



# Exploring the Boundaries of Art, Design, Aerospace Engineering & Popular Culture

**Aldo Spadoni**

President – Aerospace Imagineering  
Former Manager - Engineering Visualization  
Northrop Grumman Aerospace Systems

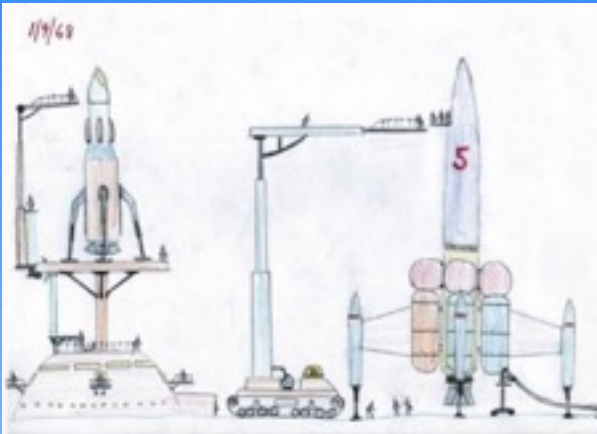
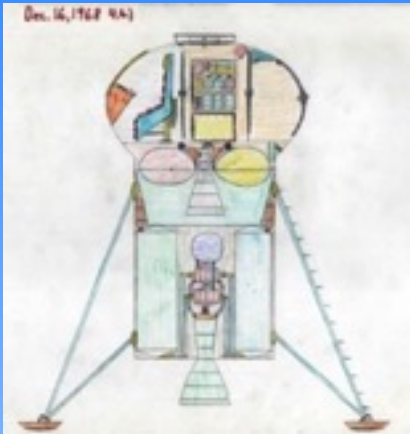
October 17, 2018





- **Brief Bio**
- **Aerospace Engineering & Art**
- **Aerospace & Entertainment**
- **Public Outreach**
- **STEM/STEAM Education**

# Early Artwork & Influences



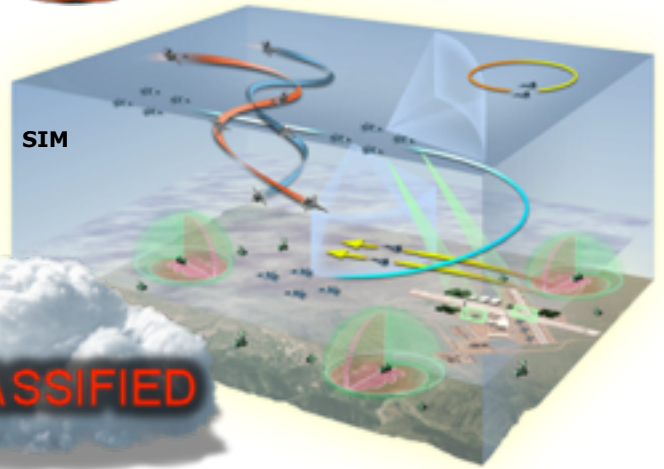
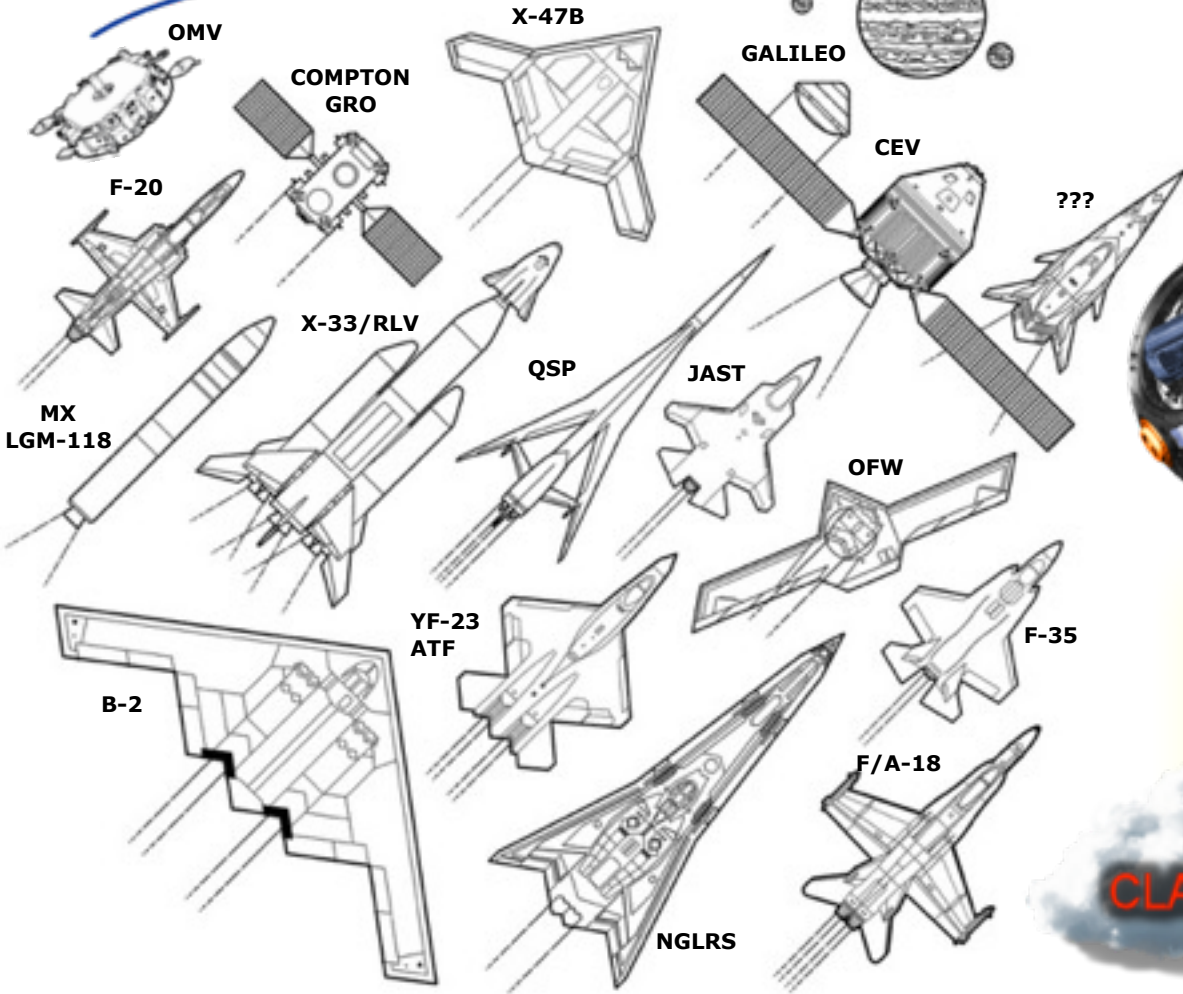
## John Glenn 1962







STRUCTURAL DESIGN  
MASS PROPERTIES ANALYSIS  
NAVIGATION SYSTEMS ENGINEERING  
ATTITUDE CONTROL SYSTEMS  
CONFIGURATION DESIGN & INTEGRATION  
SYSTEMS ANALYSIS & SIMULATION



**CLASSIFIED**



**Northrop  
Grumman  
Engineering  
Visualization  
Resource  
(EVR)**

**YF-23 ATF**



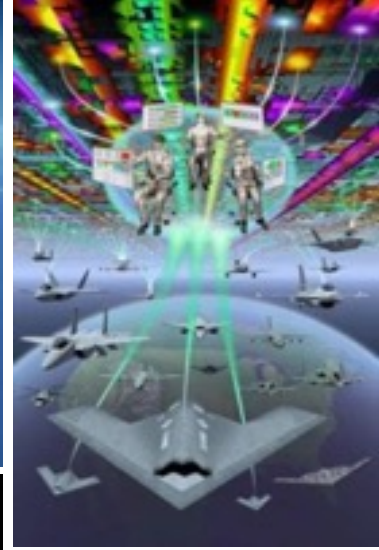
**Del Jacobs**



*Nov 71. Lt/Col Del Jacobs  
Ready for 168<sup>th</sup> Combat  
MISSION.(F-4E fighter)  
Da Nang Air Base  
S. Vietnam*







