The Problem

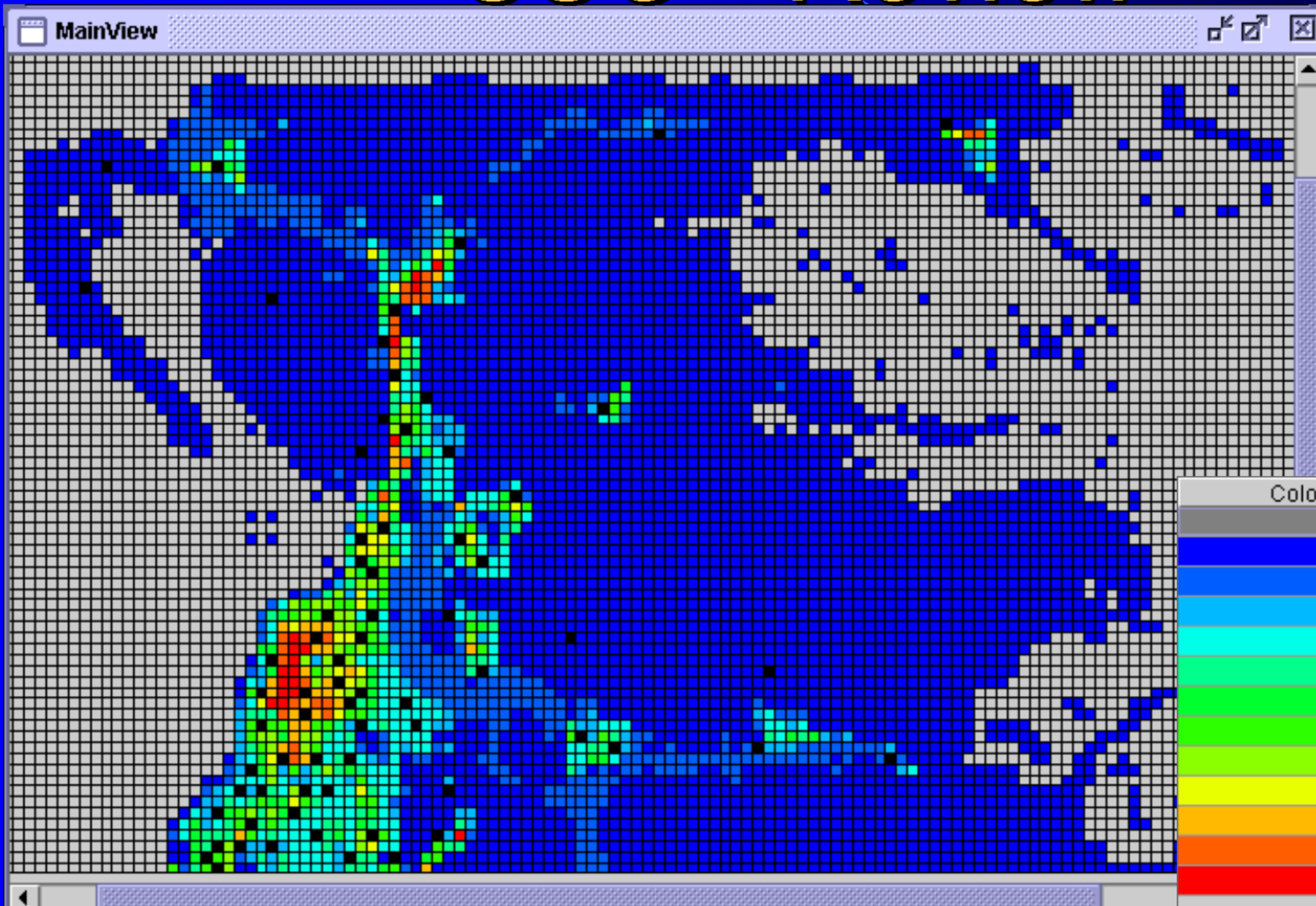
$$
\begin{array}{lll}
\underset{x}{\text{minimize}} & f(x) & \text{objective} \\
\text{subject to} & l \le x \le u & \text{simple bounds} \\
 & l_A \le Ax \le u_A & \text{linear constraints} \\
 & l_C \le c(x) \le u_C & \text{nonlinear constraints}
\end{array}
$$

where x, l, u are in $\mathbb{R}^n$, A is an $m_1 \times n$ matrix, $c(x)$ is an m_2-vector of smooth nonlinear functions and $f(x)$ is a smooth scalar function.

Placement of Substations in an Electrical Network (SSO)


Electric Utility Substation
Risk Analysis and Planning
Orange County Emergency Management

SSO - Review



Color	Interval
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	.000E00 .931E03
	.931E03 .186E04
	.186E04 .279E04
	.279E04 .372E04
	.372E04 .465E04
	.465E04 .558E04
	.558E04 .652E04
	.652E04 .745E04
	.745E04 .838E04
	.838E04 .931E04
	.931E04 .102E05
	.102E05 .112E05
	>.112E05

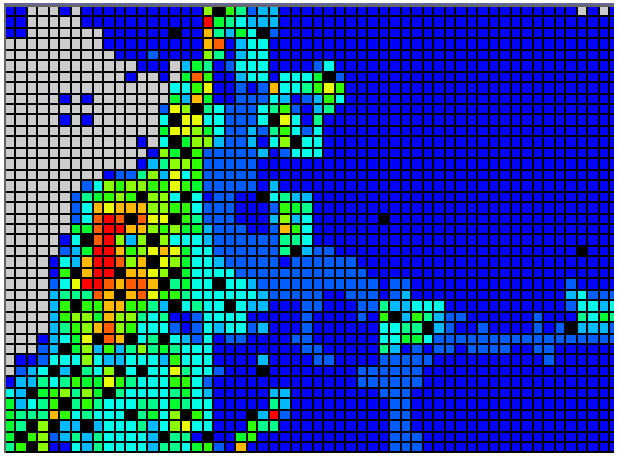
Service area: each grid block is 1/2 mile by 1/2 mile

Colour:

- *Black – substation*
- *Other – Kw Load*

SSO - Review

- "Model distribution lines and substation locations and
  - Determine the optimal substation capacity additions
    - **To serve a known load at a minimum cost"**



Service area: each grid block is 1/2 mile by 1/2 mile

SSO - Review

Characteristics:

More substations:

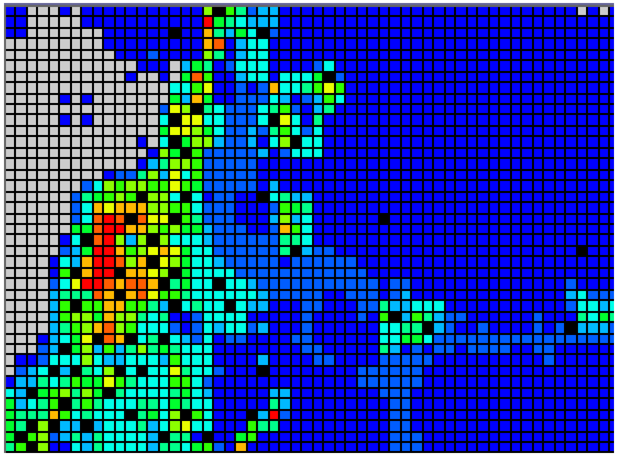
- Higher capital cost
- Lower transmission cost

Capital costs:

$4,000,000 for a 28 MW substation

Cost of losses:

$3,000 per kw of losses



Service area: each grid block is 1/2 mile by 1/2 mile

Variables

$\bar{I}$: Vector of currents at each node in the network

V : Vector of voltages at each node in the network

Y : Network Admittance matrix

y_i : Binary variable specifying whether node i has a substation or not.

C_{cap} : The installation cost of a substation.

C_{loss} : The cost of electrical losses in a network.

S_{cap} : Capacity of a substation.

ℓ_i : Electrical load at node i.

$m \times n$: Grid dimension.

