

# **SOLAR ELECTRIC PROPULSION (SEP) FOR EXPLORATION: LESSONS FROM THE GLOBAL ECONOMY**

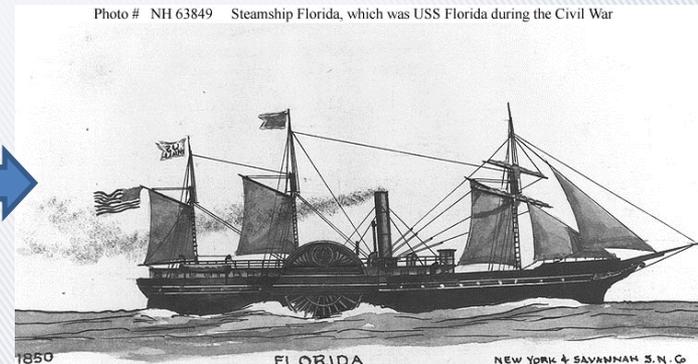
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# EVOLUTION OF THE GLOBAL ECONOMY

- 1600's to 1800's –Sailing Ships, Horses, Wagons, Barrels
- 1800's to 1900's – Age of Sail replaced by Steamships, Railroads
- Mid 1900's to present – Intermodal Freight



- Transportation costs are now reduced to the point where fish caught in Scotland are shipped to China for filleting
- The cost to ship a sweater 3000 miles is 2.5 cents
- A can of beer shipped that same 3000 miles is one penny
- Railroads move one ton of freight an average of 425 miles on a single gallon of fuel (425 ton-miles/gallon)
- Container ships move one ton of freight more than 1100 miles on a single gallon of fuel (1100 ton-miles/gal)
- There are 20 million shipping containers in service on 6000 container ships

## WHAT DOES IT TAKE?

- A networked and interconnected use of various means of transportation: Intermodal shipping
- in•ter•mo•dal — *adj.*  
The transfer of products involving multiple modes of transportation — truck, railroad or ocean carrier.