**Northrop Grumman**



**EVR**





Northrop Grumman

**EVR**





# CONOPS OV-1 Visualization





**Space Exploration Poster (2004)**  
**Scott Seymour – NGIS VP & GM**

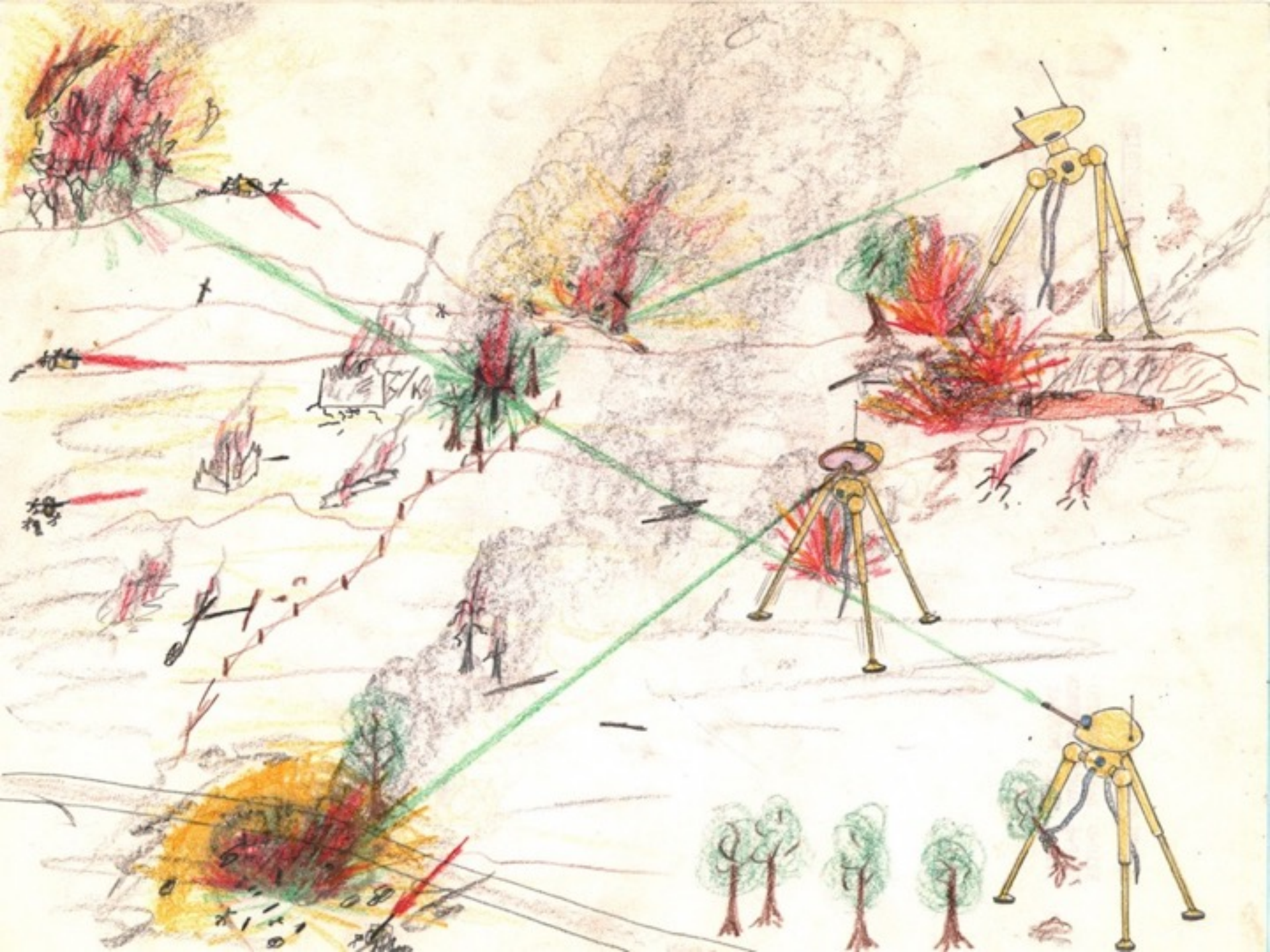




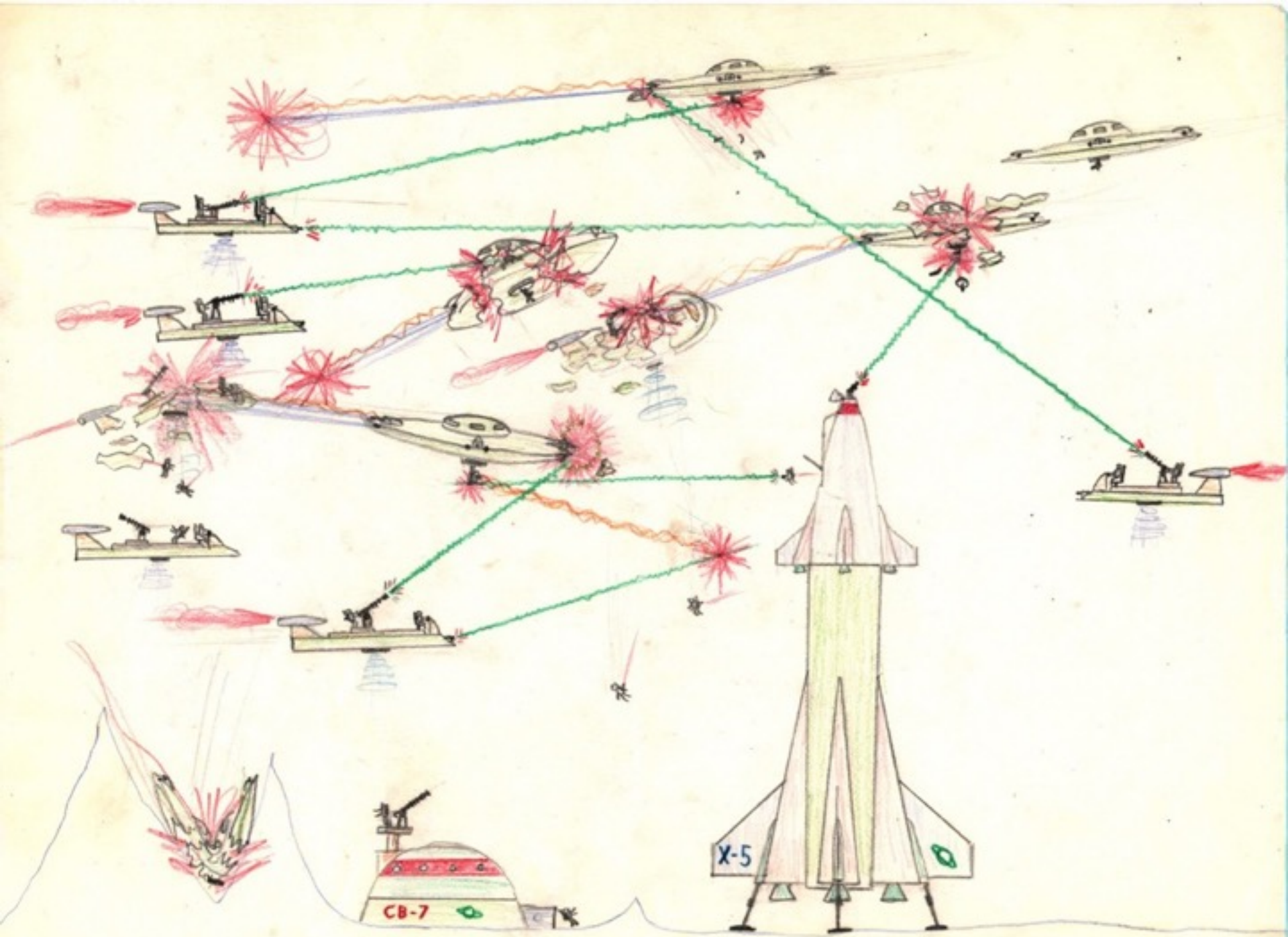
**Space Exploration Poster (2004)**  
**Scott Seymour – NGIS VP & GM**















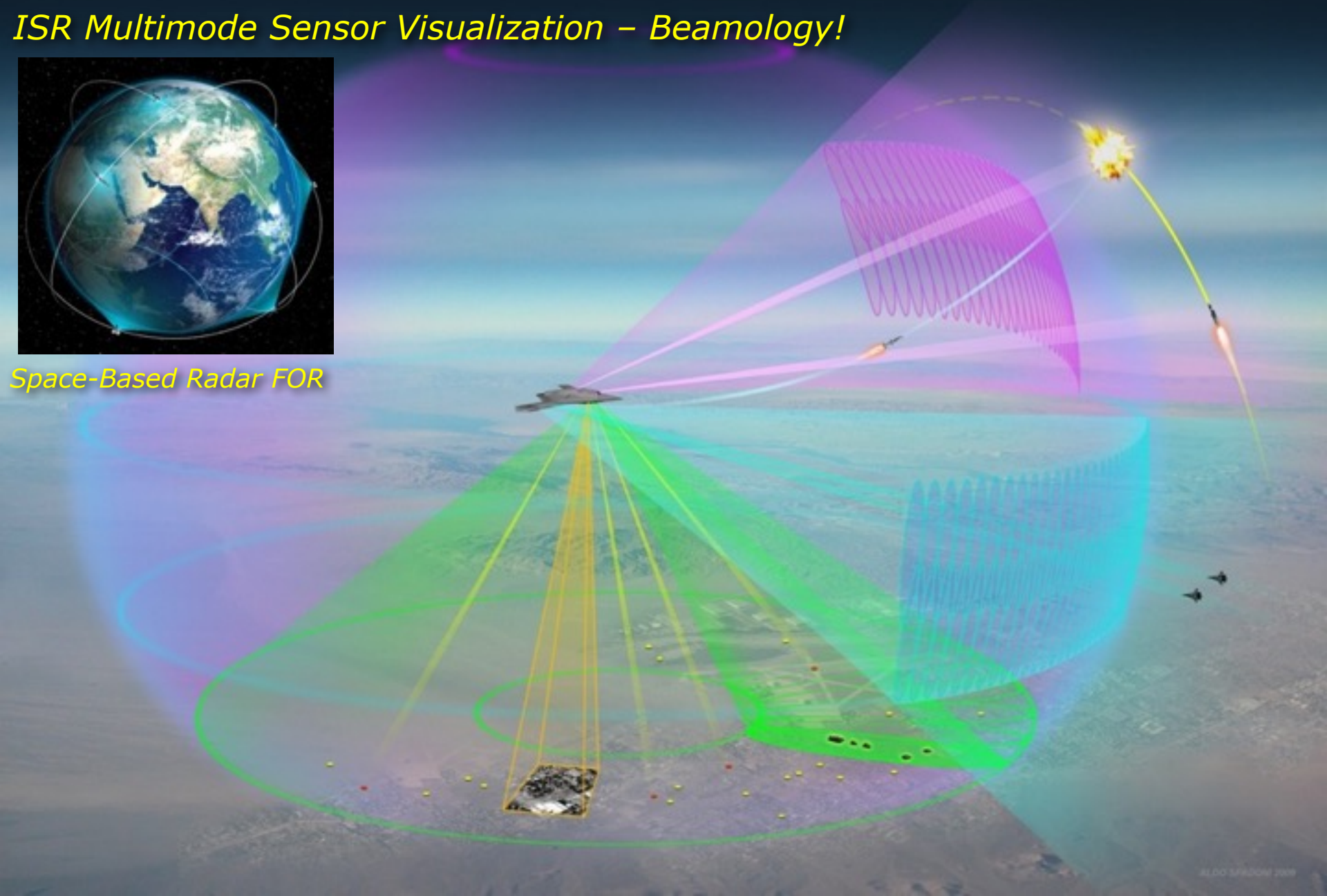




# ISR Multimode Sensor Visualization – Beamology!



Space-Based Radar FOR







**STEP 1: FUSELAGE ASSEMBLY**

- Assemble structural main frame
- Install skins
- Seal fuel tank (fillet and dome seals)

A 3D model of an aircraft fuselage assembly. The model is shown in a perspective view, with a person standing next to it. Two other people are standing in front of the model, one pointing at it. The model is surrounded by a railing and a staircase.

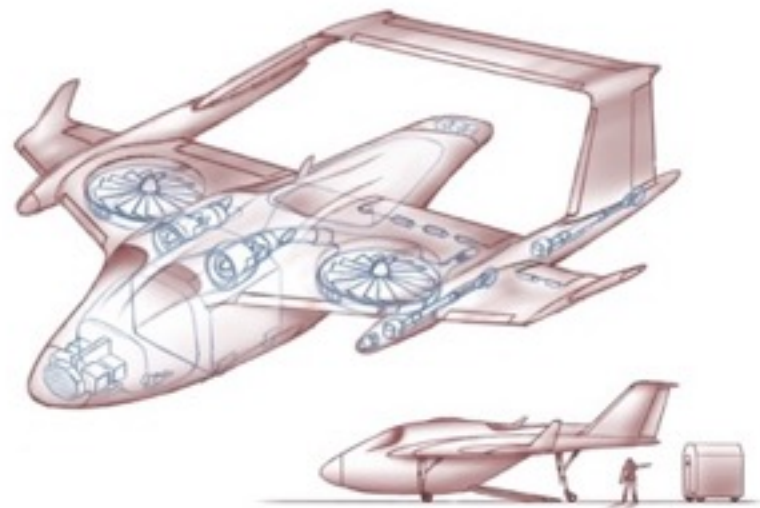
Three people are interacting with a large, glowing blue table. The table displays a 3D model of an aircraft fuselage and various components. The man on the left is wearing a white and black striped shirt. The man in the middle is wearing a white shirt. The man on the right is wearing an orange and white striped shirt. The table is surrounded by a railing and a staircase. The background shows a globe with glowing lines and a person working at a computer workstation.