Problem of Interest

SSO

$$\begin{aligned} \min_{V,\bar{I},y} \quad & C_{cap} e^T y + C_{loss} V^T Y V \\ \text{subject to} \quad & \bar{I} - YV = 0 \\ & V^l \leq V_i \leq 1 \ \text{ for all } i \\ & \bar{I}_i \leq S_{cap}, y_i = 1 \ \text{ for all } i \\ & \bar{I}_i = \ell_i, y_i = 0 \ \text{ for all } i \\ & y_i \in \{0,1\} \ \text{ for all } i \end{aligned}$$

Admittance Matrix

$$Y = \begin{pmatrix} A_1 & B_1 & & & \\ B_1 & A_2 & B_2 & & \\ & \ddots & \ddots & \ddots & \\ & & B_{n-2} & A_{n-1} & B_{n-1} \\ & & & B_{n-1} & A_n \end{pmatrix}$$

Y is symmetric and positive semidefinite.

Y has one zero eigenvalue with an associated eigenvector $(1, \ldots, 1)$.

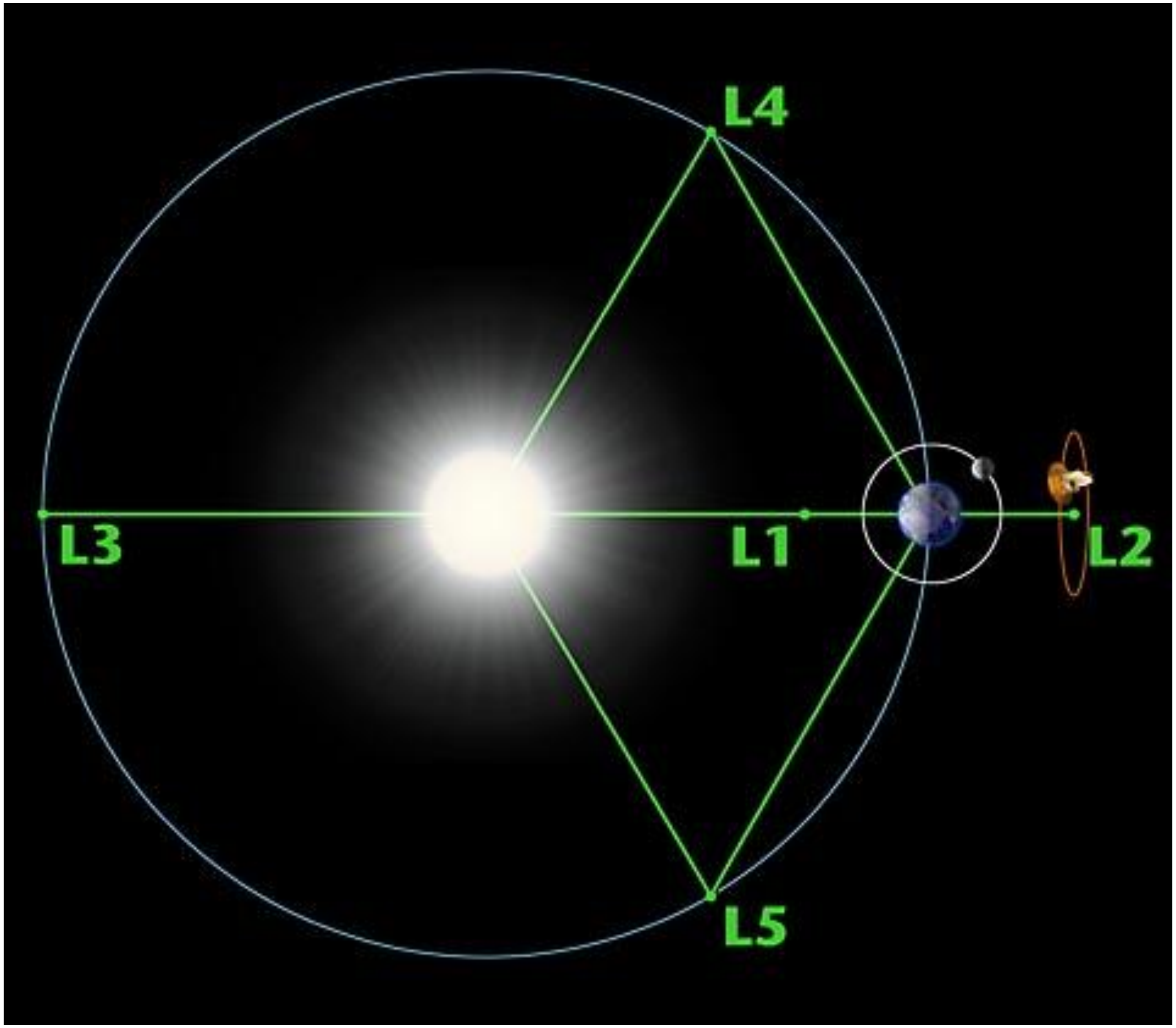
A_i and B_i are tridiagonal and diagonal matrices, respectively.

OPTIMIZATION OF LIBRATION POINT MISSION TRAJECTORIES

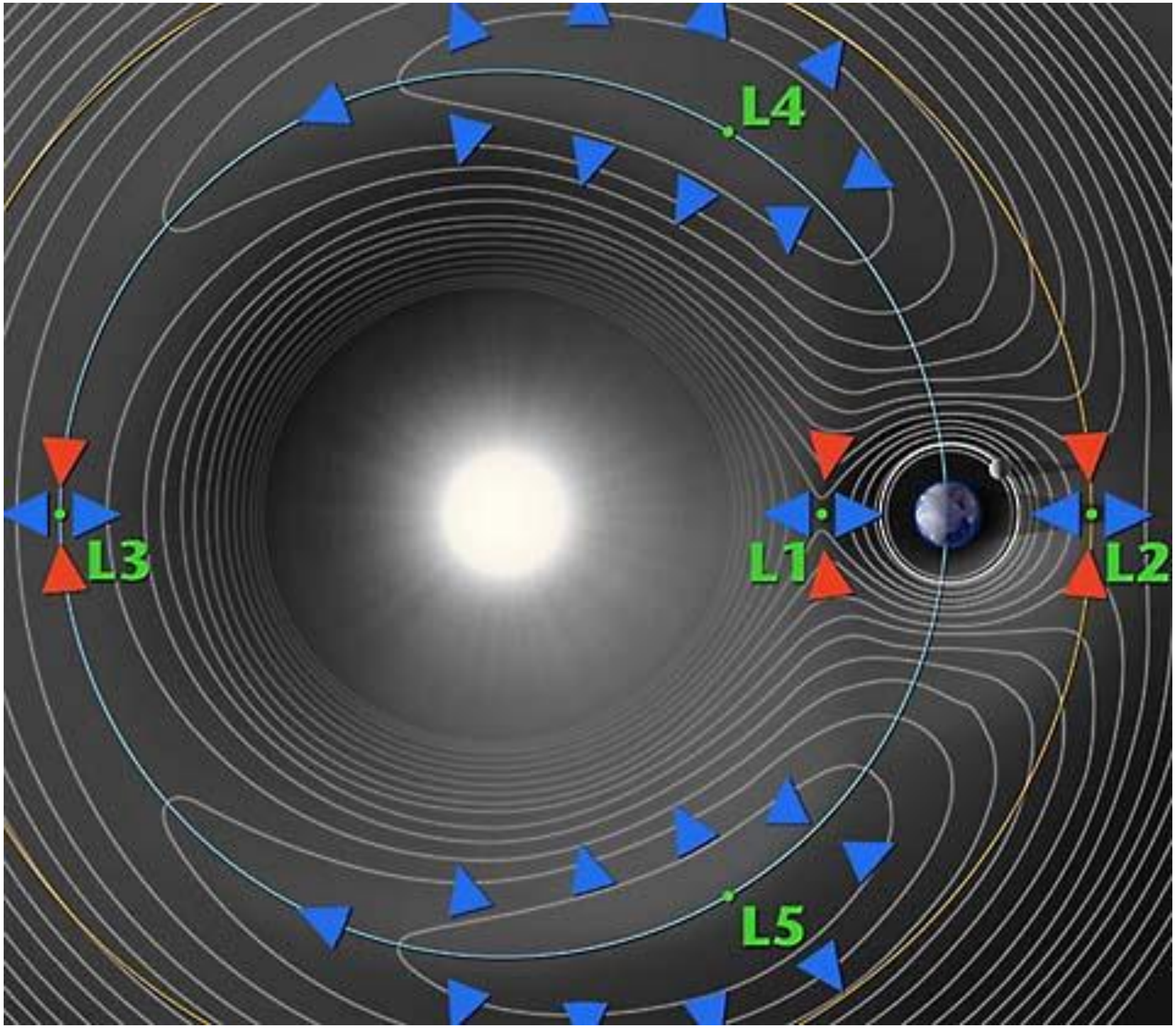
- At a libration or Lagrange point the forces of two orbiting celestial bodies balance to zero. The two points for the Sun-Earth system that are colinear are known as the L_1 and L_2 points (there are 5 points altogether). In theory if a body was placed at such a point it would remain. The trick is to put it there. At such points no energy is needed to loiter forever, which is what makes it attractive for long term missions. The points are also sufficiently close to Earth that communications is not a issue.

