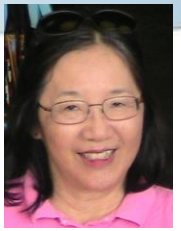

interstel
technologies
COSMOS
Comprehensive Open-architecture Solution for Mission Operations Systems
Facilitated by
XLR8UH

Company Team



- Administration experience
- Project manager for research projects
- MA in Educational Psychology

Claudia Kamiyama
Business Manager

Founder

Dr. Trevor Sorensen
CEO
- Aerospace Engineer
- 45 years experience in space field (NASA, DoD, commercial)
- Expert in mission operations
- Computer game designer

Interns

Lindsay Root
Marketing & Sales
UHM MBA Candidate

Founder

Eric Pilger
VP, Technology
- Lead Software Engineer of HSFL and COSMOS
- 30 years experience in planetary science instrument development
- MA in Astronomy

Lauren Kurashige
Legal
UHM JD/MBA Candidate

Founder

Dr. Miguel Nunes
VP, Engineering
- Aerospace Engineer
- Deputy Director HSFL and Lead Engineer COSMOS (simulation and testing)
- PhD in Mechanical Engineering (UHM)

CEO's Experience

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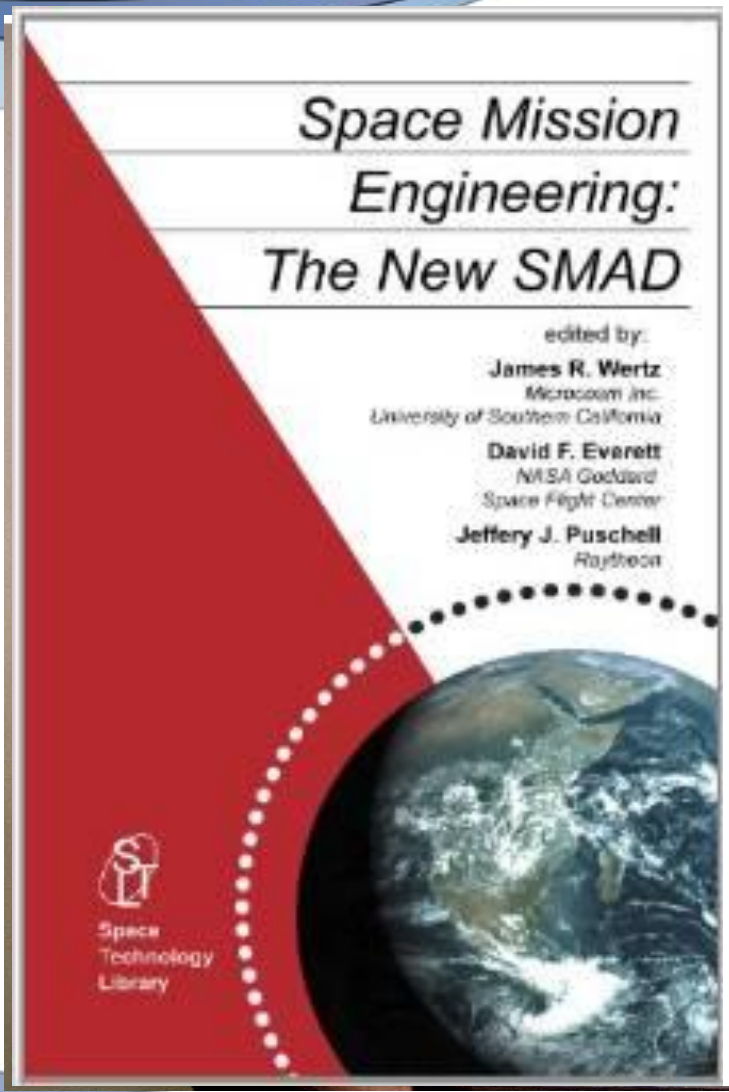


29 Mission Operations

Trevor C. Sorensen, *University of Hawaii*
with support from members of the AIAA Space Operations and Support Technical Committee*

* The author would like to acknowledge the support of Joachim Kehr (DLR, retired), J. Jeffrey Devine, and Richard Campion (Honeywell Technology Solutions, Inc.), and the following members of the AIAA Space Operations and Support Technical Committee: Franz Newland (Com Dev International), Patricia Klein (Naval Research Laboratory), David LaVallee (Johns Hopkins University Applied Physics Laboratory), Carrie Olsen (NASA Marshall Space Flight Center), and David Welch (LASP/Honeywell Technology Solutions, Inc.

It is possible to design and build the best possible spacecraft and even launch it into space, but it is useless unless there is a way for it to accomplish its mission. This is the role of *mission operations*. Contrary to a popular misconception, mission operations is not limited to what happens in the Mission Control Room or even the Mission Operations Center (MOC). That is really only the tip of the iceberg. Mission operations includes what happens on the spacecraft or launch vehicle, at ground stations, in engineering offices and science labs, to accomplish the goals of the mission, from design and development through mission execution. It is an integrated system of people, hardware, software, and activities that have to work together to ensure the successful execution of the mission. All organizations that fly space missions, from government agencies to industry and academia, perform mission operations activities. They nonetheless have different requirements for mission operations and often have their own philosophies and methodologies for developing and implementing mission operations. What is presented in this chapter are the methods that have worked for the author and have worked for others from all types of missions – manned, robotic, Earth orbit, deep space, small, large, single and multiple satellites.

Mission operations can be categorized into four basic functions: spacecraft or launch vehicle operations, payload operations, ground operations, and mission management. Mission operations also vary by the phase of the mission life cycle and are divided into two fundamentally different modes separated by the launch. Mission operations design, development, and testing occurs during the study (Phase A), design (Phases B and C), and the assembly, integration and testing (Phase D) phases of the mission. Mission operations execution occurs during the flight phase (Phase E) and termination phase (Phase F).

