‘Charybdis’ - The Next Generation of Ocean Colour and Biogeochemical Remote Sensing

Christopher Lowe

Small Satellite Conference, AIAA/Utah State University
Aug 13-16, 2012

INTRODUCTION

1. Introduction
2. Ocean Colour
3. Tidal Theory
4. Tidal Synchronism
5. Constellation Properties
6. Summary

" Tidal Lunar Day"

"Tidal Synchronous orbit"

OCEAN COLOUR

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- Ocean colour is related to many natural & man-made phenomena.
- Tidal influence stronger in coastal regions

NASA

There exists a lack of high temporal, high spatial resolution imagery of Coastal and inland waterways for the scientific community

TIDAL THEORY

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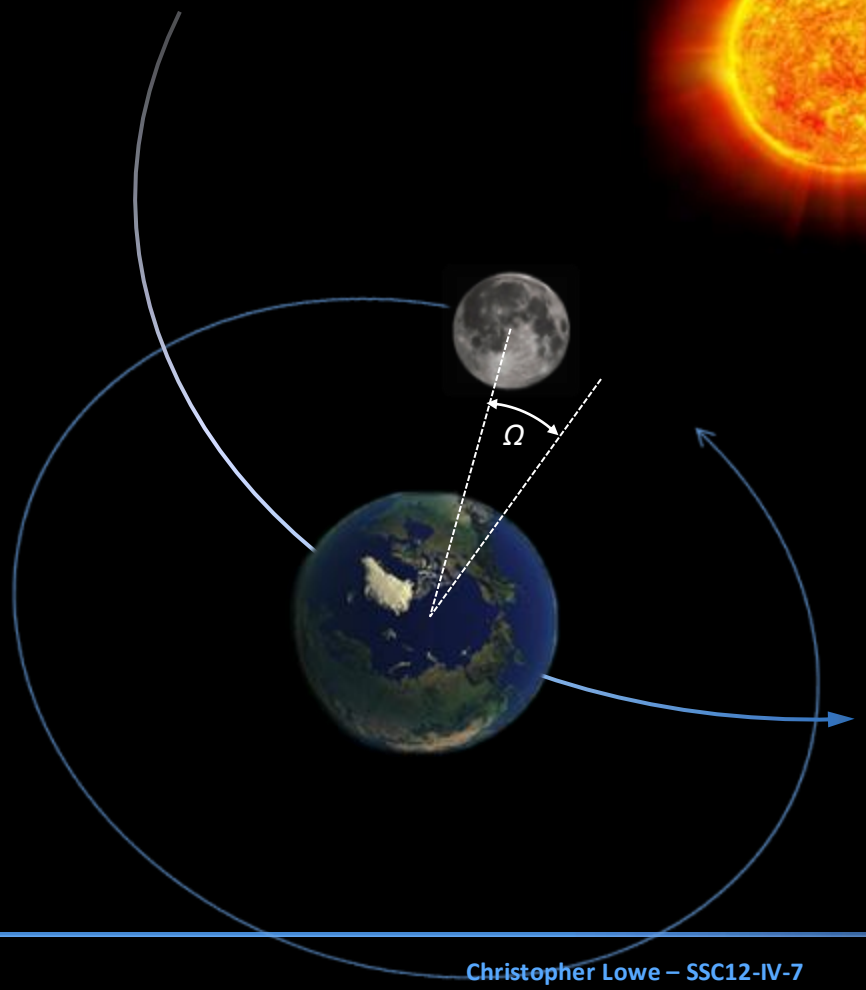

24.8412… hours
"Tidal Lunar Day" = τ_T

"Tidal Synchronous" = repetition of sub-satellite point after integer number of *Tidal Lunar Days*.

TIDAL SYNCHRONISM

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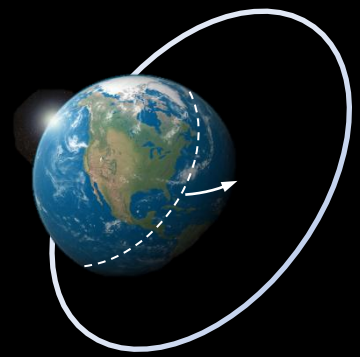

- Change in Right Ascension of Ascending Node ($\Delta\Omega$) required to satisfy Ω.
- Magnitude of $\Delta\Omega$ dependent on orbit parameters and No. τ_T before repeat.

No. τ_T before repeat SSP (m)	ΔRAAN ($\Delta\Omega$) per year	Achievable naturally?	Comment
N/A	*360*	*Yes*	*Sun-Synchronous*
57	**355.2**	**Yes**	**Almost Sun-Synchronous**

$$\Delta\varphi = \frac{-3\pi J_2 R^2 \cos i}{a^2(1-e^2)^2}$$ *(Change in RAAN over 1 orbit)*

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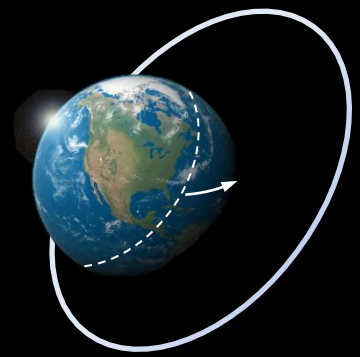