AFRICA  
SOUTH AMERICA

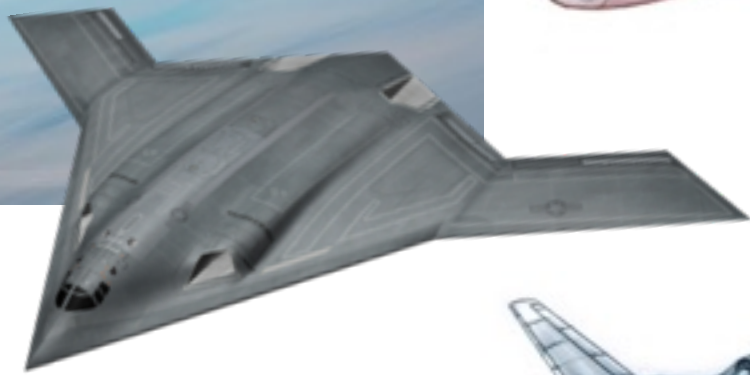


Northrop Grumman

# EVR



“Artist Concept”



FUTURE AIR DOMINANCE



Aldo Spadoni 2013

RIA Concepts



A. SPADONI '08

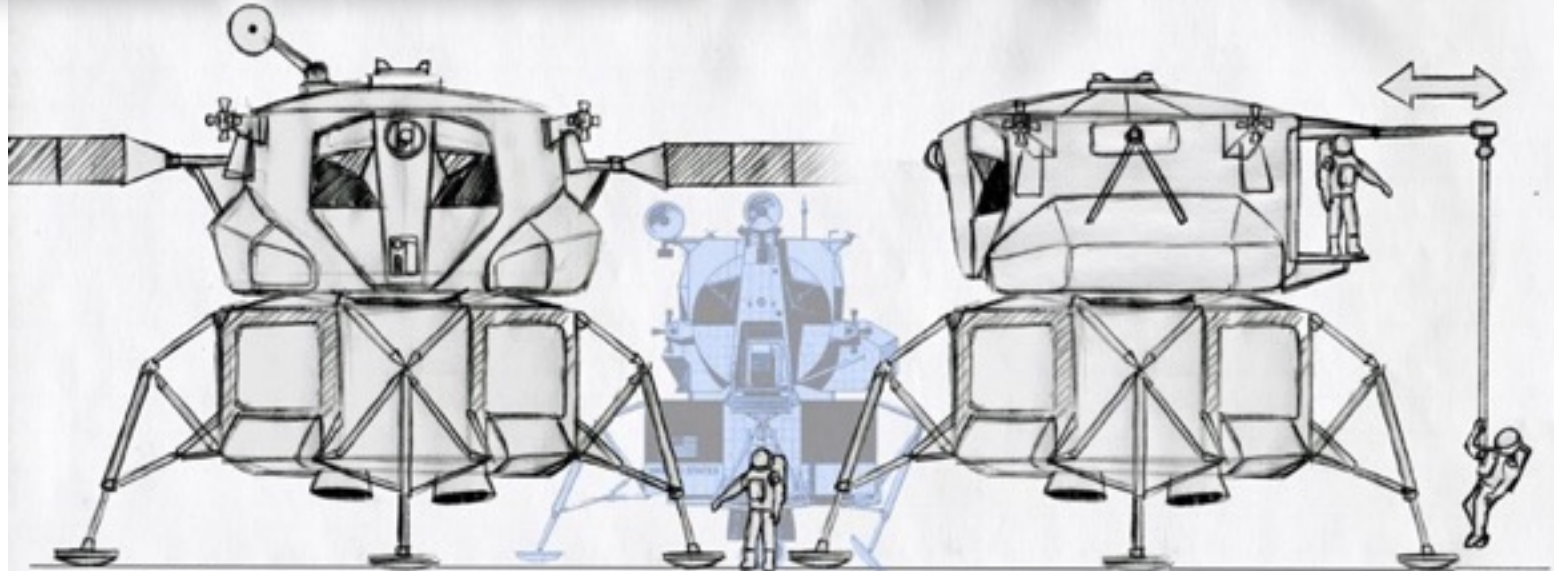
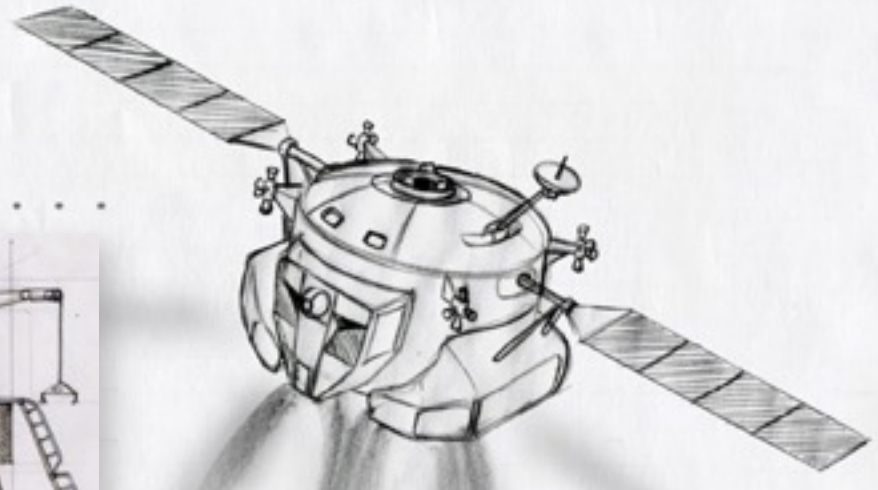
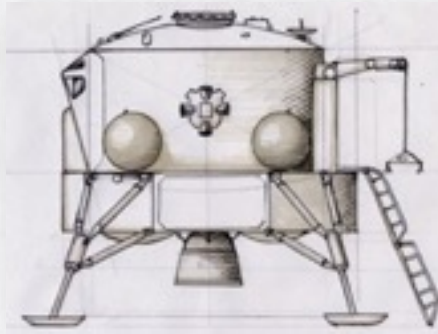
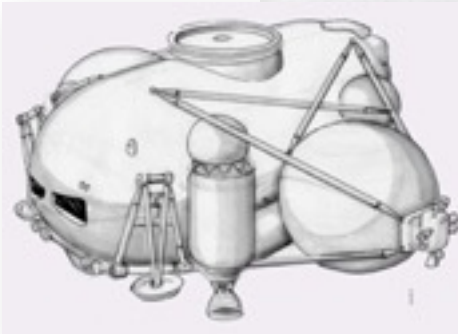






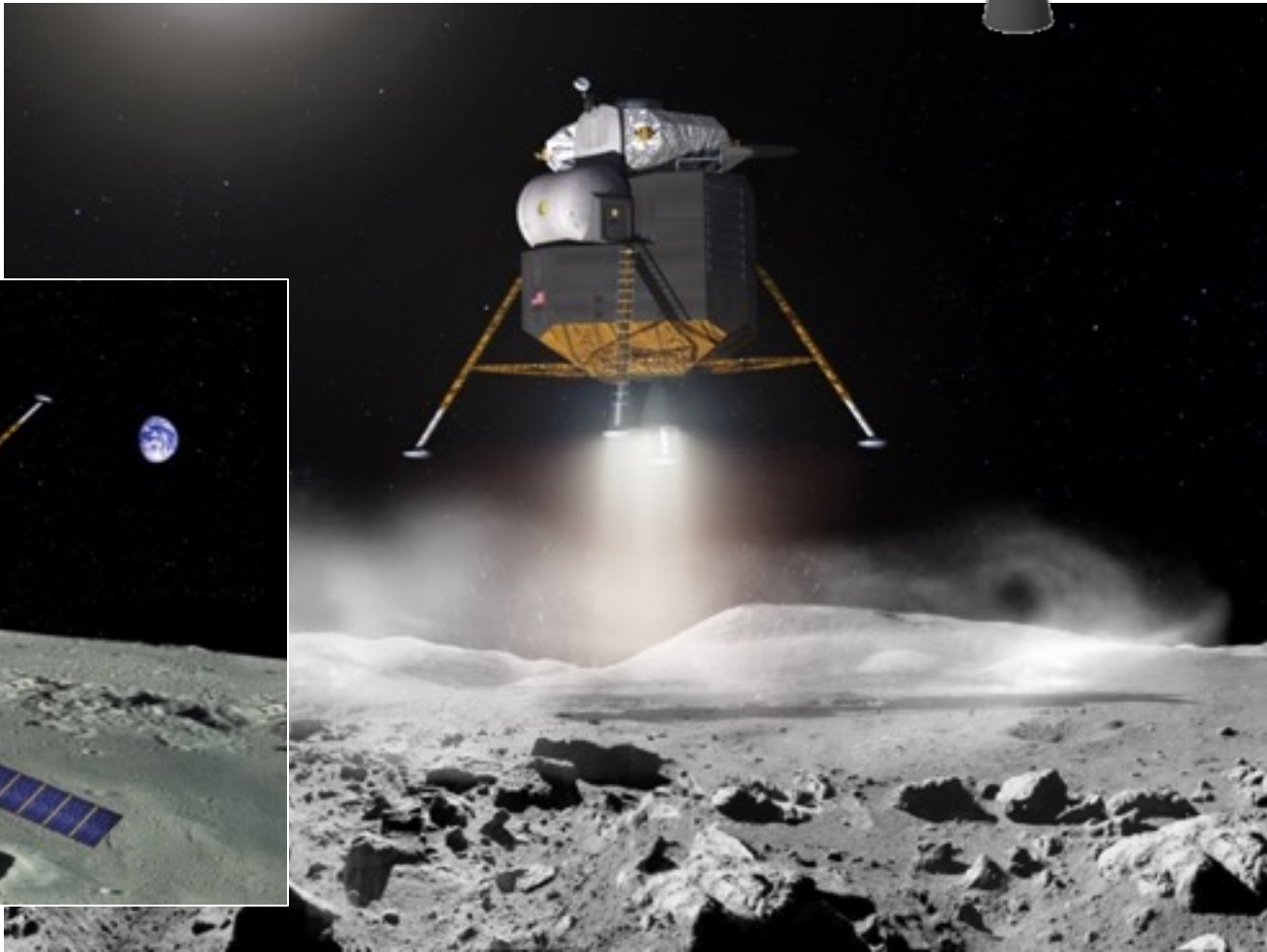
# Early LSAM "Altair" Lunar Lander Concepts NASA Constellation Program

"Super LM"  
LSAM Configuration . . .