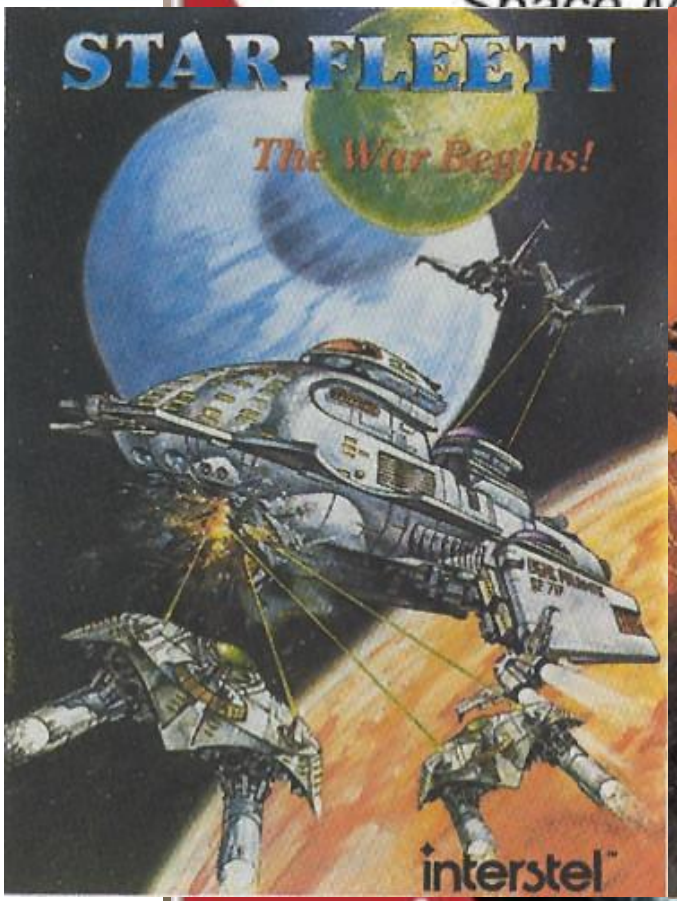
The following definitions of the four basic mission operations functions are based on those by Kehr [2007]:

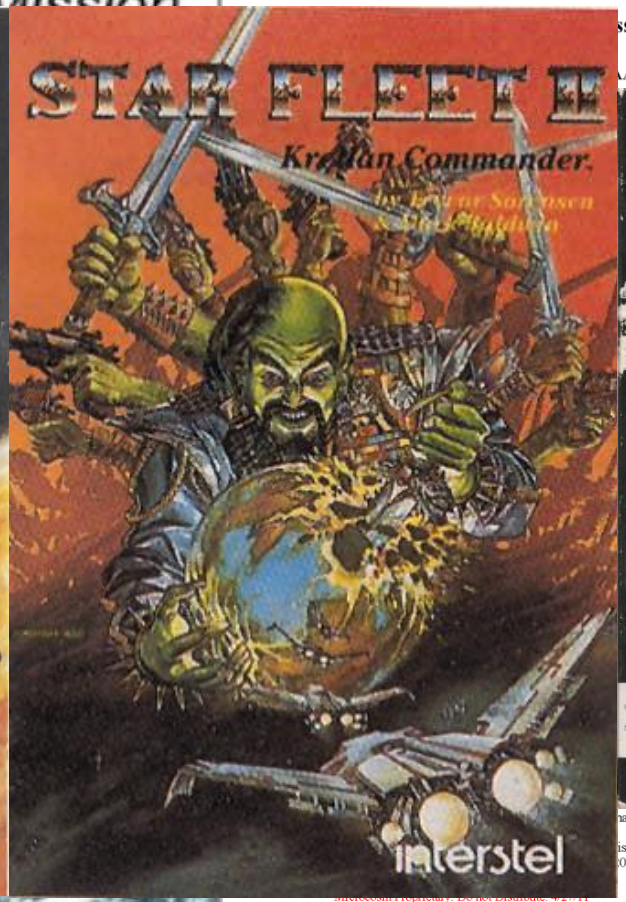
Spacecraft/Launch Operations covers the preparation and implementation of all activities to operate a space vehicle (manned and unmanned) or launch vehicle under normal, non-nominal and emergency conditions. This includes the specification, design, production and qualification of all means (tools, procedures and trained personnel) to perform the task of spacecraft/launch operations. It also involves designing operability into the space segment. The main challenges in this area are the cost-efficient combination of tools, degree of automation (for both space and ground segments), and staffing to provide secure and reliable operations. A very prominent role is played by the mission database containing all pertinent spacecraft and ground operations data parameters to be maintained throughout the mission. It is initially created by the spacecraft designers and handed over to the operations personnel during Phases C-D to be augmented by the specific ground operations parameters.

Payload operations cover the preparation and implementation of all activities related to the payload,* which is generally the primary reason for the mission. Details of typical spacecraft payloads are covered in Chap. 15.18 and not repeated here. Payload operations differ from spacecraft operations in that unique mission-specific expertise may be required to make decisions with regard to tasking the payload and retrieving and interpreting its data. That being said, for small spacecraft and relatively simple payloads, the payload operations are often included as another subsystem within spacecraft operations. In this case, the spacecraft operations team may retrieve and distribute the payload data to clients directly, without the intervention of a dedicated payload operations team. Large spacecraft, on the other hand, often have complex and independent payloads, such as

* Although the payload is usually contained within the spacecraft bus, sometimes it might be separate, such as a separable probe or inspector vehicle.