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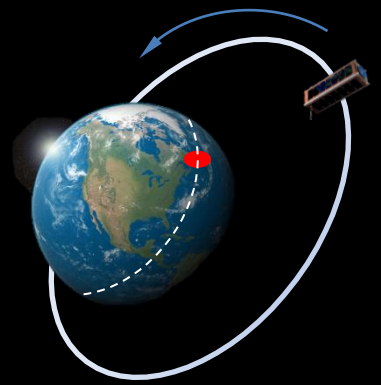

$$\tau = \frac{m\tau_T}{n}$$

$$a = \left[\mu\left(\frac{\tau}{2\pi}\right)^2\right]^{1/3}$$

$$e = ?$$

$$\Delta\varphi = \frac{2\pi\tau}{\tau_T}\left(\frac{\zeta}{m} - \frac{\tau_T}{\tau_E}\right)$$

$$\zeta = \left\lfloor \frac{m\tau_T}{\tau_E} + 0.5 \right\rfloor$$

Where;

m = No. TLDs before repeated sub-satellite point.

n = No. complete Satellite orbits in period '$m\ \tau_T$'

ζ = Nearest No. Sidereal Days in period '$m\ \tau_T$'

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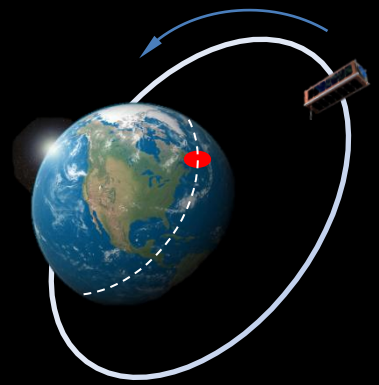

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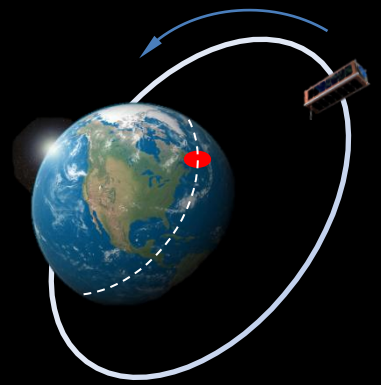

$$i = \cos^{-1}\left[\frac{-\Delta\varphi a^2(1-e^2)^2}{3\pi J_2 R^2}\right]$$

$$\Omega, \omega \;\&\; \nu = ?$$

Where;

p = No. Earth rotations (wrt S/C orbit) before repeated sub-satellite point

q = No. Satellite orbits before repeated sub-satellite point

Further restrict definition of '*n*':

$$n = \frac{q\zeta}{p} \in \mathbb{Z}$$

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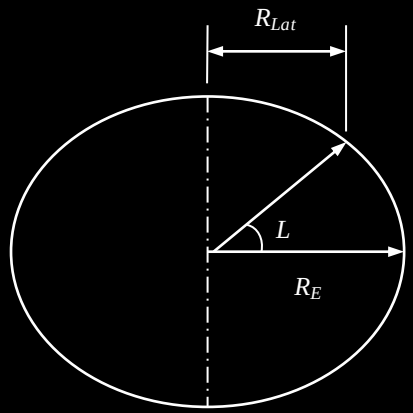

$$N_{S/C} = \left[\frac{2\pi \cos L \sqrt{\dfrac{{R_E}^2}{1 + \sin L \left[\dfrac{1}{(1-f)^2} - 1\right]}} \sin\left(\dfrac{\pi}{2} - \sin^{-1}\left(\dfrac{\cos i}{\cos L}\right)\right)}{w\left(\dfrac{n\tau_E}{m\tau_T} - \cos\left(\dfrac{\pi}{2} - \sin^{-1}\left(\dfrac{\cos i}{\cos L}\right)\right)\right)} \right]$$

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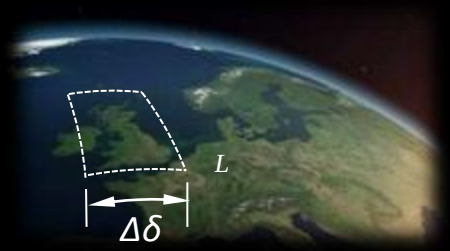

$$N_{S/C} = \left\lceil \frac{R_{Lat} \sin \alpha \, \Delta\delta}{w} \right\rceil$$

Mission	*m*	*n*	*w (km)*	*L* (°)	Alt (km)	Coverage	S/C per plane	*p*	*q*
A	57	860	122.4	0	707.8	Global	23	-	-
B	57	885	122.4	50	573.9	Regional (UK)	6	1	15

SUMMARY

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1. Lack of high temporal and high spatial resolution information on coastal areas.
2. Tidal synchronous orbits could enhance information on ocean colour.
3. Many tidal synchronous orbit options exist, depending on altitude, inclination and eccentricity combinations.
4. Tidal synchronism can be determined from just two parameters (m & n), with further restrictions from two more (p & q).
5. Analytical solutions to global/regional coverage presented.
6. Two potential missions presented:
   A. Daily global coverage at alt 708km using 23 sat/plane.
   B. Daily regional (UK) coverage at alt 573km with 6 sat/plane

Thank You