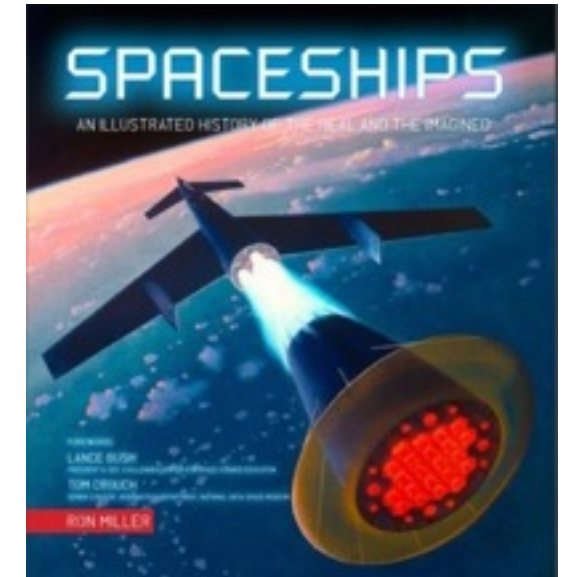
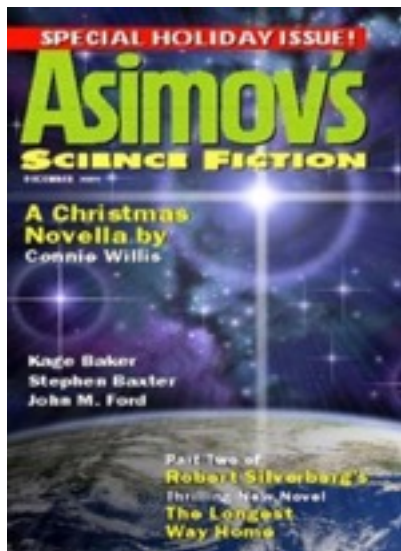
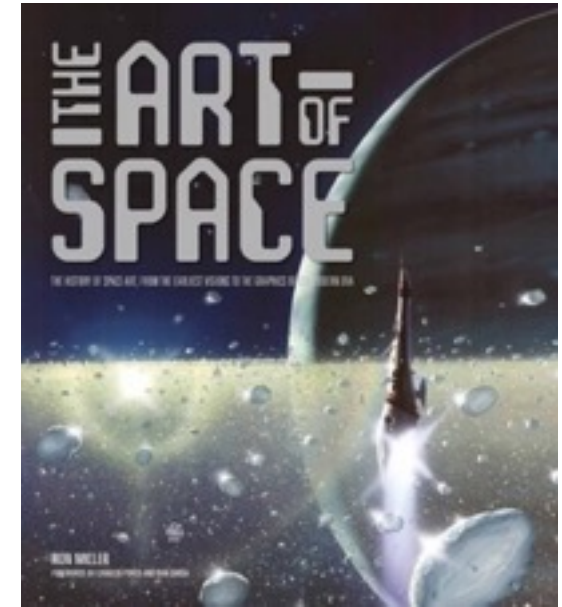


# “Altair” Lunar Surface Access Module (LSAM) (2006)





## MAGAZINES & PUBLICATIONS





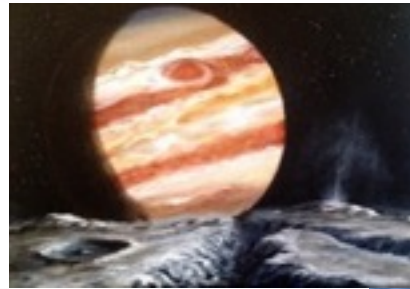
Robert McCall



Don Dixon



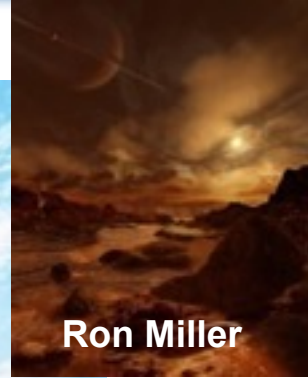
Michael Carroll



Pamela Lee



Ron Miller



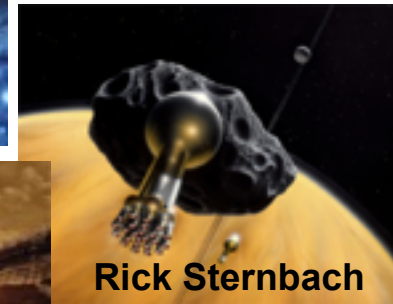
Alan Bean



Don Davis



Lucy West



Rick Sternbach



Marilynn Flynn



William Hartmann



David A. Hardy



Simon Kregar



Ron Garan

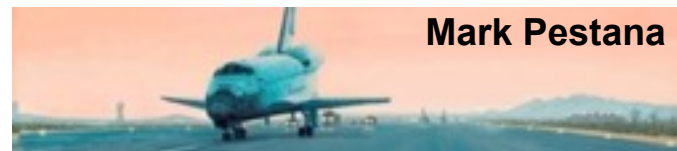


Nicole Stott

Dan Durda



Mark Pestana

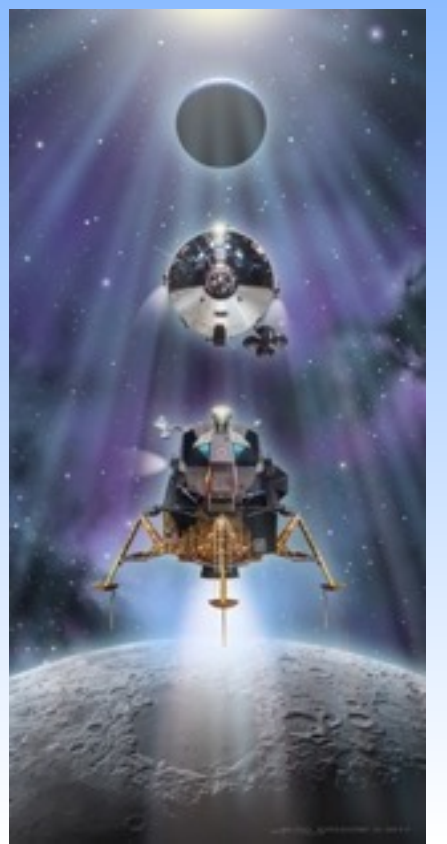


MANY OTHER ARTISTS!

Pat Rawlings









# AEROSPACE IMAGINEERING





# Finding A Balance . . . Dream Aircraft Designs by C. W. Miller

## IDEAL PLANES

Or what can happen if one of the team gets all their own way!