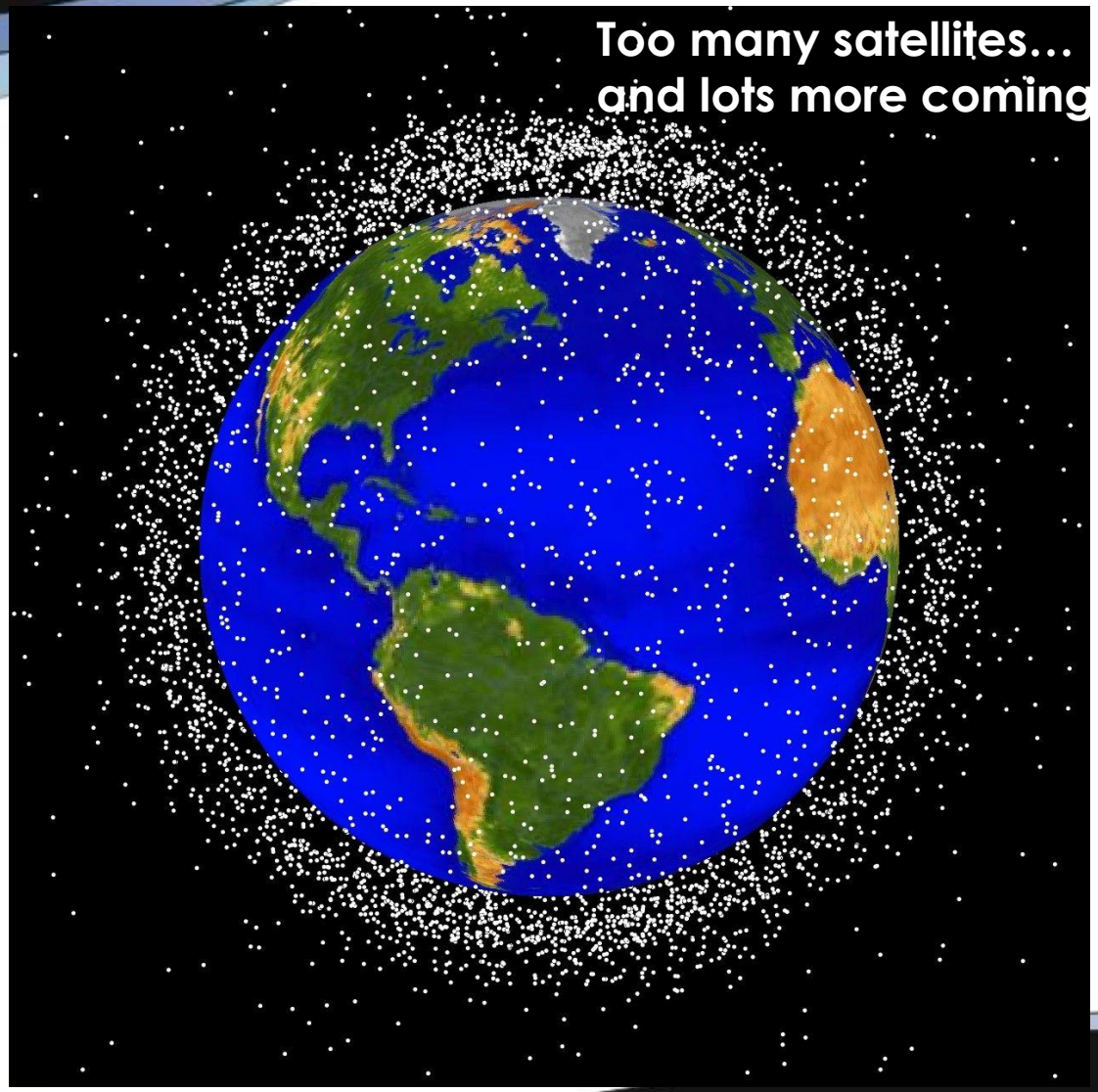
CEO's Experience





PROBLEM

Problem



Problem


How do we efficiently monitor & control hordes of satellites?

Problem

Ops systems for multiple satellites are TOO COMPLICATED…
…and hard to adapt to new missions!

Problem

A good COTS solution is missing!

Voice of the Customers

"Adaptability is a definite problem for every mission I have worked on."

Paul Douglas, NOAA Satellite Operations Facility

"System needs flexibility and configurability."

Chris Jones, Iridium Operations Director

"Need to integrate everything into one system/tool that shows the status of everything in the system including spacecraft, ground stations, etc.."

Dave LaVallee, Project Leader, Applied Physics Laboratory

"COTS don't quite do what we need; they are not flexible."

Chris Jones, Iridium Operations Director

"At Space X we could not find a COTS solution for our mission operations and had to develop our own."

Dr. Marco Villa, former Director of Mission Operations, SpaceX

Problem

Is there a solution?

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Yes, there is a solution - it's…..

Developed by real rocket scientists (engineers)!

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COSMOS

COSMOS

COSMOS

The only operations software toolkit that is comprehensive with nodal architecture

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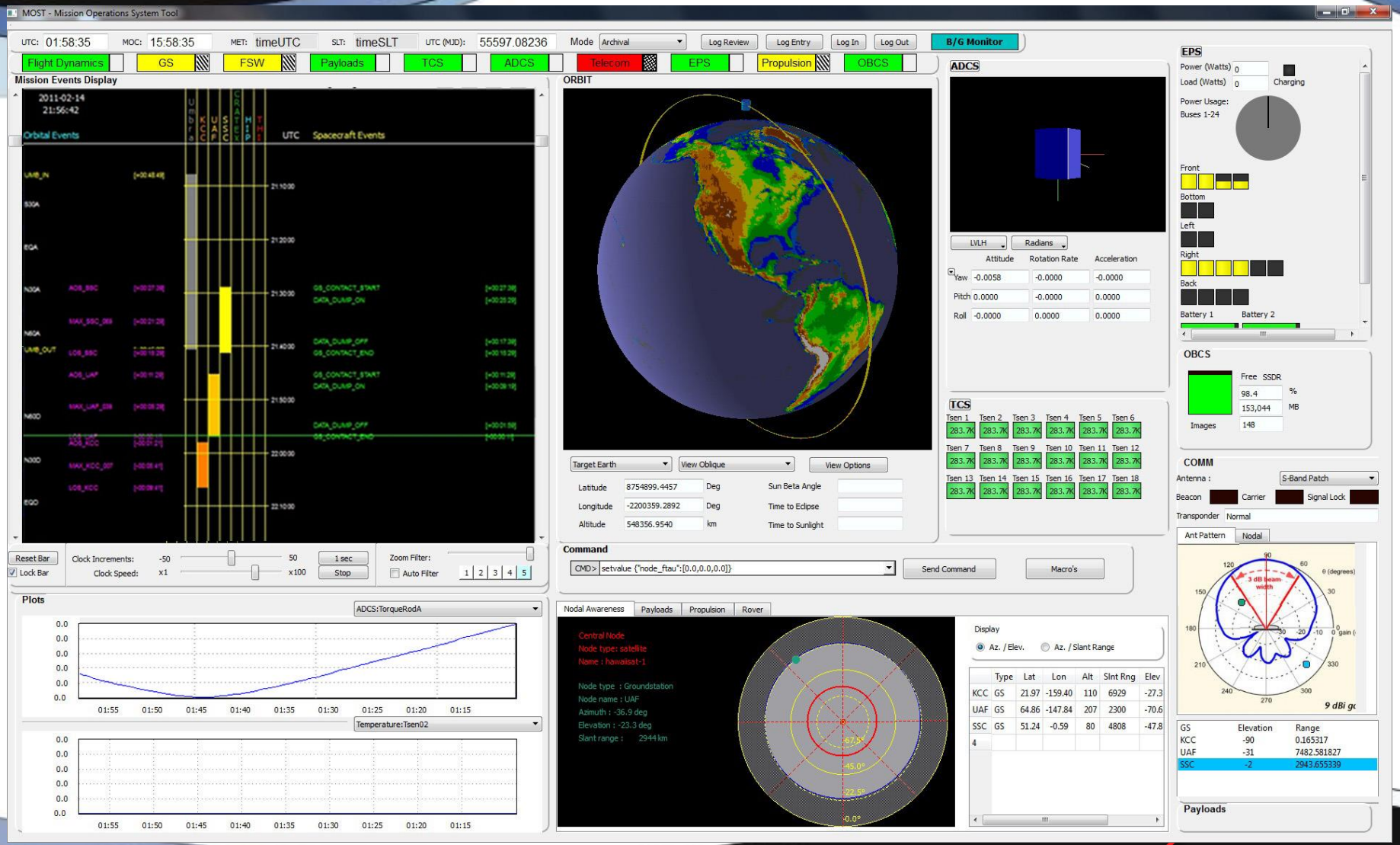
COSMOS

