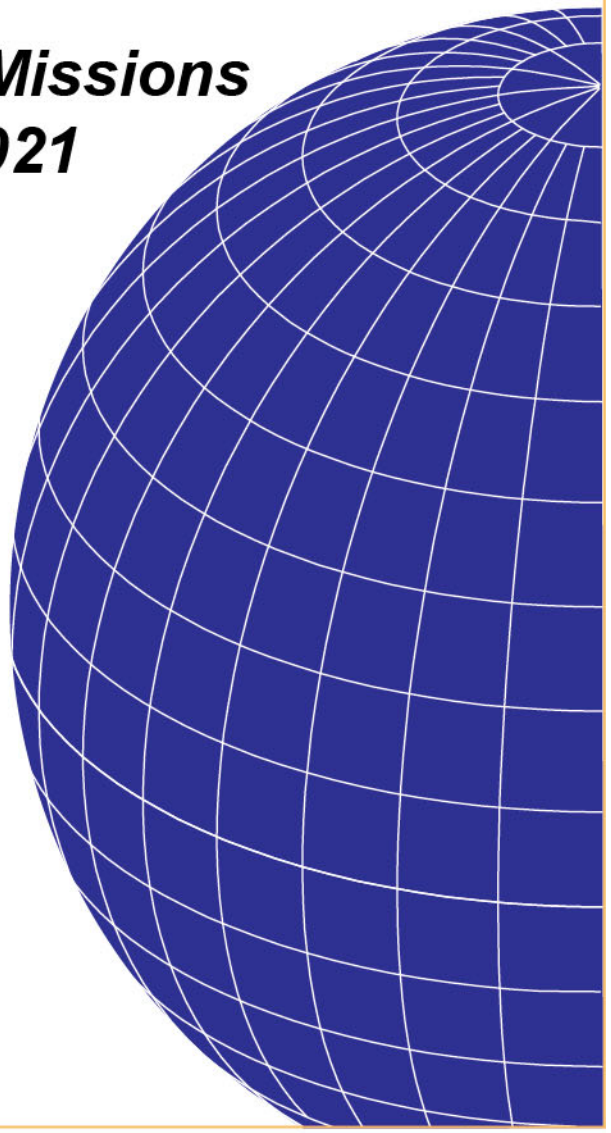
Reinventing Space:
Low-Cost, Responsive Space Missions
USC ASTE 523, Spring 2021



Supplement 2

The Iridium Experience

A. Iridium

B. GlobalStar and ICO

C. The Need for a Systems Approach

THE IRIDIUM EXPERIENCE

- The Iridium constellation has been one of the most publicized bankruptcies in spaceflight history and, therefore, provides a rich set of "lessons learned"
- Several cautionary notes:
  - Iridium financial data has not been made public — the cost guesses here should be regarded only as semi-realistic learning tools and can not be quoted or referenced outside of class
  - Iridium had strong, competent systems engineering and did many things right
    - Launched the satellites before the software was done to cut a year off the system schedule (an excellent choice)
    - Developed satellite manufacturing techniques that allowed them to turn out satellites at more than 1 per week (See SMAD III, Sec. 19.1 for a detailed discussion; also discussed in SME Sec. 2.1.4 and 5.0)

Metric	Traditional Approach	Multi-Satellite Approach
Spacecraft Cost	$66K/kg	$20K/kg
Integration Time	225 days	24 days
Build-to-launch Time	18 months	2 months
Production Rate	> 6 months/Sat	< 1 week/Sat

- Iridium truly challenged the paradigm of how to develop satellite systems

To learn from the Iridium experience, we need to try to distinguish what was done badly from what was done well — both extremes occurred.

SOME OF THE IRIDIUM "KNOWNS"

- Iridium was originally designed with 77 satellites, but was later reduced to 66 to reduce cost (We'll discuss later how that was done)
  - Full constellation was launched in 13 months, with no launch failures
- Filed for bankruptcy, August, 1999, after defaulting on $1.55B in bank loans
- System cost was over $5 billion with 5 year life
- Initial pricing was about $3000/phone and $7/minute, later dropped to $3/minute
- Finances for January, 2000 (from *Satellite Finance*, 3/8/00):
  - Customers — 50,000
  - Revenue — $1.5 Million ($30/month/customer)
  - Expenses — $110.5 Million
  - Reported loss — $112.6 Million
- In March, 2000, Iridium got a $3 million loan to continue operation — lasted 11 days
  - Implies operations cost of $2 million/week, $100 million/year with all payload operations fully automated on board
- Iridium on-orbit assets sold for $25 Million in 2001
  - Original investors lost over $5 Billion
  - "New" Iridium is profitable and a second generation has been built and is on orbit