- In reality the forces are more complex and are not independent of time, which implies not only will the point move but the movement leaves any satellite in the old position subject to force and it will also move and continue to move.

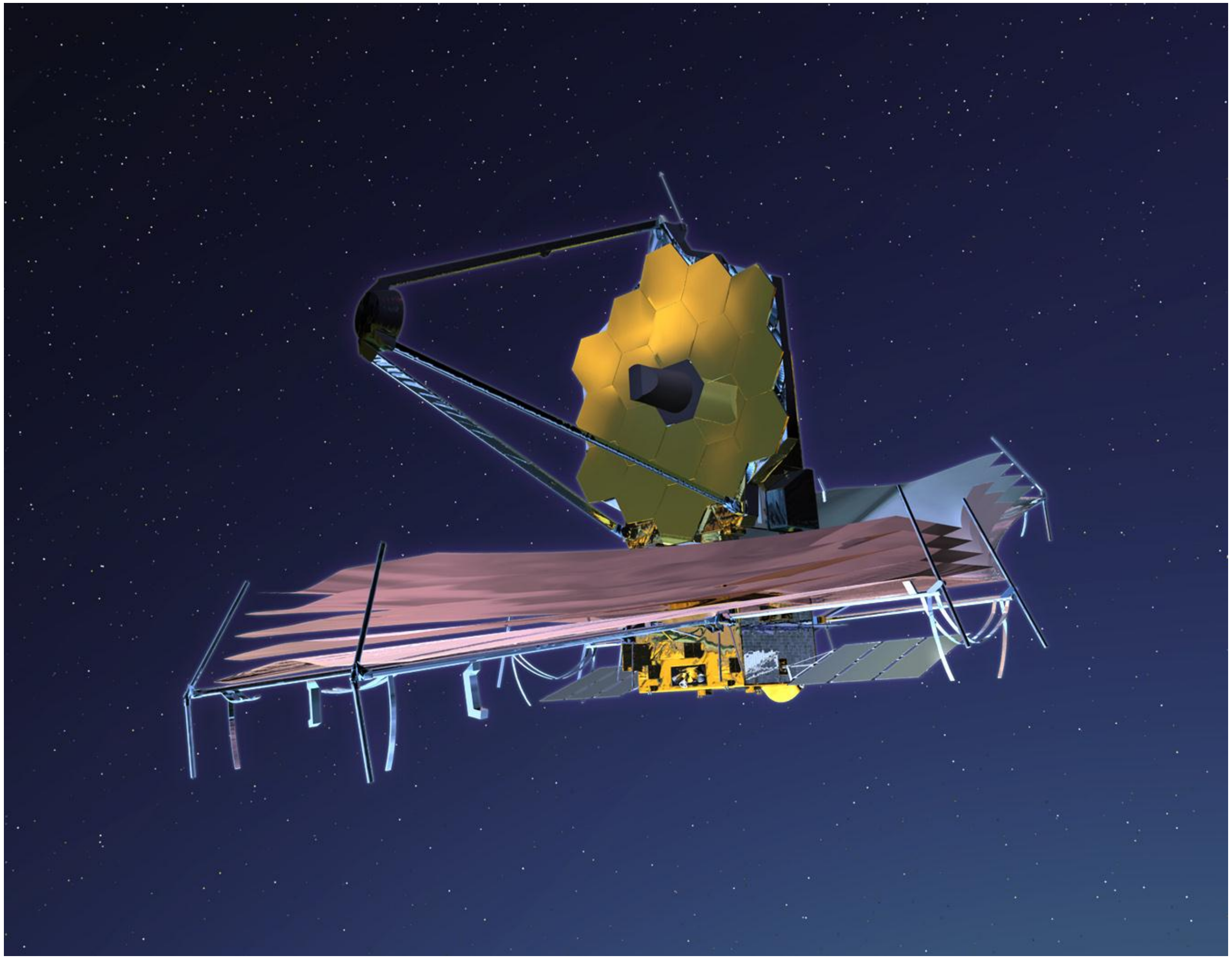
Background



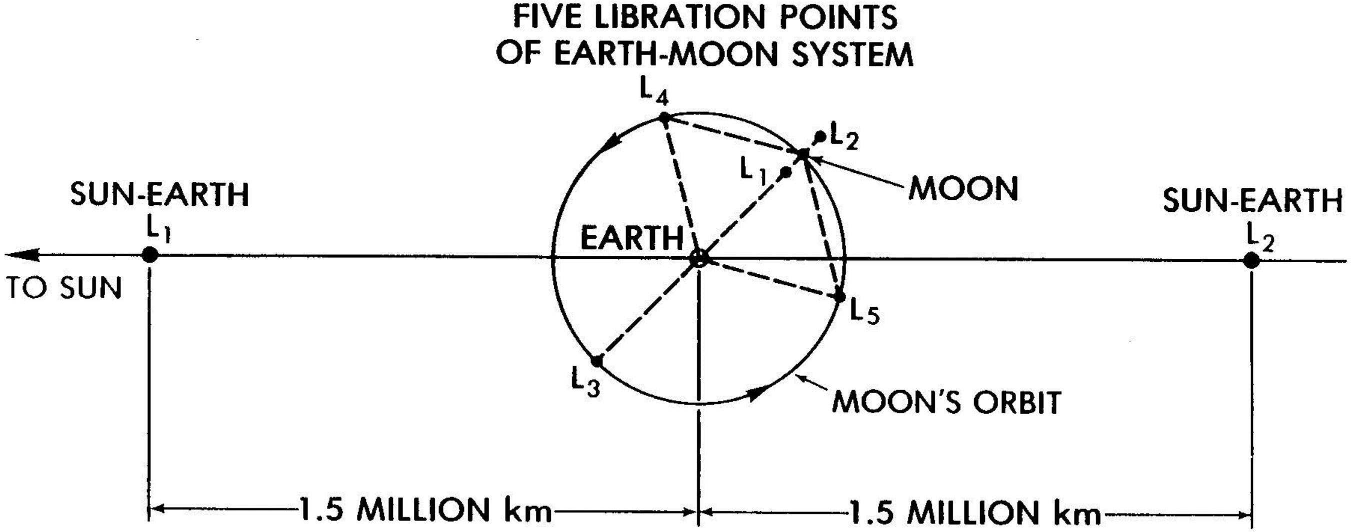
Background



James Webb Space Telescope



Background

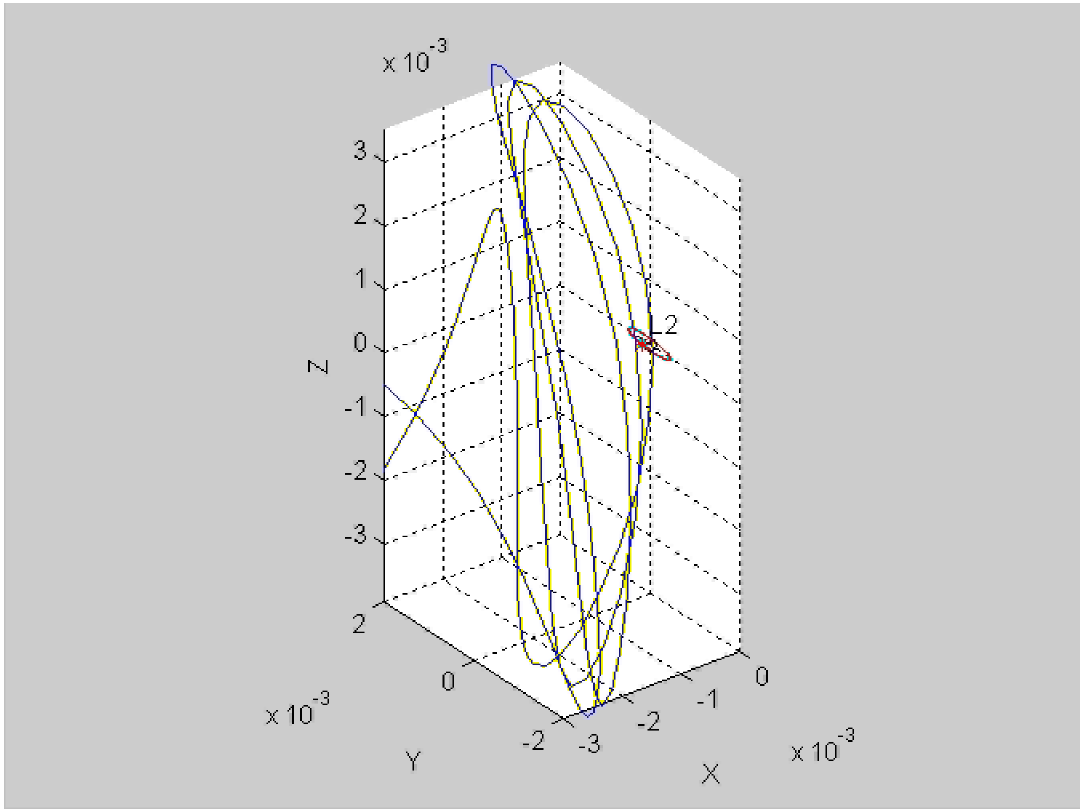


FIVE LIBRATION POINTS
OF EARTH-MOON SYSTEM
L4
L2
L1
MOON
SUN-EARTH
L1
SUN-EARTH
L2
EARTH
TO SUN
L5
L3
MOON'S ORBIT
1.5 MILLION km
1.5 MILLION km

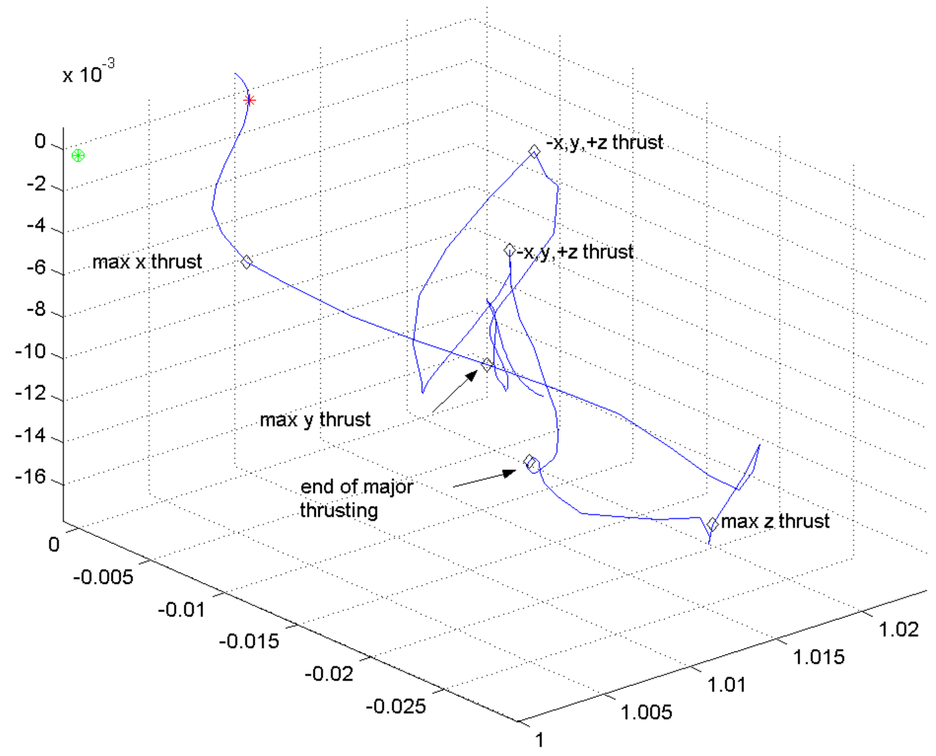
Equations of Motion

$$
\begin{aligned}