COSMOS Mission Ops Functions (Tools)

- Mission planning & scheduling (MPST)
- R/T command & control (MOST)
- Ground segment C&C (GSCT)
- System executive management (CEO)
- Flight dynamics (FDT)
- Data system management (DMT)
- Test bed & simulators (TBCT)
- Analysis tools

COSMOS


MOST - Mission Operations System Tool
UTC: 01:58:35
MOC: 15:58:35
MET: timeUTC
SLT: timeSLT
UTC (MJD): 55597.08236
Mode
Archival
Log Review
Log Entry
Log In
Log Out
B/G Monitor
Flight Dynamics
GS
FSW
Payloads
TCS
ADCS
Telecom
EPS
Propulsion
OBCS
Mission Events Display
Orbital Events
Spacecraft Events
ORBIT
ADCS
EPS
Power (Watts)
Load (Watts)
Charging
Power Usage:
Buses 1-24
Front
Bottom
Left
Right
Back
Battery 1
Battery 2
LVLH
Radians
Attitude
Rotation Rate
Acceleration
Yaw -0.0058 -0.0000 -0.0000
Pitch 0.0000 -0.0000 0.0000
Roll -0.0000 0.0000 0.0000
TCS
Tsen 1 283.7K
Tsen 2 283.7K
Tsen 3 283.7K
Tsen 4 283.7K
Tsen 5 283.7K
Tsen 6 283.7K
Tsen 7 283.7K
Tsen 8 283.7K
Tsen 9 283.7K
Tsen 10 283.7K
Tsen 11 283.7K
Tsen 12 283.7K
Tsen 13 283.7K
Tsen 14 283.7K
Tsen 15 283.7K
Tsen 16 283.7K
Tsen 17 283.7K
Tsen 18 283.7K
OBCS
Free SSDR
98.4 %
153,044 MB
Images 148
COMM
Antenna :
S-Band Patch
Beacon
Carrier
Signal Lock
Transponder
Normal
Ant Pattern
Nodal
3 dB beam width
9 dBi gc
Target Earth
View Oblique
View Options
Latitude 8754899.4457 Deg
Longitude -2200359.2892 Deg
Altitude 548356.9540 km
Sun Beta Angle
Time to Eclipse
Time to Sunlight
Reset Bar
Lock Bar
Clock Increments: -50 50
Clock Speed: x1 x100
1 sec
Stop
Zoom Filter:
Auto Filter
1 2 3 4 5
Command
CMD> setvalue {"node_ftau":[0.0,0.0,0.0]}
Send Command
Macro's
Plots
ADCS:TorqueRodA
Temperature:Tsen02
Nodal Awareness
Payloads
Propulsion
Rover
Central Node
Node type: satellite
Name : hawaiisat-1
Node type : Groundstation
Node name : UAF
Azimuth : -36.9 deg
Elevation : -23.3 deg
Slant range : 2944 km
Display
Az. / Elev.
Az. / Slant Range
Type Lat Lon Alt Slnt Rng Elev
KCC GS 21.97 -159.40 110 6929 -27.3
UAF GS 64.86 -147.84 207 2300 -70.6
SSC GS 51.24 -0.59 80 4808 -47.8
GS Elevation Range
KCC -90 0.165317
UAF -31 7482.581827
SSC -2 2943.655339
Payloads

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COSMOS

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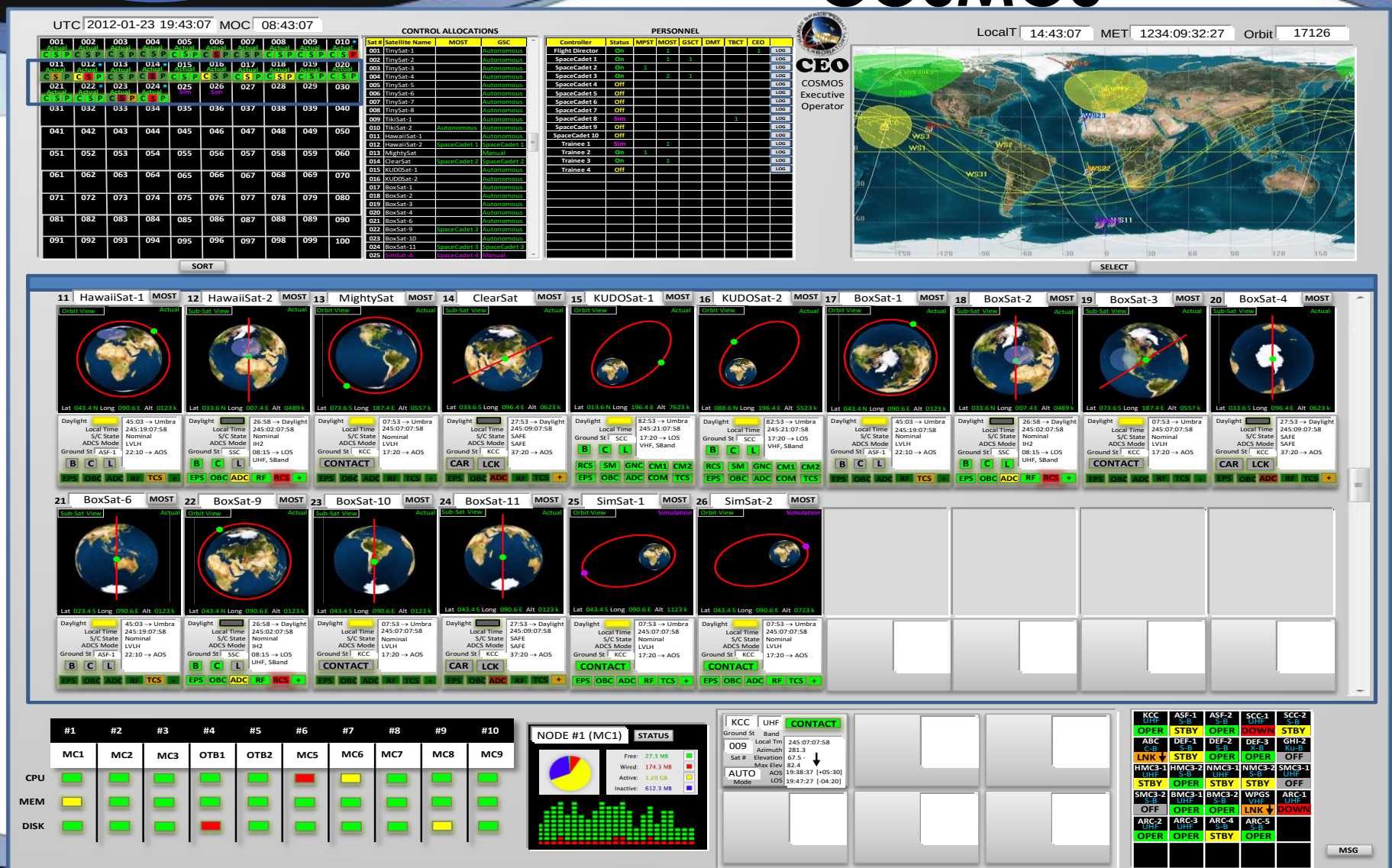
COSMOS


