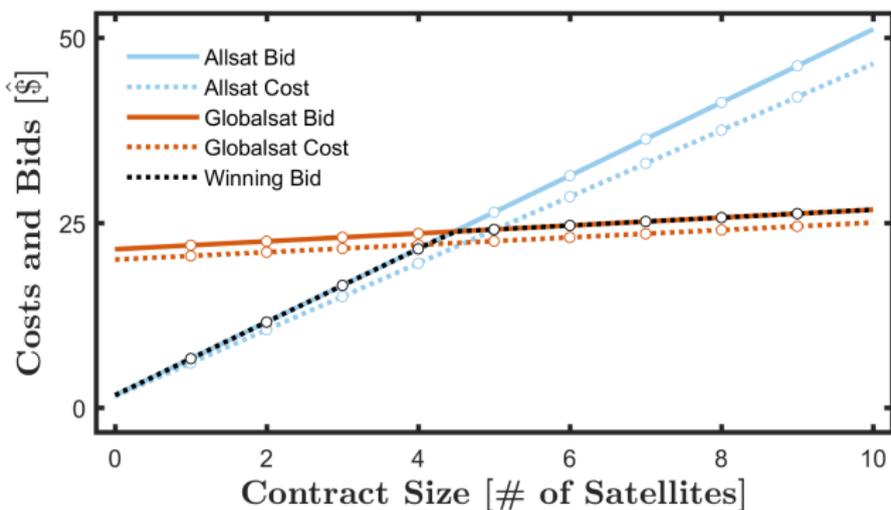
- Lines represent the analytical model
- Circles represent simulation values

In this model, satellites must be produced using available
transponders and buses
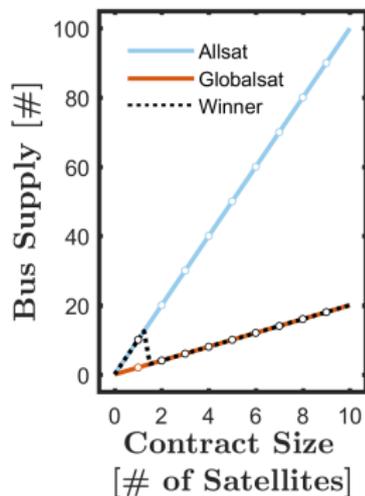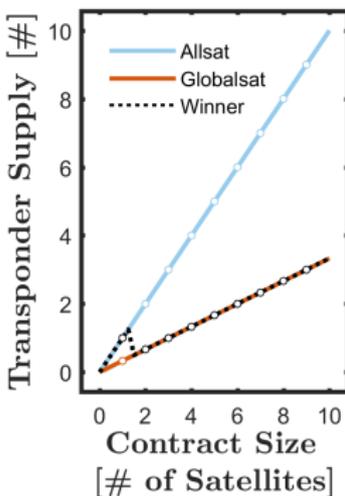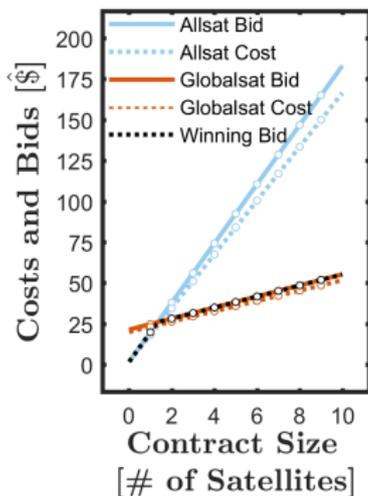
A3 layout

In this model, satellites must be produced using purchased transponders and buses

Model A3
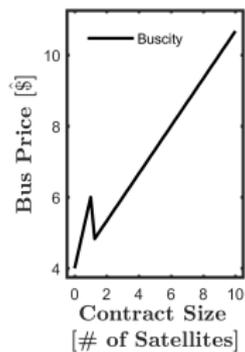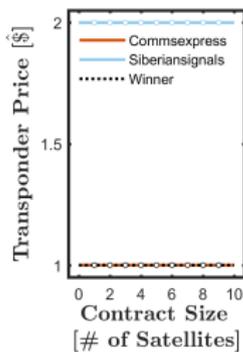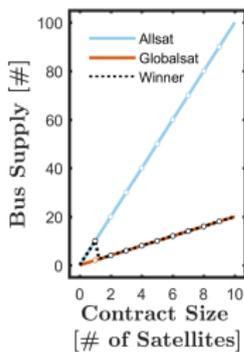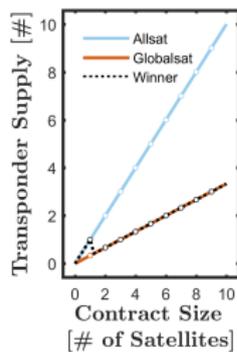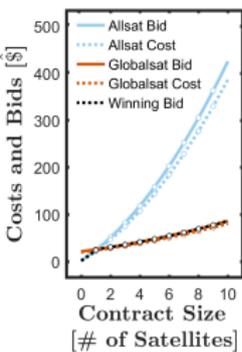
Summary

Commercial space is complex. Complexity extends to

- supply chains and production decisions;
- random events and environmental hazards;
- regulatory policies and long-term agreements.

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- regulatory policies and long-term agreements.

The SES addresses this complexity by

- allowing users to flexibly specify players and products,
- allowing users to supply custom inputs to players and simulate realizations over inputs, and
- mediating and aggregating agent interactions through the marketplace.

SES with data? Use cases?

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Demonstrating Agent-Based Modeling on Satellite Market Data

See 13.0205 in Canyon after this!
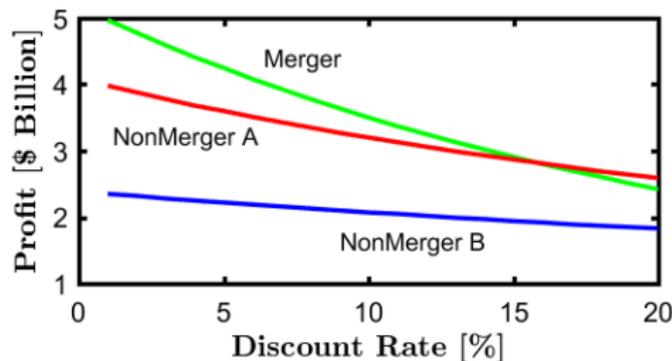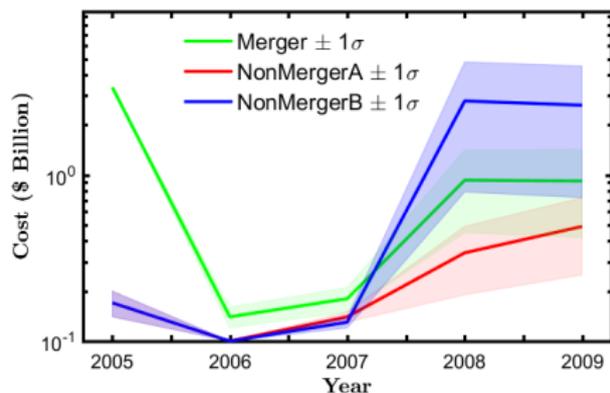
THANK YOU!

Questions / Comments?

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