\ddot{x} &= 2\dot{y} + x - \frac{(1-\mu)(x-\mu)}{r_{13}^3} - \frac{\mu(x+1-\mu)}{r_{23}^3} + F_x/m \\
\ddot{y} &= -2\dot{x} + y - \frac{(1-\mu)y}{r_{13}^3} - \frac{\mu y}{r_{23}^3} + F_y/m \\
\ddot{z} &= -\frac{(1-\mu)z}{r_{13}^3} - \frac{\mu z}{r_{23}^3} + F_z/m,
\end{aligned}
$$

Small Halo



Loitering



x 10^-3
0
-2
-4
-6
-8
-10
-12
-14
-16
max x thrust
-x,y,+z thrust
-x,y,+z thrust
max y thrust
end of major thrusting
max z thrust
0
-0.005
-0.01
-0.015
-0.02
-0.025
1
1.005
1.01
1.015
1.02

1.1 The Frequency Assignment Problem (FAP)

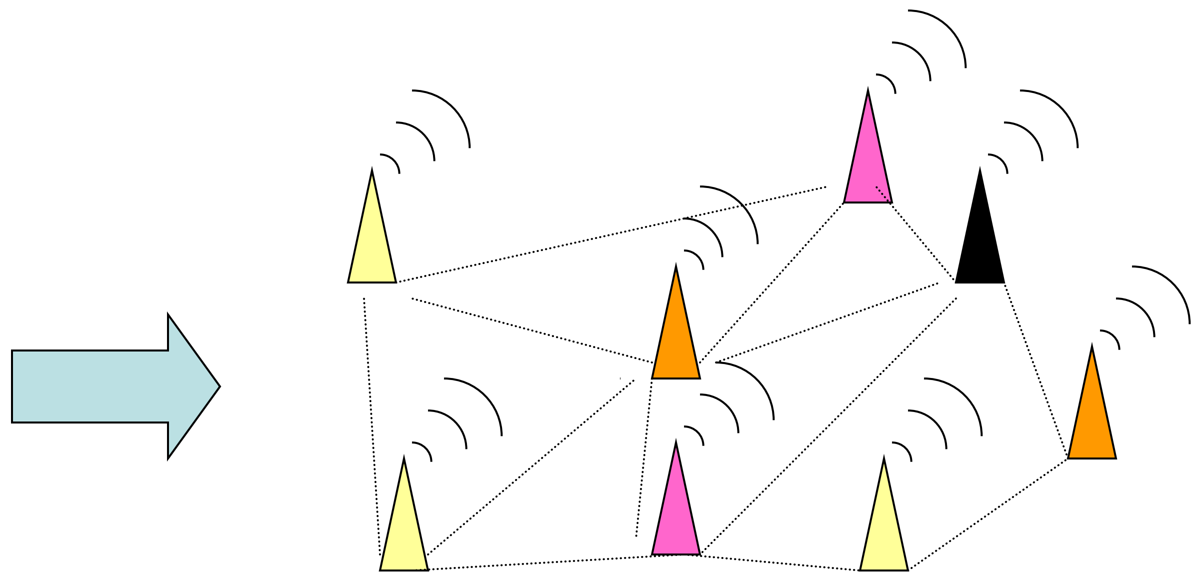
PROBLEM FORMULATION:

Find an assignment of frequencies to base stations that minimizes an objective and fulfills a set of side constraints.