UTC 2012-01-23 19:43:07 MOC 08:43:07
CONTROL ALLOCATIONS
PERSONNEL
CEO
COSMOS
Executive
Operator
LocalT 14:43:07 MET 1234:09:32:27 Orbit 17126
SORT
SELECT
11 HawaiiSat-1 MOST
12 HawaiiSat-2 MOST
13 MightySat MOST
14 ClearSat MOST
15 KUDOSat-1 MOST
16 KUDOSat-2 MOST
17 BoxSat-1 MOST
18 BoxSat-2 MOST
19 BoxSat-3 MOST
20 BoxSat-4 MOST
21 BoxSat-6 MOST
22 BoxSat-9 MOST
23 BoxSat-10 MOST
24 BoxSat-11 MOST
25 SimSat-1 MOST
26 SimSat-2 MOST
#1 MC1
#2 MC2
#3 MC3
#4 OTB1
#5 OTB2
#6 MC5
#7 MC6
#8 MC7
#9 MC8
#10 MC9
CPU
MEM
DISK
NODE #1 (MC1)
STATUS
CONTACT
MSG

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Competition

Company	Product	Nationality	Cost
L3	InControl	US	$$$
Orbit Logic	Orbit Logic	US	$$$
GMV	HiFly	European	$$$
Harris	OS/COMET	US	$$$
ESA	SCOS-2000	European	$$$
Johannes Klug	Hummingbird	European	$
OHB	Ramses	European	$$$
Kratos	Kratos C2	US	$$$
Braxton	ACE Premier	US	$$$
Interstel Tech.	**COSMOS**	**US**	**$$**

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How Do We Compare?
Functions

COSMOS Mission Ops Functions (Tools)

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- R/T command & control
- Ground segment C&C
- System executive management
- Flight dynamics
- Data system management
- Test bed & simulators
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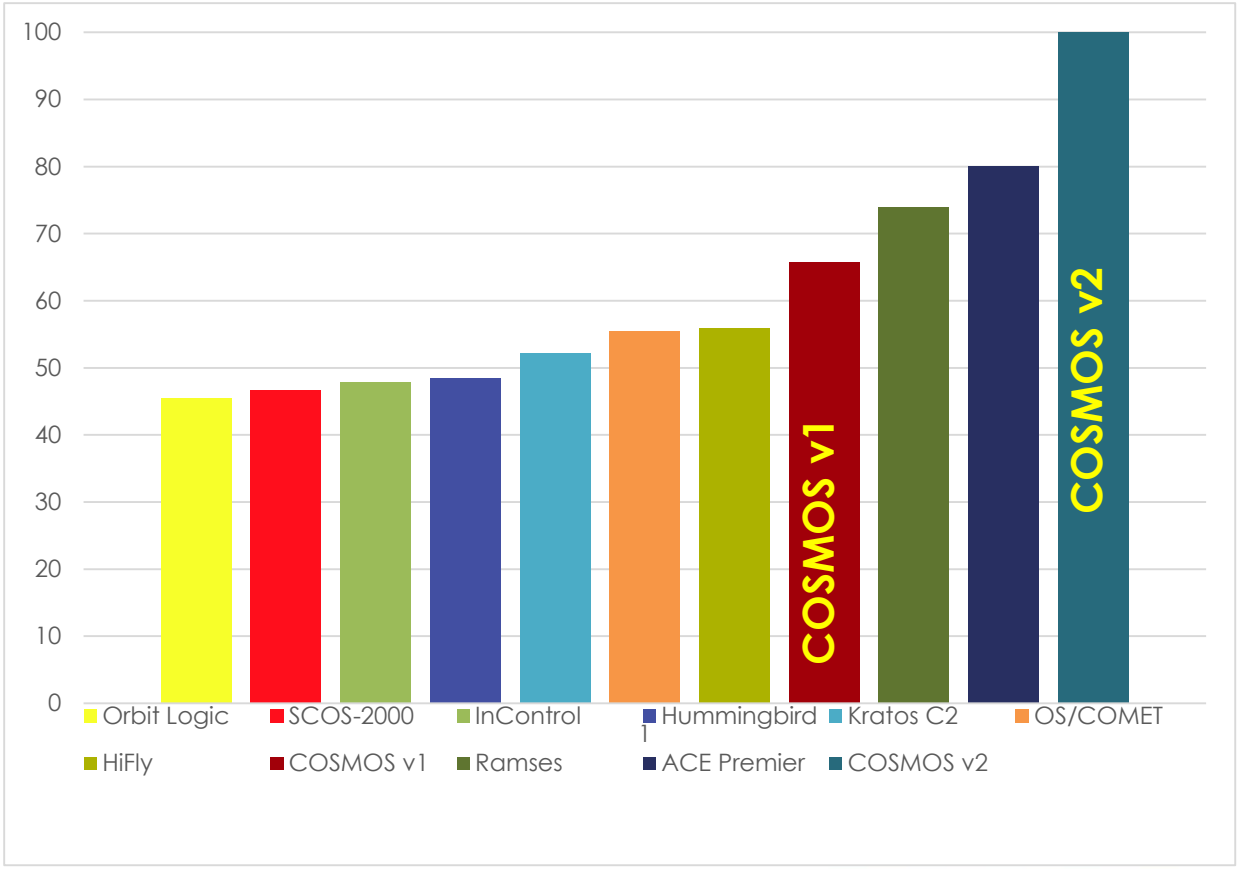