## PORT OF LONG BEACH, CA

- Infrastructure to allow ease of intermodality is the other key

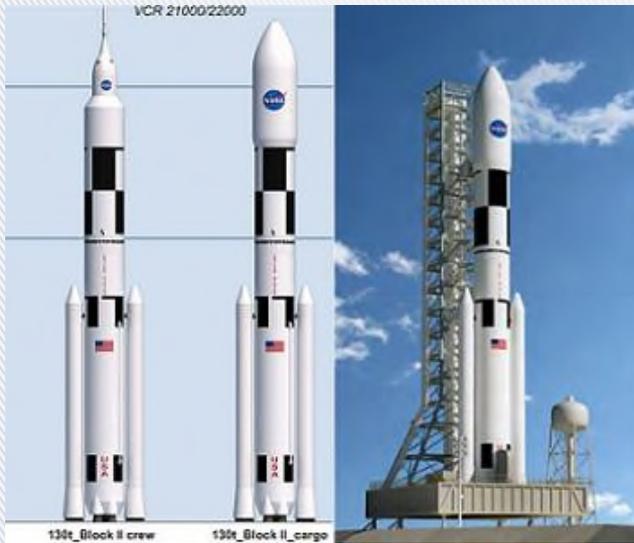


## HOW DOES THAT RELATE TO EXPLORATION?

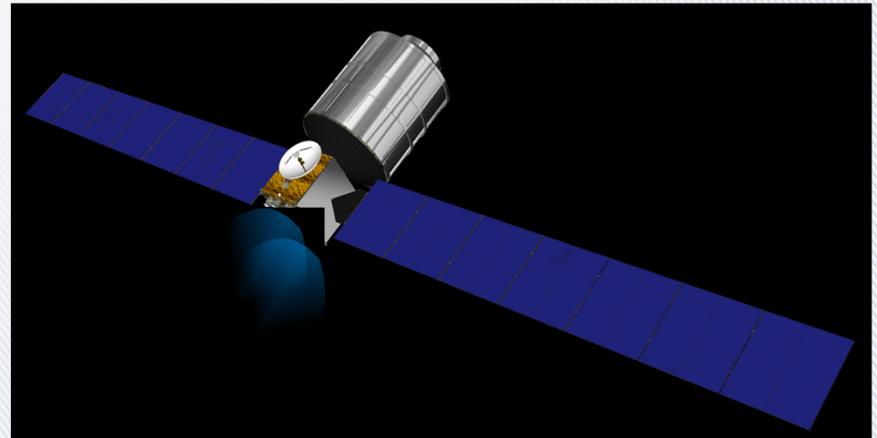
- “We have a long way to go in the space race. We started late. But this is the new ocean, and I believe the United States must sail on it and be in a position second to none”. - JFK, 1961
- The further we go into space, the more important it is to have true space ships – Heinlein got it wrong.
- We need to maximize the amount of useful mass we take into space at the cost of \$20,000 / kg.



# NEW SHIPS FOR THE NEW OCEAN



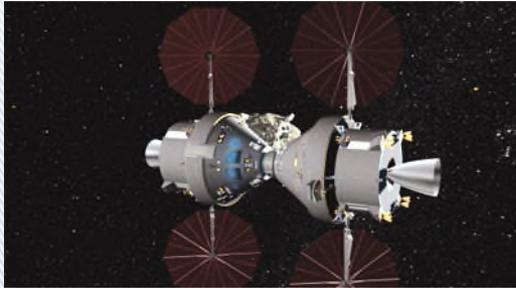
Heavy Lift Launch



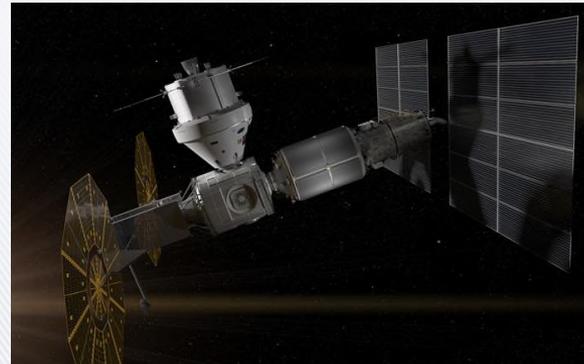
Solar Electric Propulsion Module

***THE INTERMODAL TRANSPORTATION SYSTEM FOR DEEP SPACE***

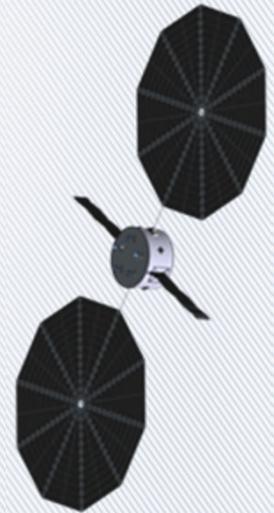
# WHAT WILL OUR DEEP SPACE INFRASTRUCTURE LOOK LIKE?



Orion Crew Vehicles



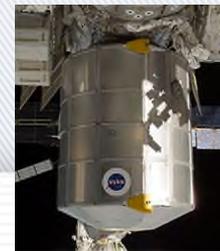
Deep Space Habitat



SEP Module (cargo)



SLS Heavy Lift Launch



Cargo modules or habs (Cygnus or MPLM)