Equipment Group



Electrical Group



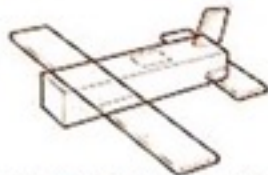
Hydraulics Group



Aerodynamics Group



Weight Group



Computer Aided Design Group



Stress Group



Empennage Group



Production Engineering Group



Armament Group



Wing Group



Fuselage Group



Mechanical Controls Group



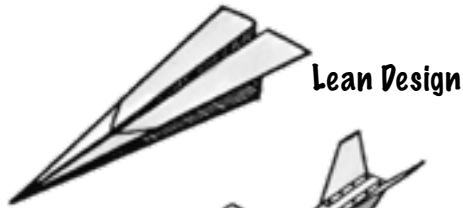
Power Plant Group



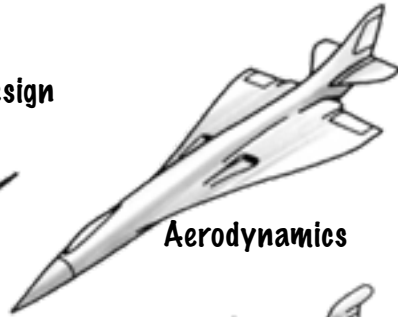
Service Group



# Finding A Balance . . . Dream Aircraft Designs:



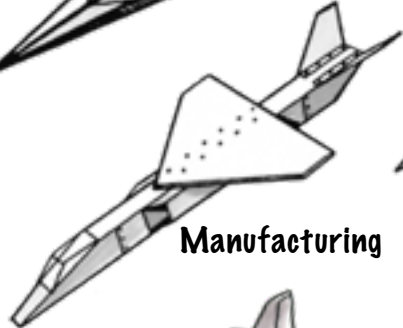
Lean Design



Aerodynamics



Maximum Aircrew Visibility



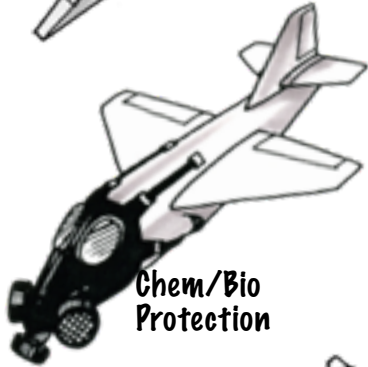
Manufacturing



Maximum Stealth



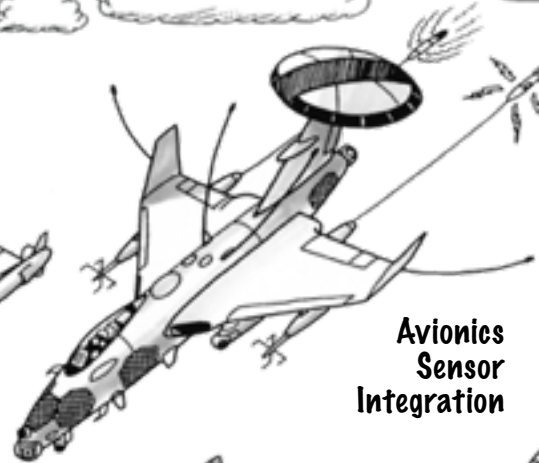
Maximum ECM



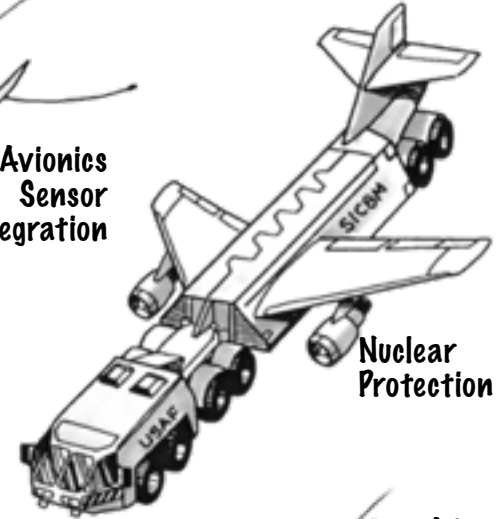
Chem/Bio Protection



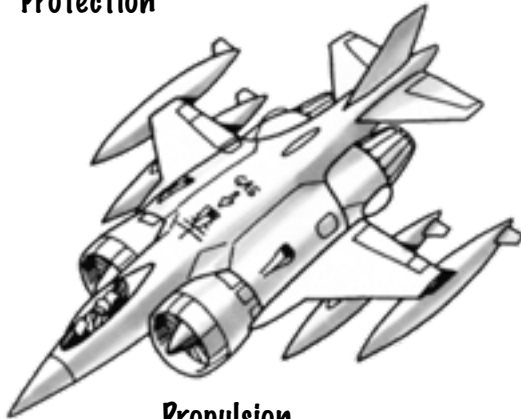
Weapons Integration



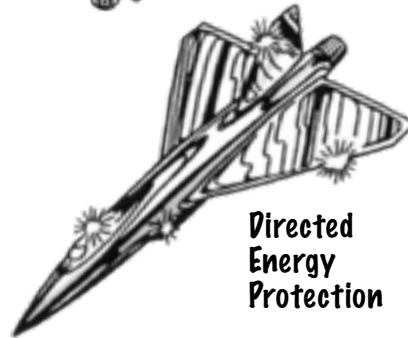
Avionics Sensor Integration



Nuclear Protection



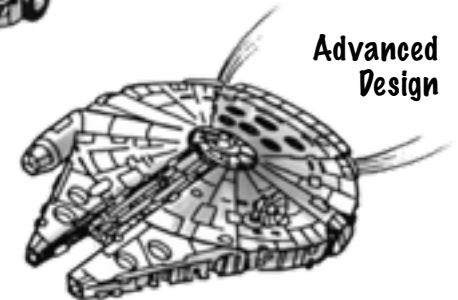
Propulsion



Directed Energy Protection



Ballistic Protection

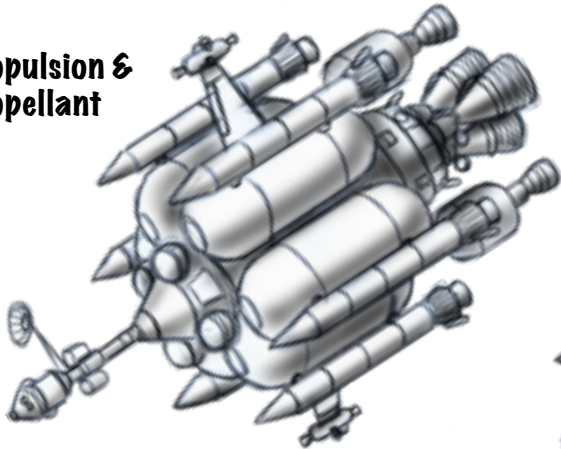


Advanced Design

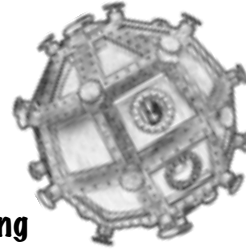


# Finding A Balance . . . Dream Spaceship Designs:

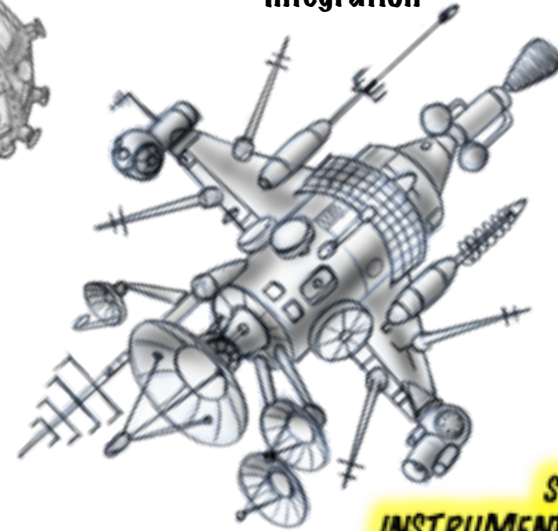
**Propulsion & Propellant**



**Structural Design & Manufacturing**

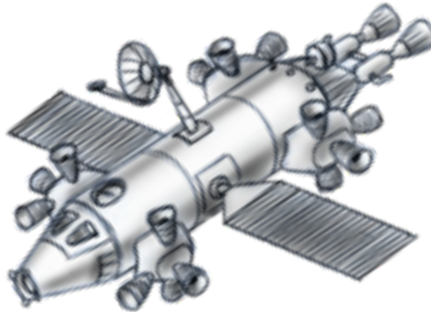


**Comms, Sensors & Electromagnetic Integration**

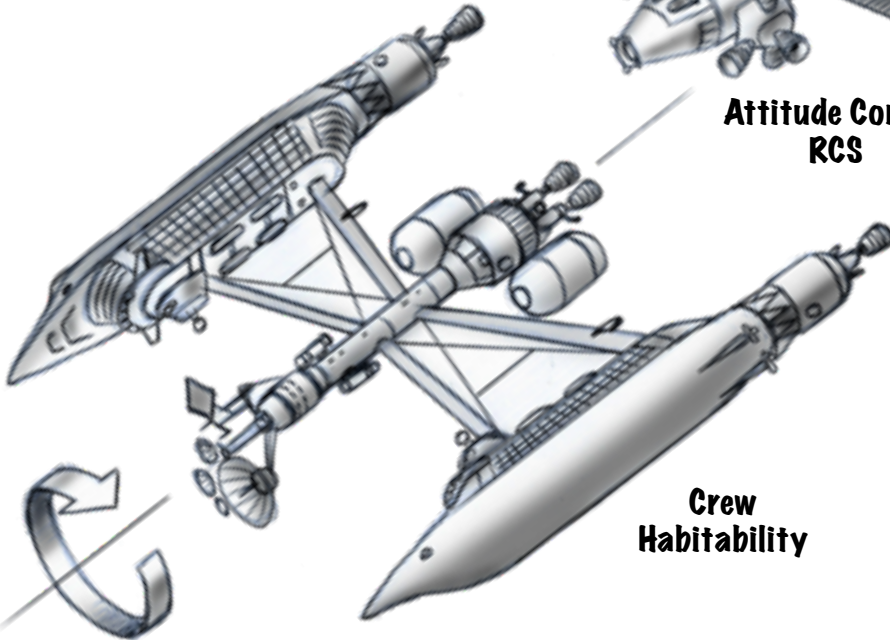


**SCIENCE INSTRUMENTATION**

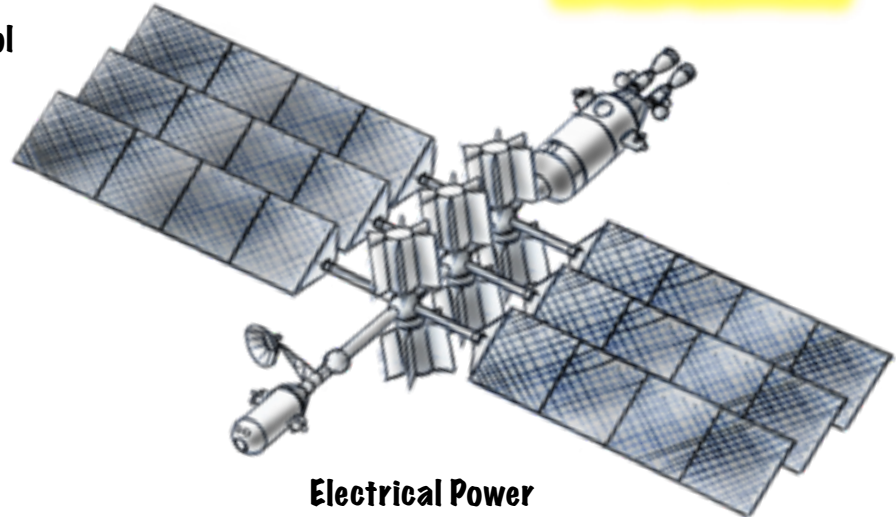
**Attitude Control RCS**



**Crew Habitability**



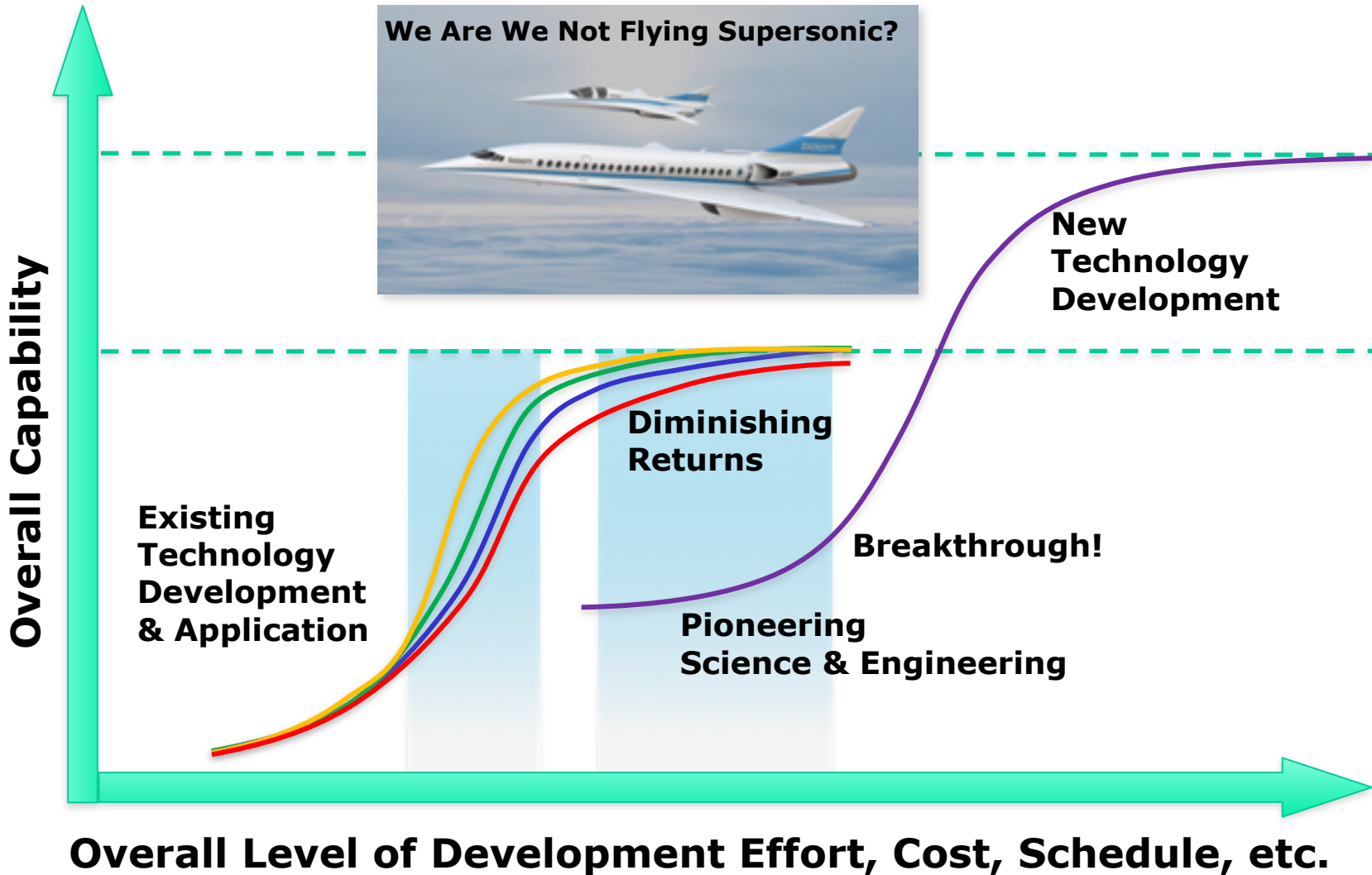
**Electrical Power**







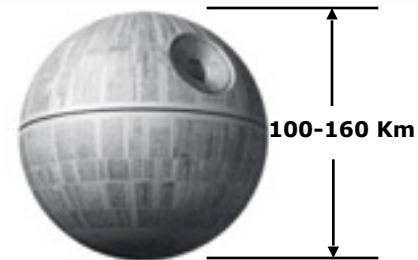
# Finding A Balance . . . The Knee of the Curve! Kinetic vs Non-Kinetic



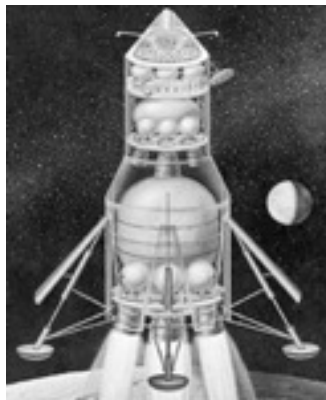


# The Design Thought Process - Work Backwards!!!

- What are the Requirements???