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How Do We Compare?
Desirable Features

How do we efficiently monitor & control hordes of satellites?

Users want ease of use and overall executive tool

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How Do We Compare?
Desirable Features

Ops systems for multiple satellites are TOO COMPLICATED…
…and hard to adapt to new missions!

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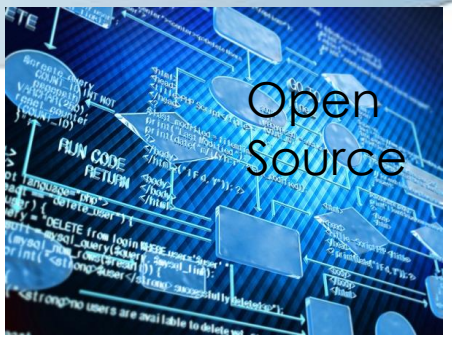
How Do We Compare?
Desirable Features



Remote Virtual Ops

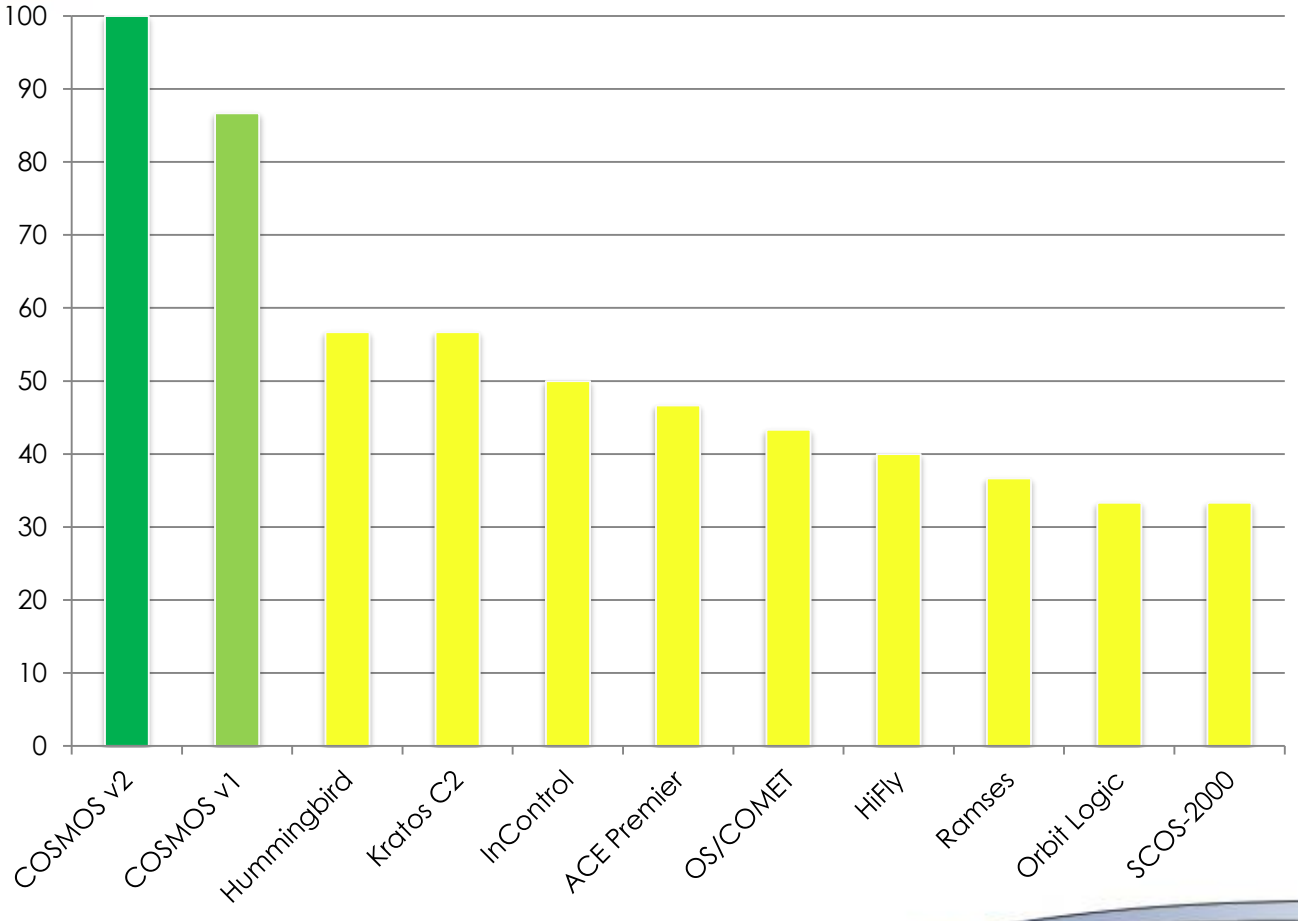
Plug and Play

Scalable

Error Handling

Automation

How Do We Compare?
Desirable Features



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Market

Satellites + UASs + Ground Stations

2020 Estimate

$24 B
Ground Equipment, Flight Software, Ground Software, Services, Ops

$2.4 B
Addressable Market

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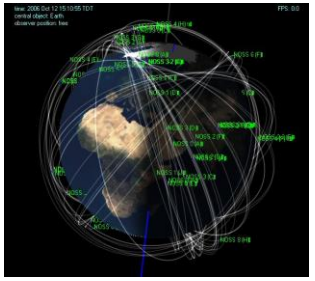
Revenue Models