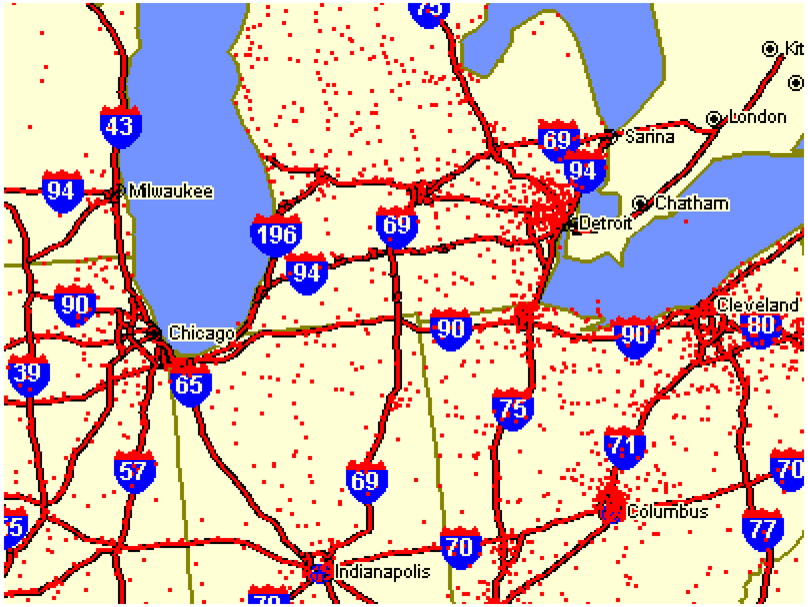
-NP hard

F1 F2

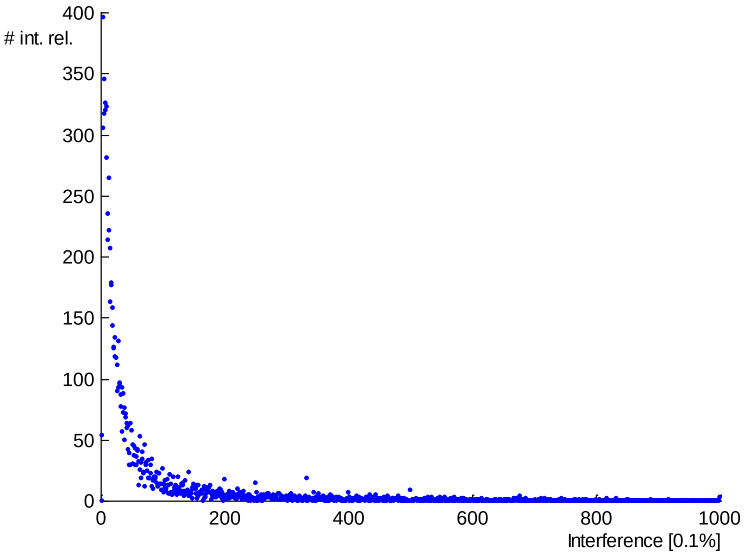
F3 F4



1.5 Characteristics of FAP Data



Geographic distribution of base station locations



Distribution of interf. relations in a data set (e.g. in a given region)

Equivalence with Global Optimization

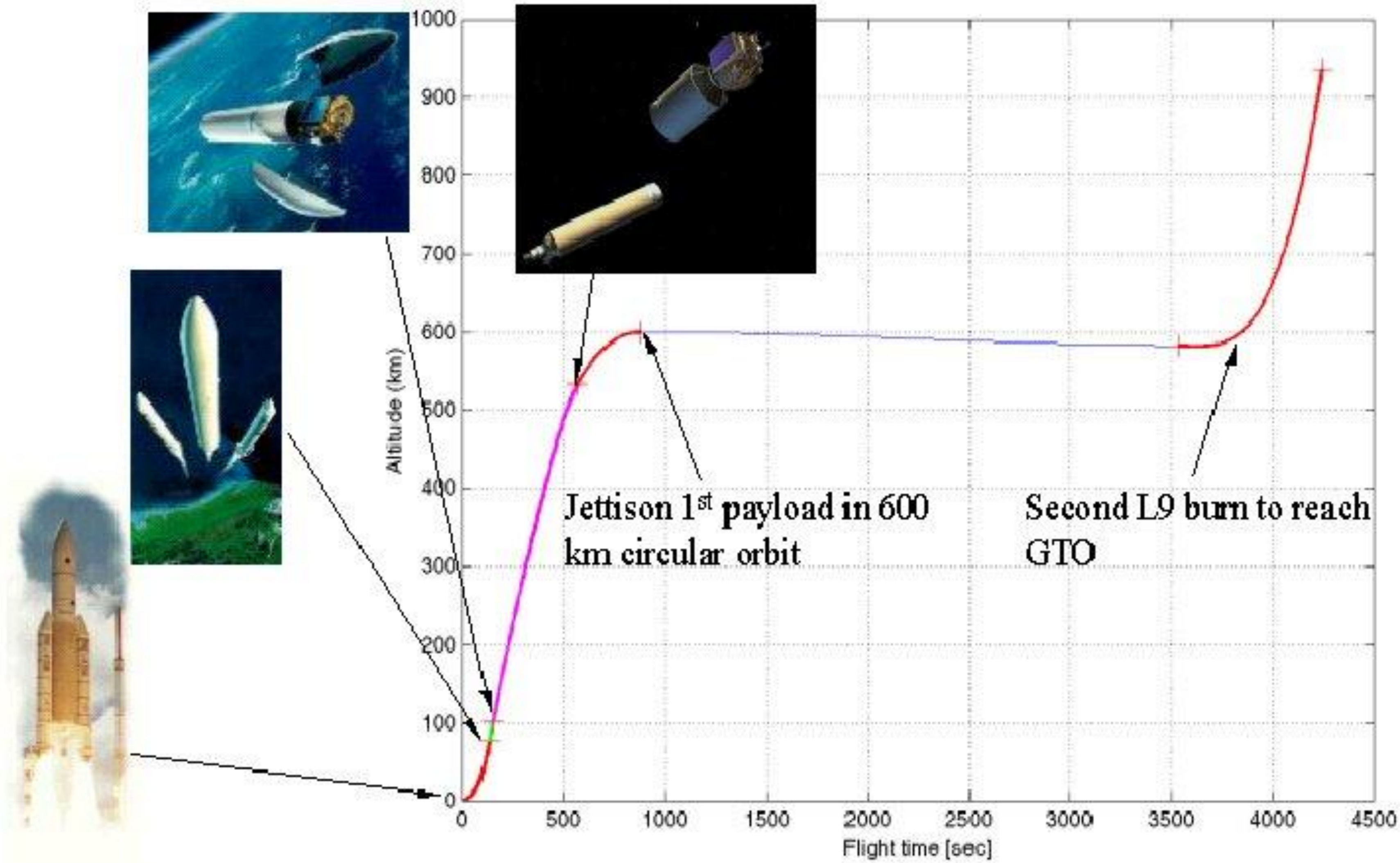
- Transformation of integer requirements to constraints

$$0 \leq x_j \leq u_j,\ x_j \in \mathbf{Z} \quad \Leftrightarrow \quad \prod_{i=1}^{\lfloor u_j \rfloor} (x_j - i) = 0$$