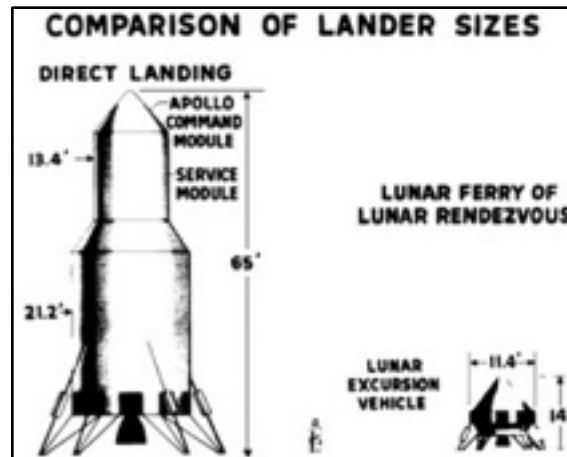


What Requirements & Trade Studies Yielded The DEATH STAR!!!?



Wernher von Braun - Lunar Direct

John Houbolt - Lunar Orbit Rendezvous

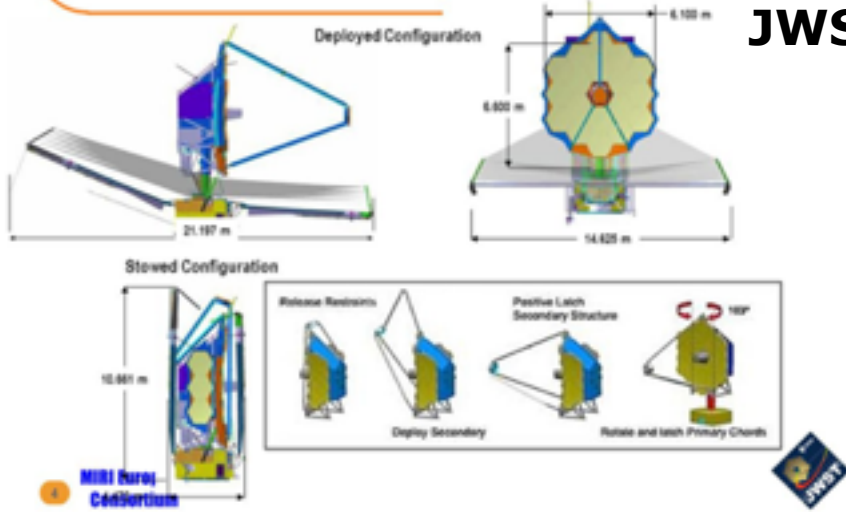


# The Impact of Existing Infrastructure on Design

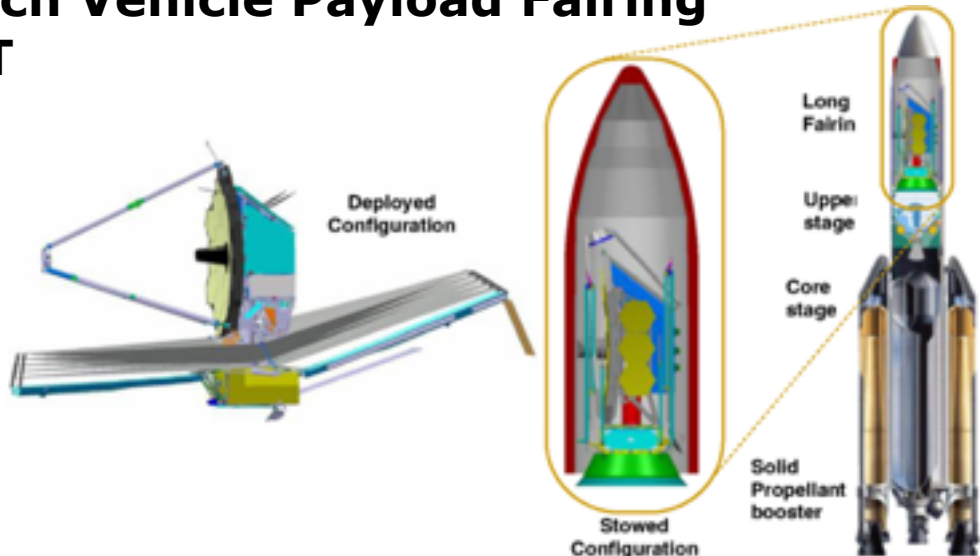
- Global Air Travel Infrastructure Investment - NASA ERA Program



## STOWED / DEPLOYED configuration



## • Launch Vehicle Payload Fairing JWST

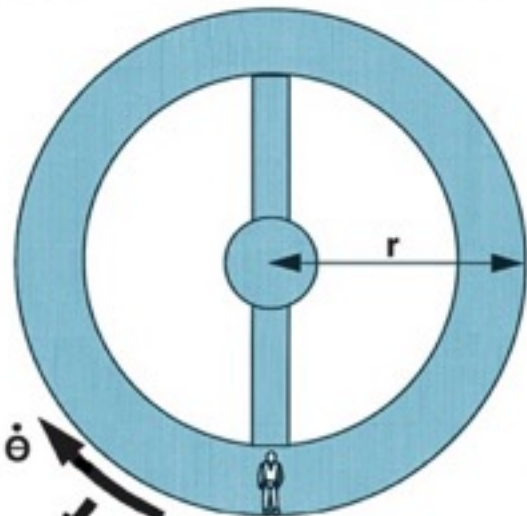




# Human Factors - Environmental Considerations



**ARTIFICIAL GRAVITY at 2 RPM**



$$a = \dot{\theta}^2 r$$

G's @ 2 R.P.M.

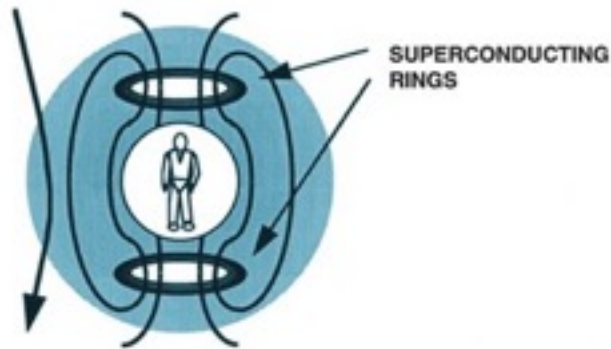
- 1 g
- 0.5 g
- 0.25 g
- 0.17 g

Centrifuge Radius

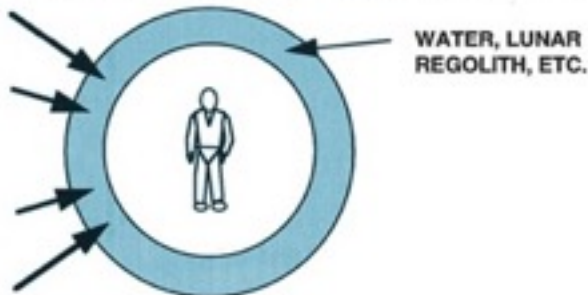
- 733 ft
- 367 ft
- 183 ft
- 122 ft

**RADIATION**

**EM RADIATION SHIELD (DEFLECTION)**



**PHYSICAL RADIATION SHIELD (ABSORPTION)**

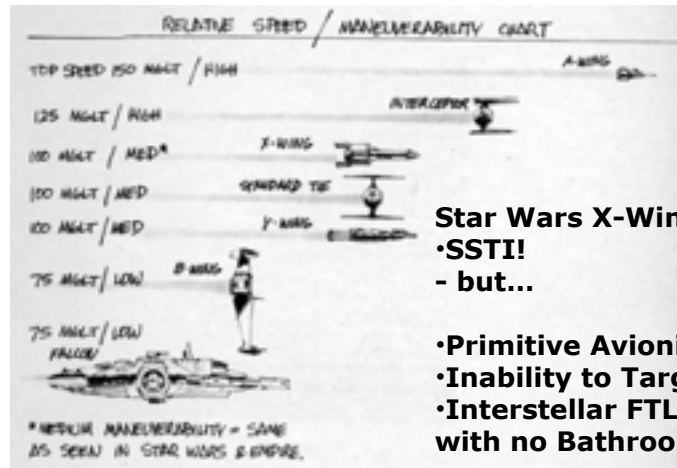


# Reality vs. Entertainment The Design Thought Process

- Use the SCRIPT as your Requirements Document
- Create a Backstory
- Work Backwards – What are you trying to do?
- Systems Engineering – Find a Balance
- Be Consistent!



Star Wars X-Wing



Star Wars X-Wing  
 •SSTI!  
 - but...  
 •Primitive Avionics  
 •Inability to Target  
 •Interstellar FTL  
 with no Bathroom!