+

Freemium Model

License Product to Reseller

Gov. Contracts
(annual licensing)



Commercial
(annual licensing)

Expansion Areas

Service

- Mission Ops
- Data on demand

Hardware

- Portable Ground Stations
- Embedded in avionics

Go to Market Strategy

Get

Seek strategic partnerships

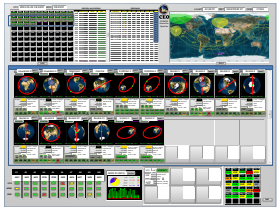
Win contracts to develop COSMOS & gain customers

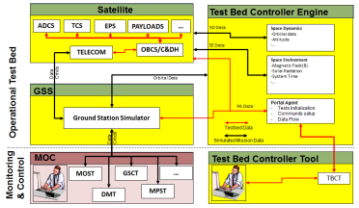
Get customers to try COSMOS demos

Freemium Model

Keep

Develop COSMOS community for developers/users



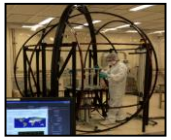


Product improvement and new features

Grow

Targeted collaborations

Provide ops services



Tiered product offerings

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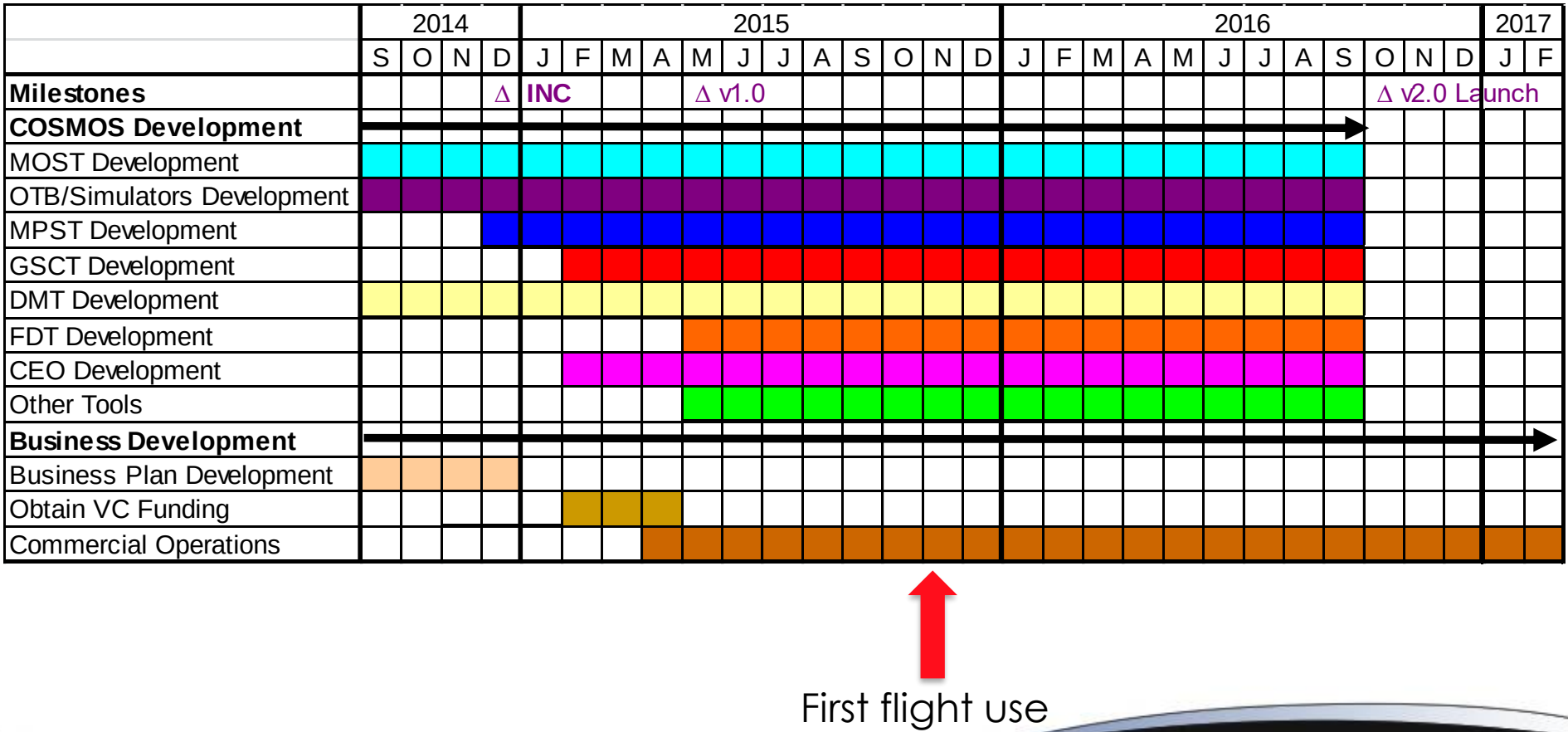
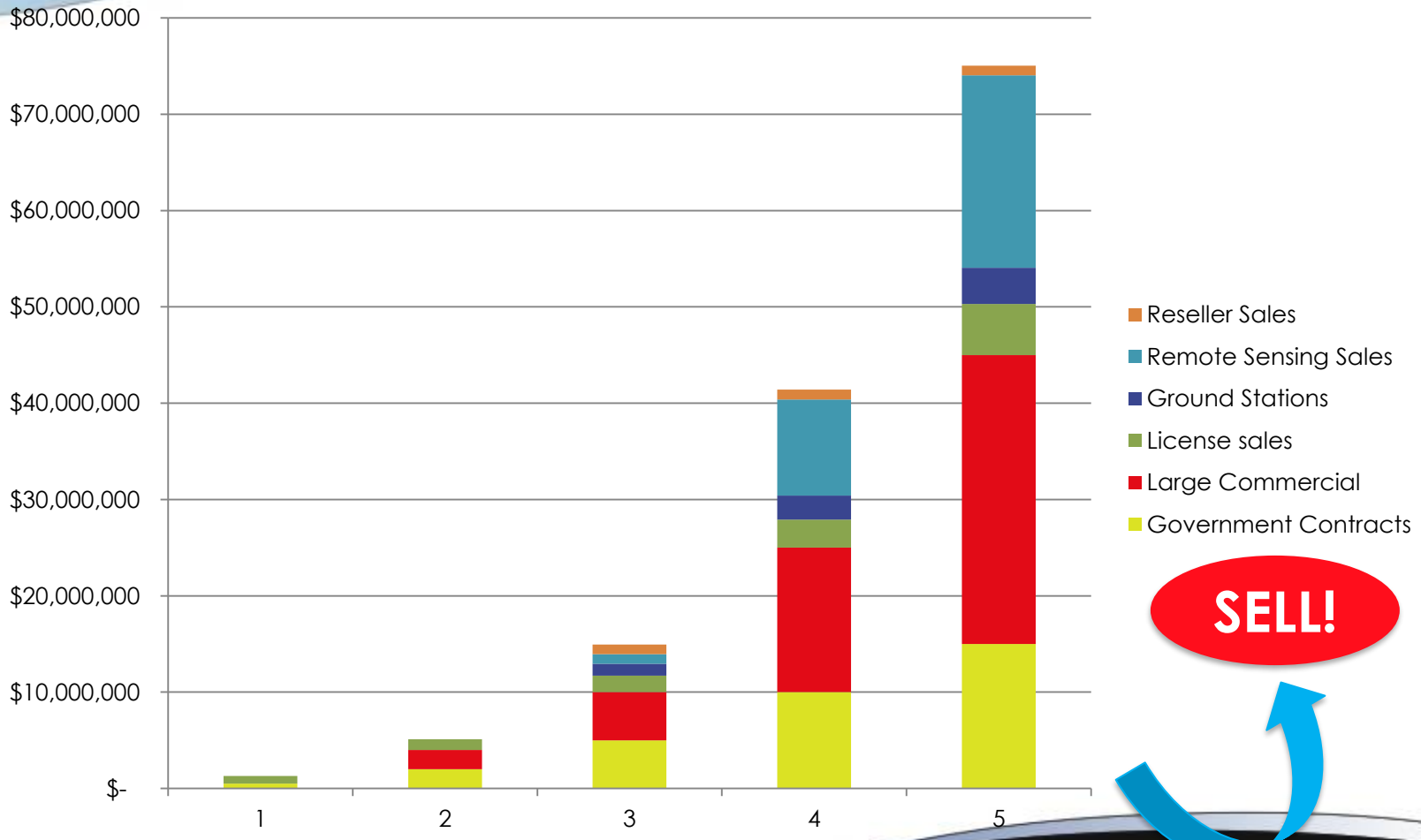
Development Plan
To COSMOS v2.0 Launch