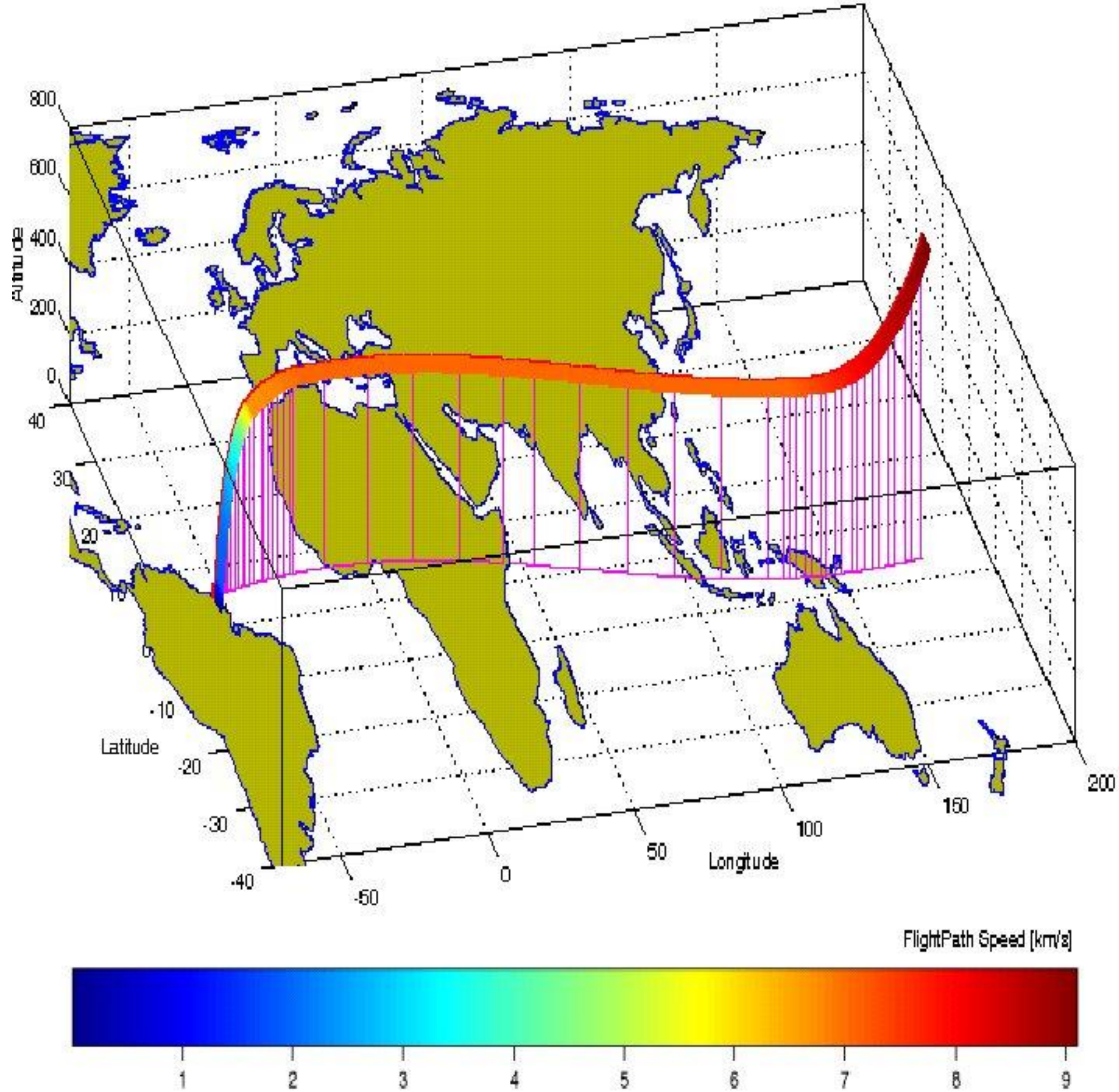
- Addition of Penalty Function

$$\begin{aligned} &\text{Minimize} && f(x) + \gamma \sum_{j=1}^{n} \prod_{i=1}^{\lfloor u_j \rfloor} (x_j - i) \\ &\text{subject to} && Ax = b \end{aligned}$$

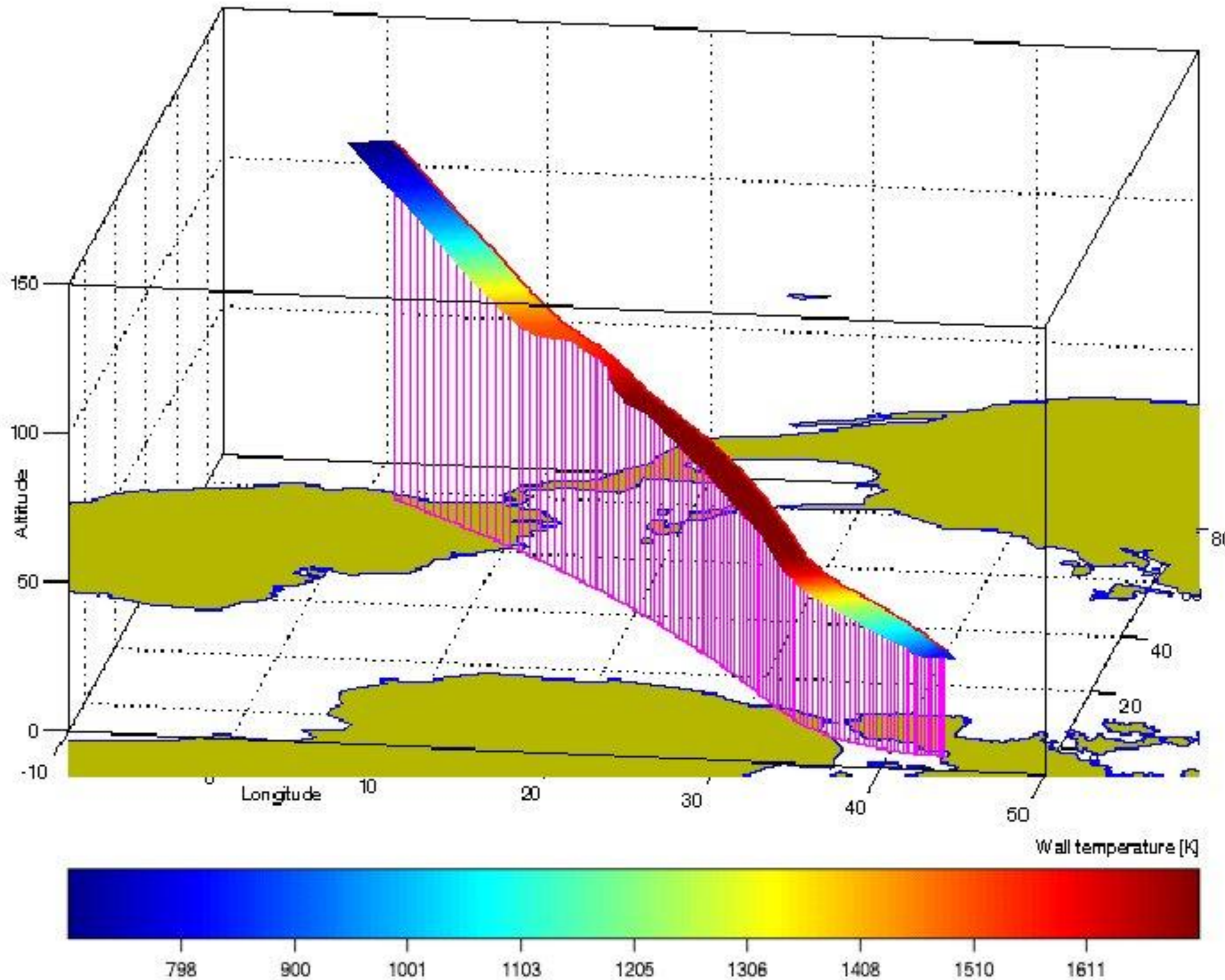
→ Need to find global optimizer of above problem