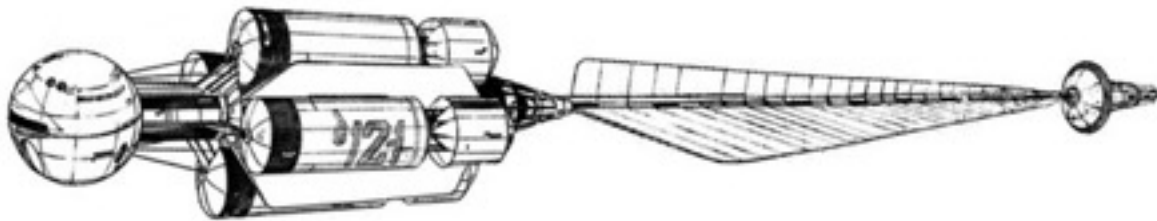
# Realistic Science Fiction Spacecraft

## The Many Faces of The Discovery . . .

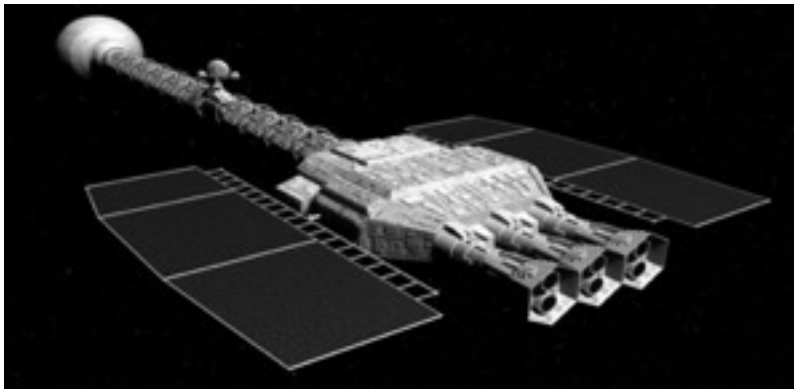
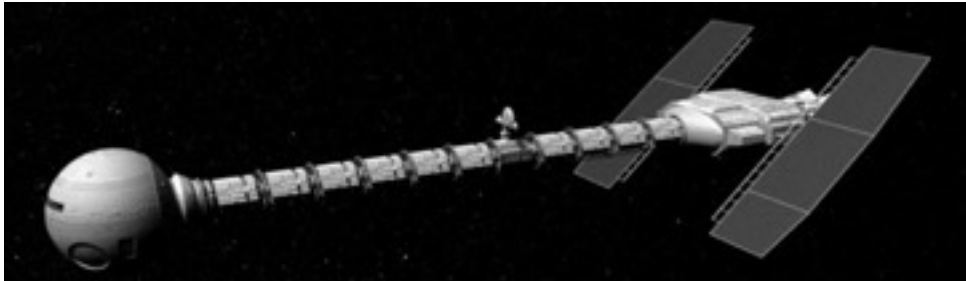
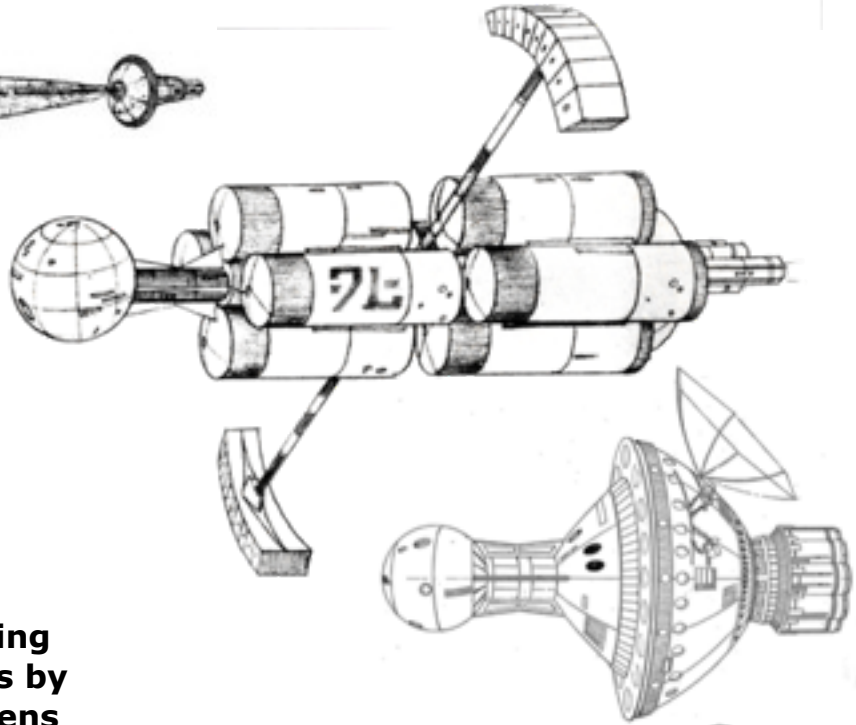
Discovery – 2001: A Space Odyssey (1968)



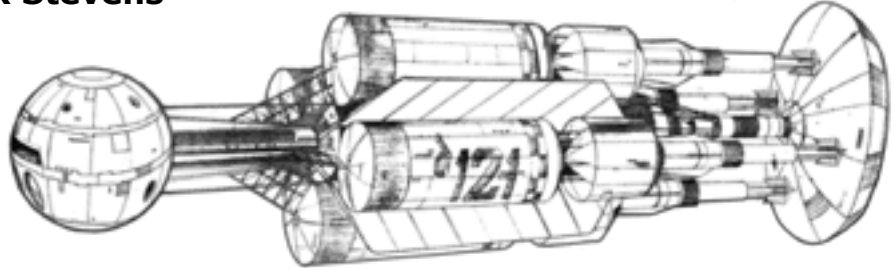
Where's The Propellant??? Where Are The Thermal Radiators???



Alternative Configuration Designs Developed During Pre-Production



3D Modeling & Renders by Nick Stevens



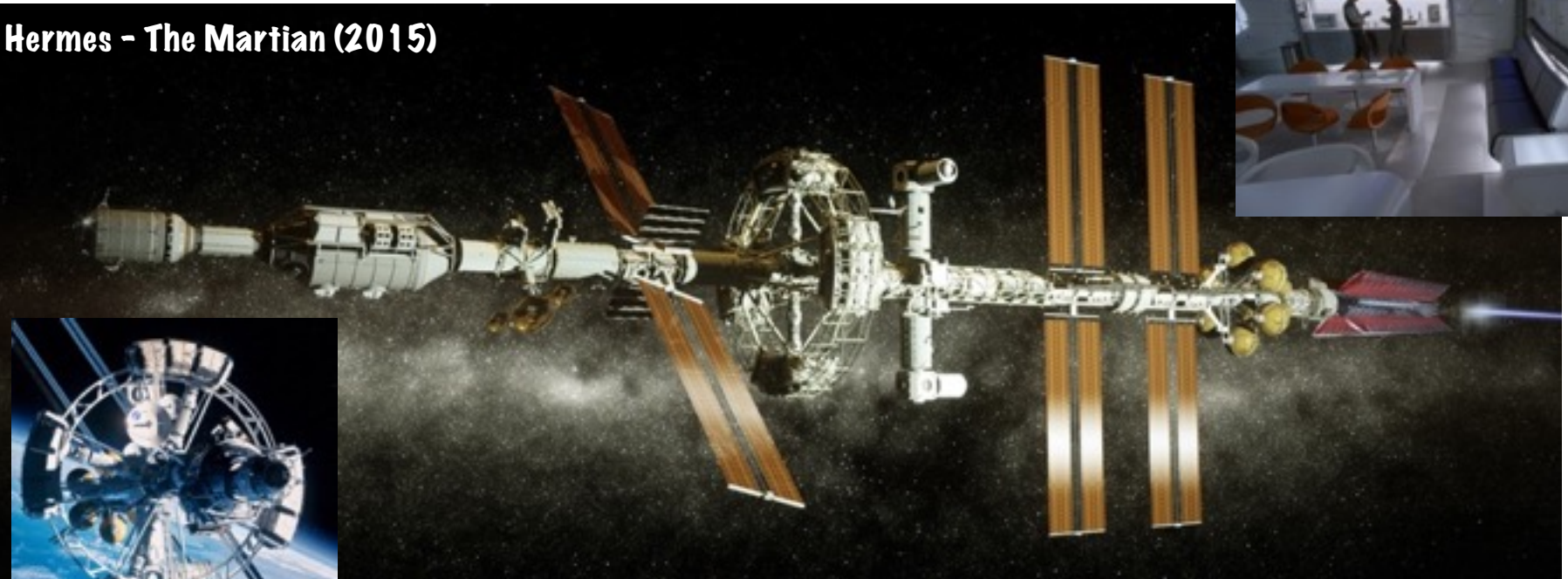


# Realistic Science Fiction Spacecraft

Consider the Crew Spaces of a Nuclear Submarine

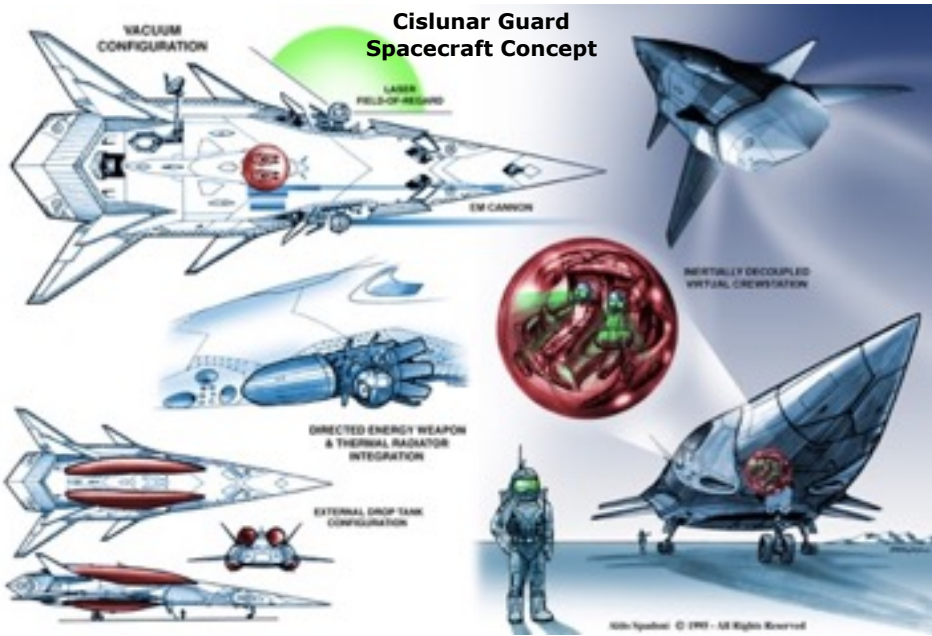


## Hermes - The Martian (2015)





# AEROSPACE IMAGINEERING – CONCEPT DESIGN EXAMPLES



## U.S. COLONIAL MARINES HEAVY ASSAULT SPACECRAFT

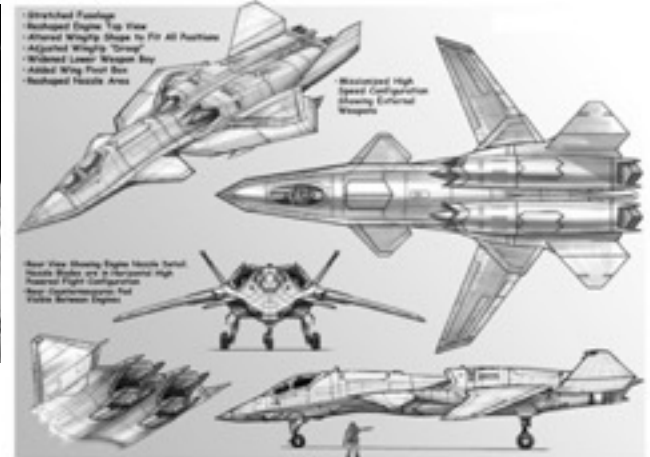
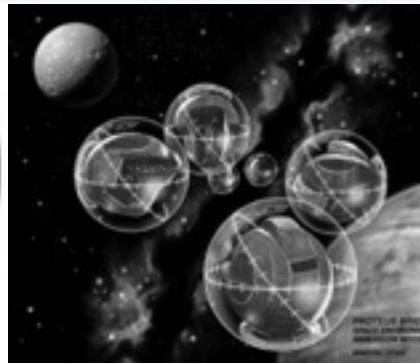
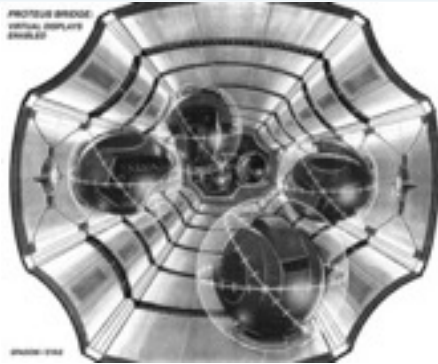