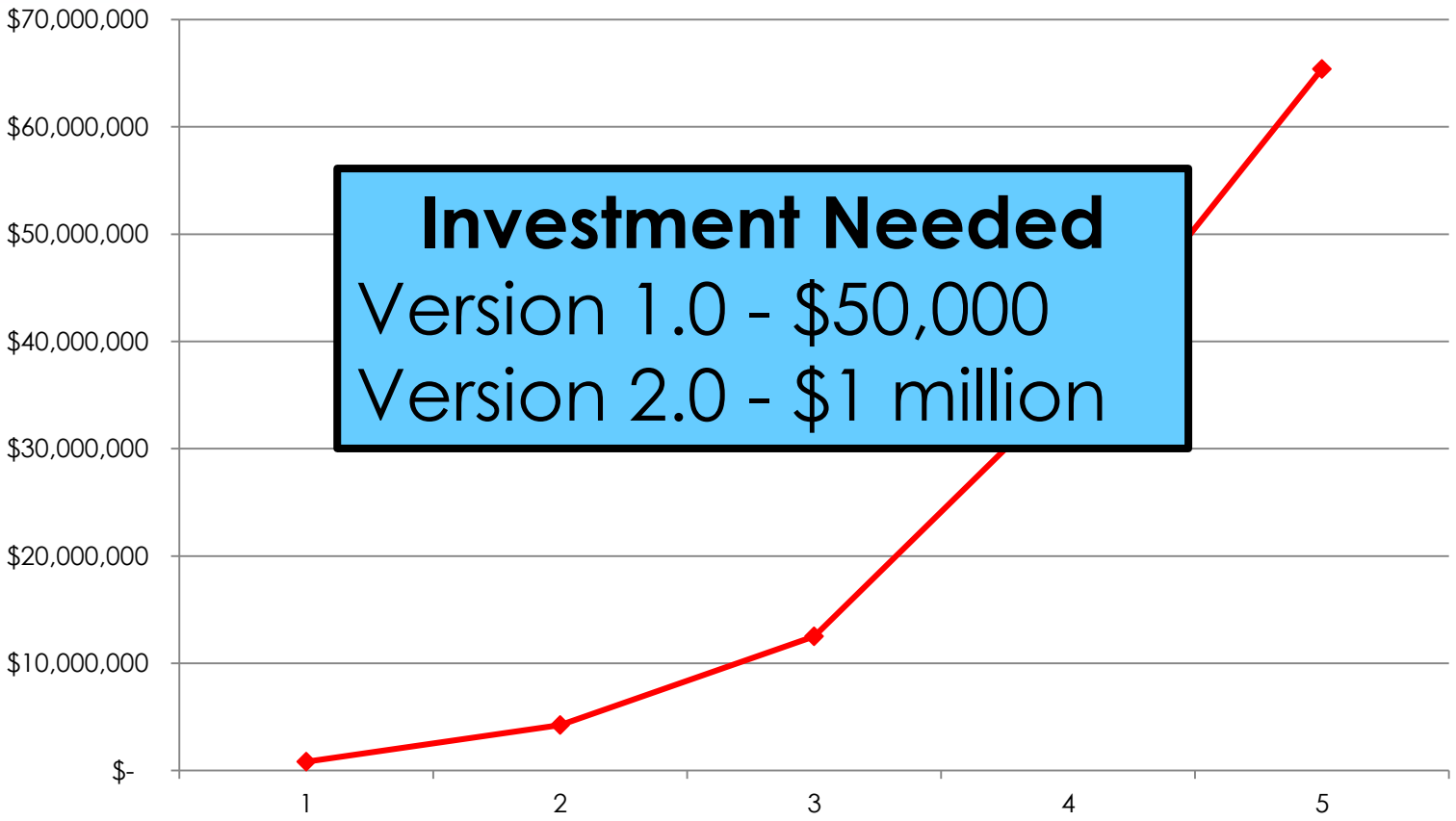


Financial Projection

Revenue



Financial Projection
Net Profit



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is expanding!

MAHALO!