IRIDIUM FINANCIAL CALCULATIONS

- Amortization estimate
  - Basis = $5 billion development, 5 year life, 10% interest
- Results of amortization analysis
  - Total cost $6.59 billion
  - Total interest $1.59 billion
  - Amortization cost $110 million/month
  - Interest only cost $42 million/month
- Operations cost of $8 million to $10 million/month
  - All payload functions automated on-board
  - These costs are after bankruptcy with very little activity going on
  - Had spent 2 years automating the ground operations to the extent possible
  - Operations team size
    - Initially 20–30 people per spacecraft
    - Down to 6 people per spacecraft after 1 year
    - Down to total of ~100 people after 2 years
  - Initial objective was to operate the system with a total team of 6 people

IRIDIUM, GLOBALSTAR, AND ICO COST COMPARISONS

- The following analysis is by the communications group ING Barings *(Satellite Finance, 4/15/99)* prior to the Iridium bankruptcy. Other financial analysts have concluded that the difference between the three are much less than shown.

MSS Break Even Points			
	Iridium	Globalstar	ICO
Annual Minutes of Use — Full Capacity	1,500m	7,000m	5,000m
Satellite System Cost	$3,450	$1,886	$2,365
Ground Segment Cost	$363m	$867m	$1,303m
Pre-Operational Cost	$328m	$251m	$682m
O&M Contract	$2,880m	$400	$400
Total Costs	$7,021m	$3,004m	$4,350m
Depreciation of Satellites (years)	5	7.5	12
Annual Cost	$1,4042m	$400.5m	$362.5m
Wholesale Charges per MoU to Cover System Costs	$0.94	$0.06	$0.07
Annual Marketing and G&A	$355m	$250m	$500m
Annual Interest Expense	$300m	$350m	$300m
Total Annual Costs Including Depreciation	$2,059.2m	$1,000.5m	$1,162.5m
Wholesale Charge per MoU to Cover All Costs	$1.37	$0.14*	$0.23

THE IRIDIUM LESSSON

- **In many respects Iridium was a technical success and a business failure**
  - — Built and launched a large number of satellites in dramatically less time than had been done before
  - — Showed that large LEO constellations were indeed technically feasible
  - — Had some technical problems, but overall the space system worked well
- **We should not take comfort in this result**
  - — It did not meet the fundamental need of those who paid for it to generate sufficient income to offset cost
  - — Many of the problems were in worldwide licensing and manufacture of the ground units (i.e., the satellite telephones)
  - — It did not anticipate the rapid growth of terrestrial cellular communications and customer expectations
- **In a sense, what failed was the mission utility analysis and mission implementation**

If space systems are to be successful, they must meet the needs of whoever pays for them in terms of both performance and cost.

IRIDIUM NEXT

- The original Iridium constellation was built for $5 billion and sold for $25 million
- The new constellation, Iridium Next, has been profitable
  - Took 10 years to build and launch
  - Completed in 2019
  - Total cost approximately $3 billion
  - Originally called Iridium-NEXT 127 was renamed Iridium-NEXT 100 before launch due to a ground software issue, which prevented the use of the number 127
  - Appears to be doing well financially.

POLITICAL AND ECONOMIC REALITIES OF CONSTELLATIONS

- **Historically, constellations have proven to be expensive and have taken longer to implement than planned**

- **Difficult to gain financial or political support to build the full system**
  - — **Government example: GPS did not have sufficient political support to get funded; needed to add NDS payload to make the constellation real**
    - **GPS took nearly 10 years to build up the constellation**
  - — **Commercial examples: Raising the necessary capital is difficult and time consuming**
    - **With Iridium, ICO, and GlobalStar it will get harder**

Cutting cost is difficult

- — **Cutting the number of spacecraft in a 50 satellite constellation by 20% reduces the spacecraft cost by 15% to 17% and the system cost by 8% to 12%**
- — **Delays are dramatically expensive for commercial programs due to cost of money**
- — **Little room to negotiate dramatically lower launch costs**
- — **Reducing non-recurring development cost often drives up operations costs by substantially more**

COST CONSTRAINED SPACE SYSTEMS DESIGN AND MANAGEMENT REQUIRES A STRONG SYSTEMS APPROACH

- Experience in dramatically reducing cost shows that one of the key elements is a willingness to trade on requirements
  - Must be willing to compromise between what you want and what you can afford
  - Multiple examples and case studies in RSMC
- Must attack all aspects of system cost
  - Non-recurring development, recurring manufacturing, and operations must all be addressed during the entire process
  - Key trades involve moving cost between major system elements
    - Examples: more spacecraft automation or allowing the spacecraft to fly itself to its final orbit
- Must emphasize life-cycle cost
  - Early non-recurring costs are "expensive," but pushing these costs downstream to operations can be even more expensive

    Space Shuttle sold on the basis of dramatically reducing launch costs

    GPS and Iridium operations costs much higher than planned

Dramatically reducing cost can be done, but requires a strong systems engineering approach, a willingness to change the rules, and an emphasis on life-cycle cost.

GEOPOSITIONING ACCURACY IS ONE EXAMPLE OF THE COUPLING BETWEEN SPACE SYSTEM ELEMENTS