Phase Configuration Ariane 5 Ascent



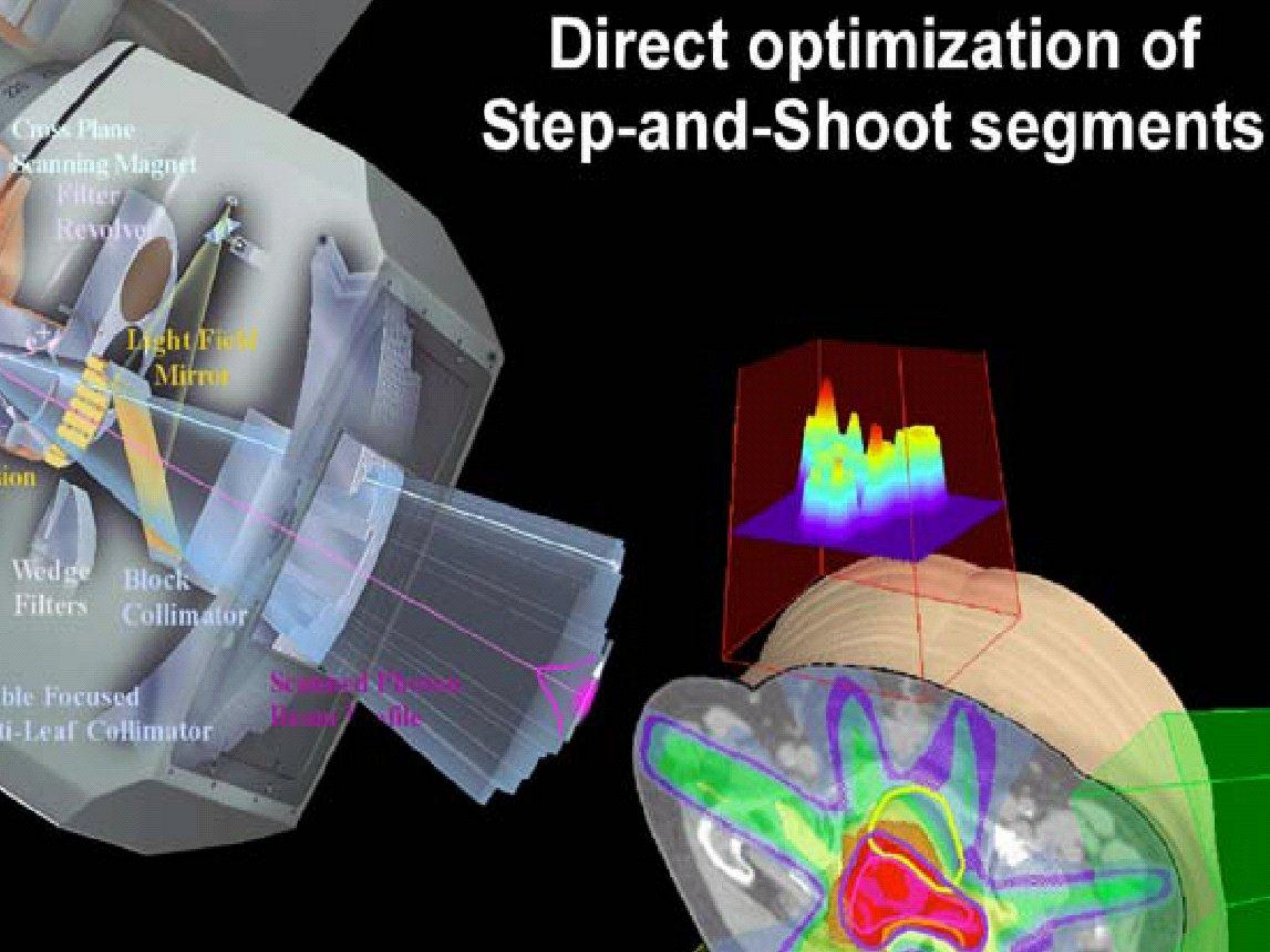
Conventional Launcher:
Ariane 5 Dual Payload LEO/GEO

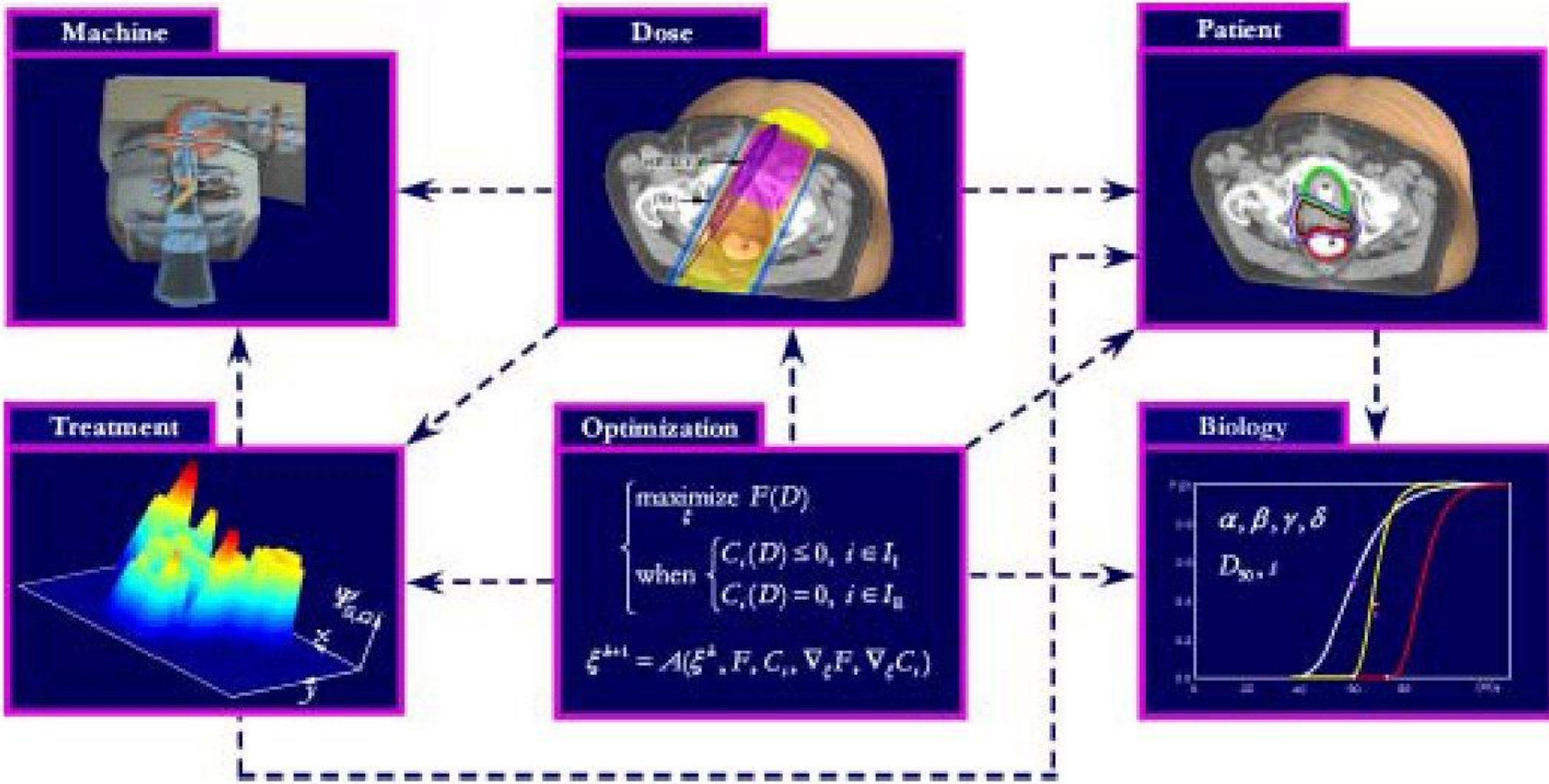


Reentry Application:

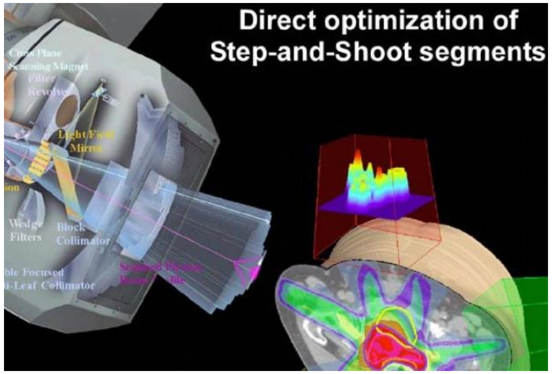
Hermes Reentry, maximum crossrange

Direct optimization of Step-and-Shoot segments

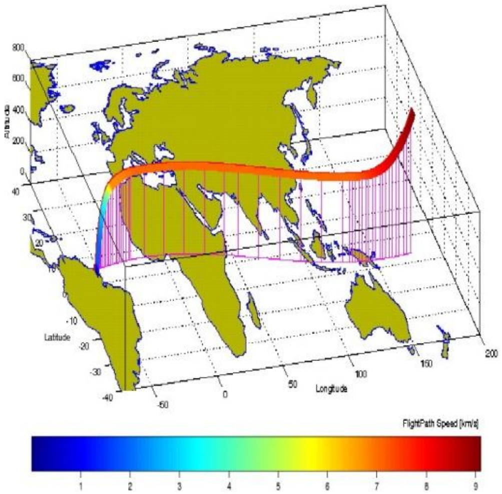



Machine
Dose
Patient
Treatment
Optimization
maximize F(D)
when
Biology

Numerical Optimization



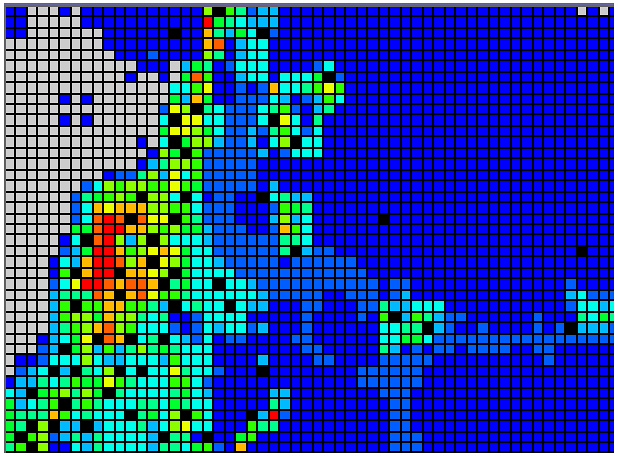
Radiating tumors



Conventional Launcher:
Ariane 5 Dual Payload LEO/GEO

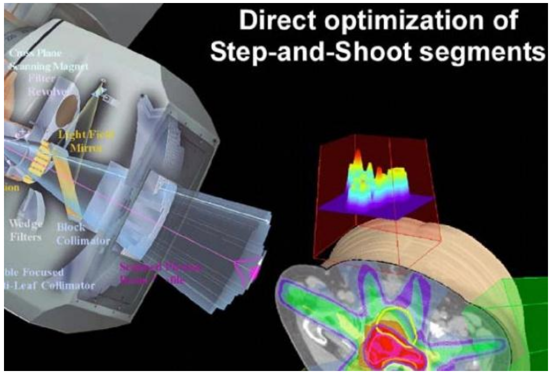
SNOPT
having an impact

Robot at JPL

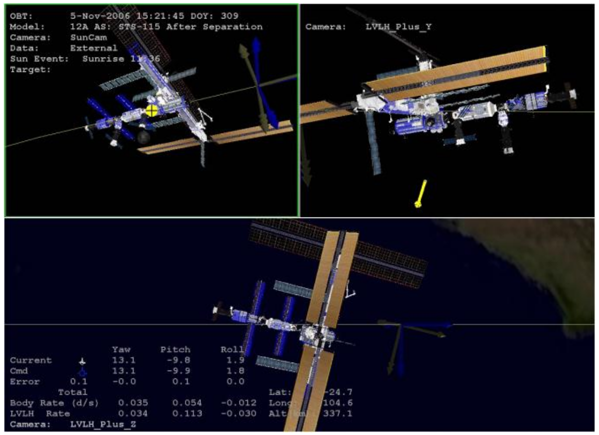


Facility location:
substations in a network

Numerical Optimization



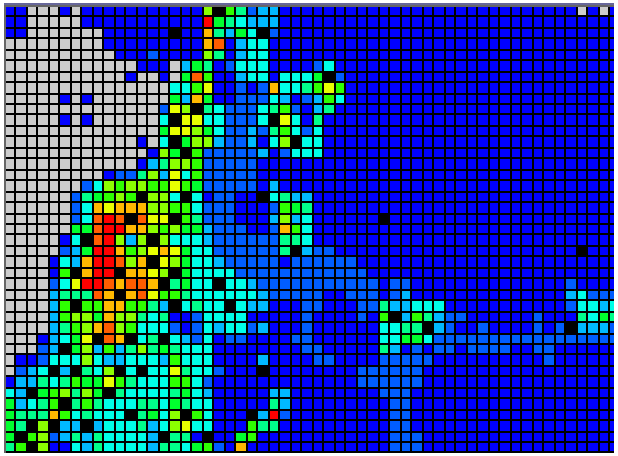
Radiating tumors



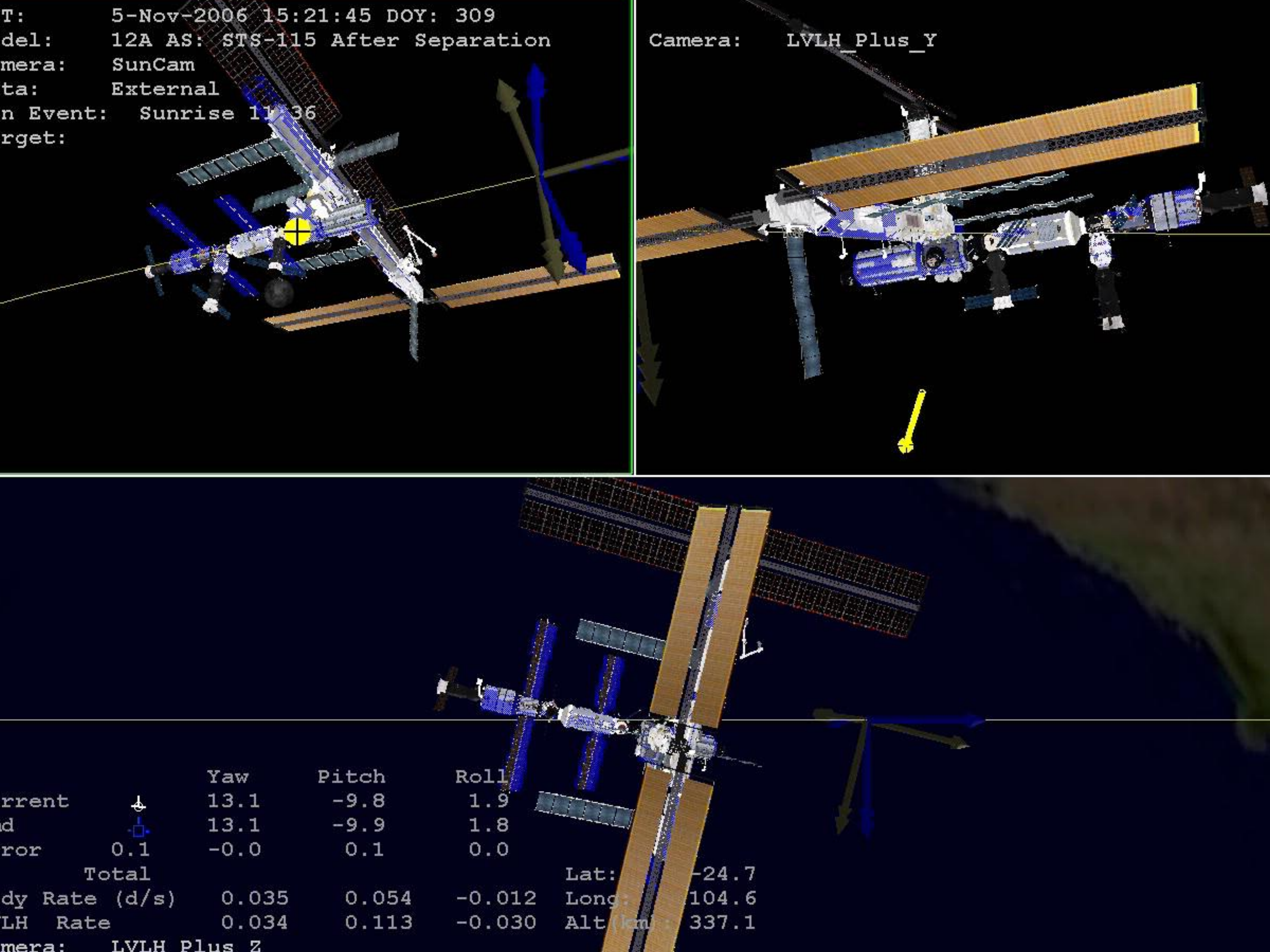
Repositioning the space station

SNOPT
having an impact

Robot at JPL



Facility location:
substations in a network


T: 5-Nov-2006 15:21:45 DOY: 309
del: 12A AS: STS-115 After Separation
mera: SunCam
ta: External
n Event: Sunrise 11:36
rget:
Camera: LVLH_Plus_Y
Yaw Pitch Roll
rrent 13.1 -9.8 1.9
d 13.1 -9.9 1.8
ror 0.1 -0.0 0.1 0.0
Total
dy Rate (d/s) 0.035 0.054 -0.012
LH Rate 0.034 0.113 -0.030
Lat: -24.7
Long: 104.6
Alt(km): 337.1
mera: LVLH_Plus_Z