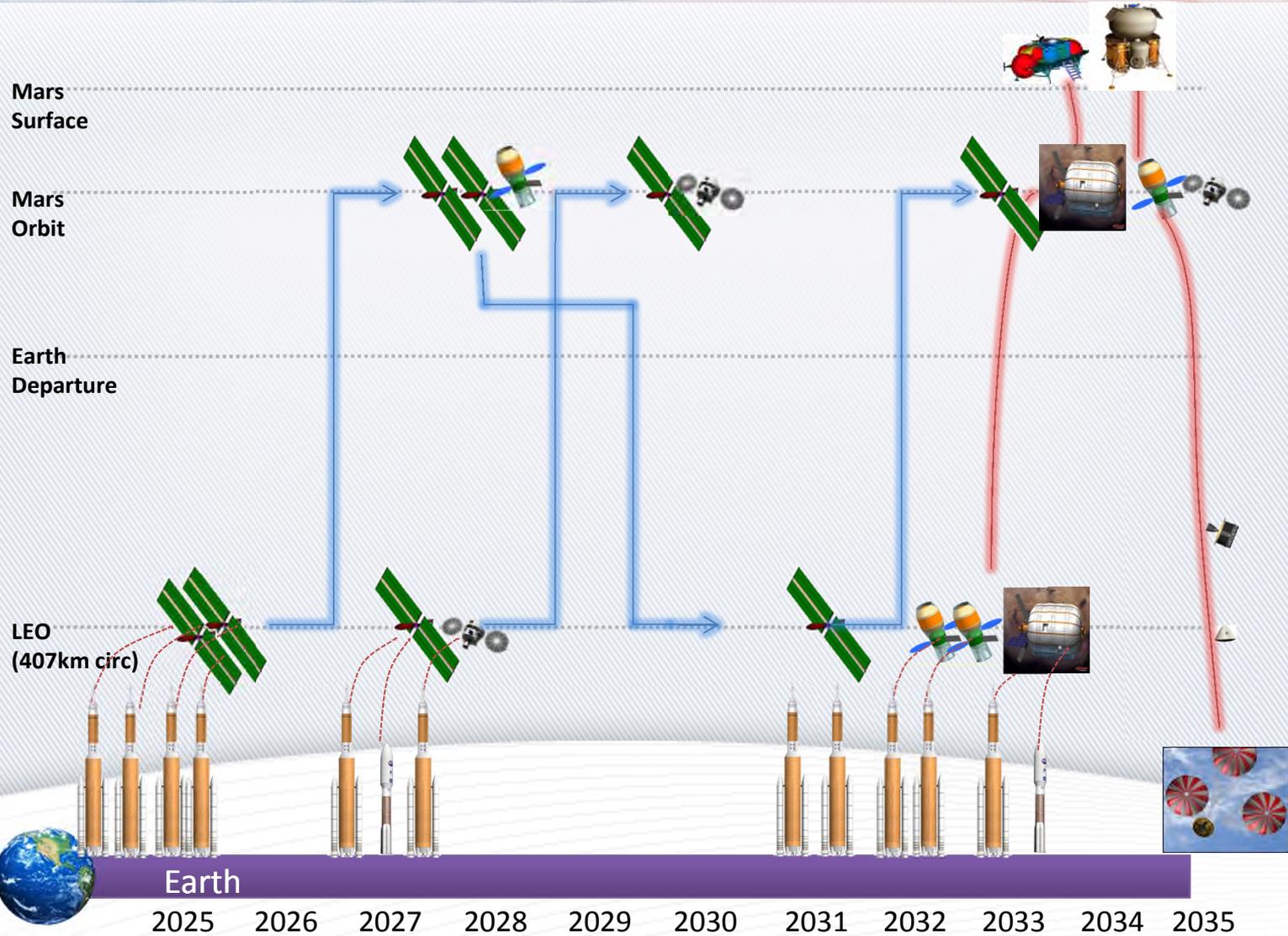
## CONCLUSIONS

- Reducing the cost through modularity and economies of scale is the key to achieving human exploration of deep space
- Use of SEP for cargo transportation reduces the IMLEO required for a human Mars mission by over 50%
- IMLEO (mass raised from Earth to orbit) has been shown to be the largest single influence on mission cost
- Coupling the capabilities of the SLS with SEP provides unique advantages

***USE OF MULTIPLE TRANSPORTATION MODES WILL OPEN UP DEEP SPACE  
JUST AS INTERMODAL SHIPPING HAS OPENED UP THE GLOBAL ECONOMY***

# Back Up Charts

# NOTIONAL MARS LANDING CAMPAIGN



# IMPACT OF IN-SPACE TRANSPORTATION ON IMLEO