## U.S.C.M. HEAVY ASSAULT SPACECRAFT

SCALE (METERS) 0 10 20 30 40 50

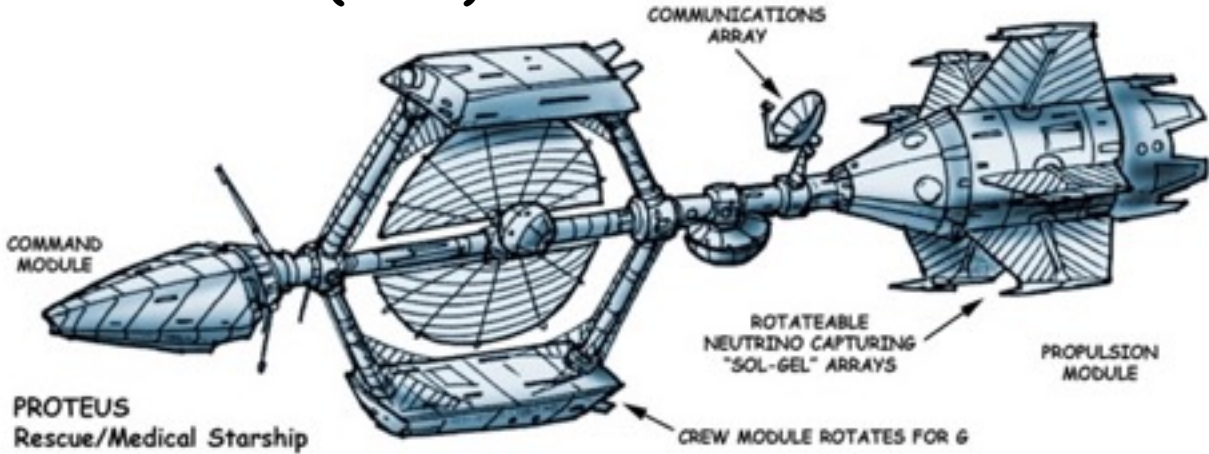






WARRIOR TALON - V7.2 ALDO ZIMMONI © 2005 10/14/05

## SUPERNOVA (2000)





# IRON MAN (2008)



J. Michael Riva



## MIT Ring



## Apogee Award

Apogee Award - That point in a terrestrial orbit, which is farthest from the Earth.

Attitude Award - Orientation of a space vehicle as determined by the relationship between its axes and some reference plane, e.g. the horizon.

Aurora Award - Arcs, rays or swaying curtains of green, yellow or white lights seen in latitudes of about 70°, such as Aurora Borealis or Northern Lights, and Aurora Australis or Southern Lights; caused by streams of electrified particles, emitted by the Sun, trapped in the Earth's magnetic field.

Azimuth Award - The angular position of an object measured in the observer's horizontal plane, usually from north through east.

Camber Award - The curved upper surface of the wing.

Constellation Award - A group of stars that make a shape, often named after mythological characters, people, animals, and things.

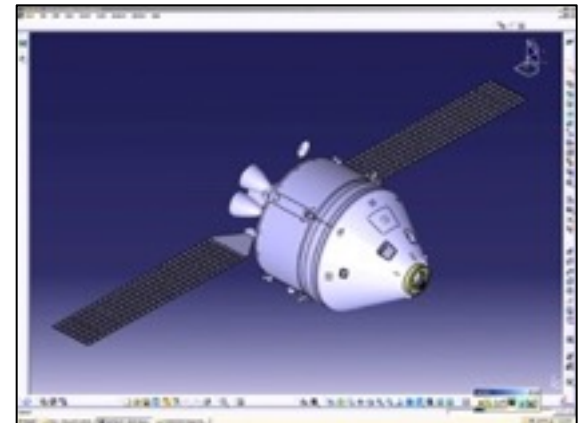
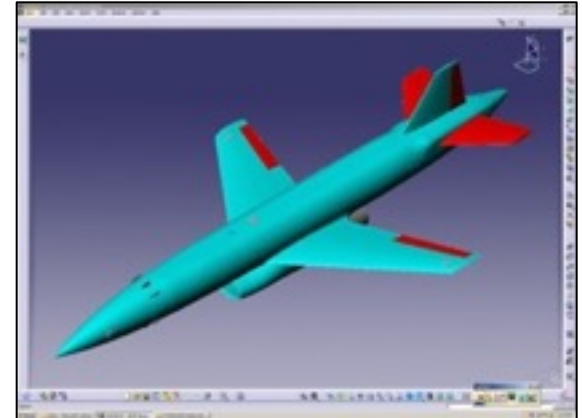
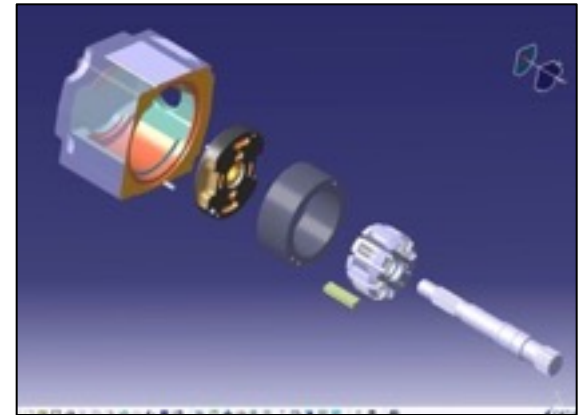
Copacetic Award - Astronaut lingo for everything is okay

Fusion Award - The combining of atoms and consequent release

## Aerospace Facilities



# CATIA 3D Design



# IRON MAN 2 (2010)





# IRON MAN 2 (2010)

Entertainment WEEKLY #1057 • JULY 24, 2009

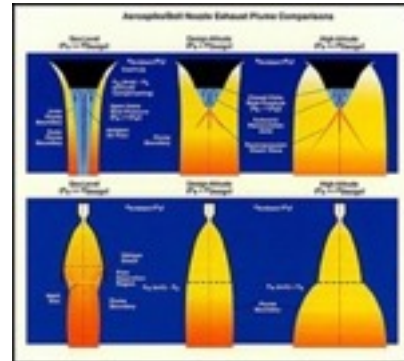
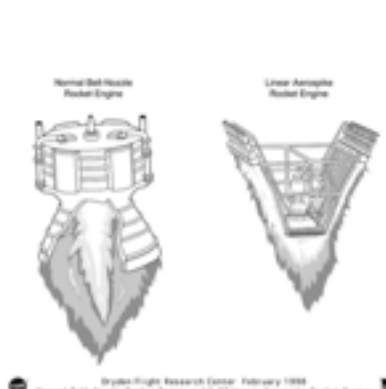




# SEVEN POUNDS (2008)



J. Michael Riva



202 INT. APOGEE AEROSPACE CONFERENCE ROOM -- DAY (FLASHBACK)

Ben, four years younger, gives a PowerPoint presentation of a ROCKET ENGINE DESIGN to a half-dozen ENGINEERS.

BEN (mid-discussion, in command)

WAS:  
Then we close by telling them she burns twenty-six percent less fuel per thirty second interval – and that she weighs one third less than her predecessor. If they pass on this baby, then quite frankly, they deserve another Sputnik . . .

IS:  
If there's one thing I've learned about winning a contract, it's tell 'em what you're gonna tell 'em, tell 'em, then tell 'em what you told 'em. So we close by telling them she has a specific impulse that's 3 % better from sea level to vacuum. If they pass on this baby, then quite frankly, they deserve another Sputnik . . .

ENGINEER #1



Gabriele Muccino





FROM THE DIRECTOR OF "THE FAST AND THE FURIOUS" AND "XXX"



JOSH LUCAS JESSICA BIEL JAMIE FOXX  
**STEALTH**

SUMMER



**Rob Cohen**  
Director



**Laura Ziskin**  
Producer



**Joel Hynek**  
Visual Effects



**J. Michael Riva**  
Production Designer

- A Small Circle of Friends** 1980
- DragonHeart** 1996
- The Fast and the Furious** 2001
- xXx** 2002
- Stealth** 2005

- Three pilots in a top-secret military program struggle to bring a UCAV artificial intelligence program under control ... before it initiates the next world war.

- Project not yet "Green-Lighted"

- Development began in 2002

- Working title WARRIOR, and briefly, AIR DOMINANCE

- Concept design requirement for two advanced aircraft, one manned, one unmanned

- Script review to incorporate appropriate "Jargon" and scene recommendations

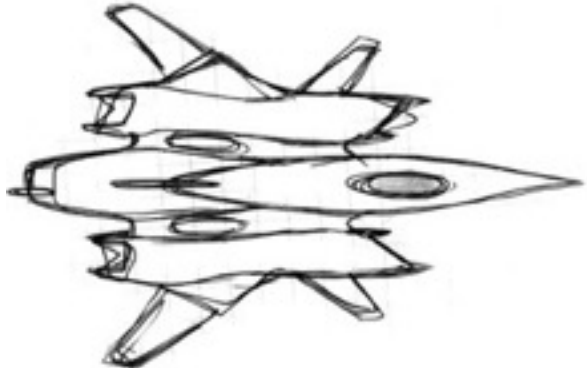
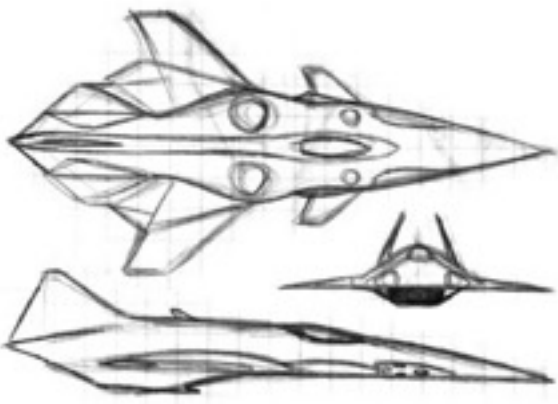
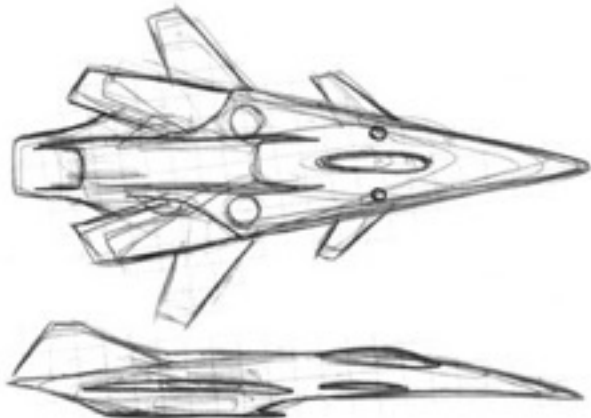
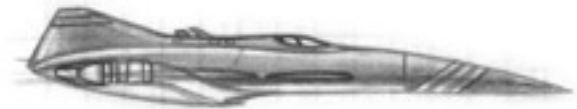
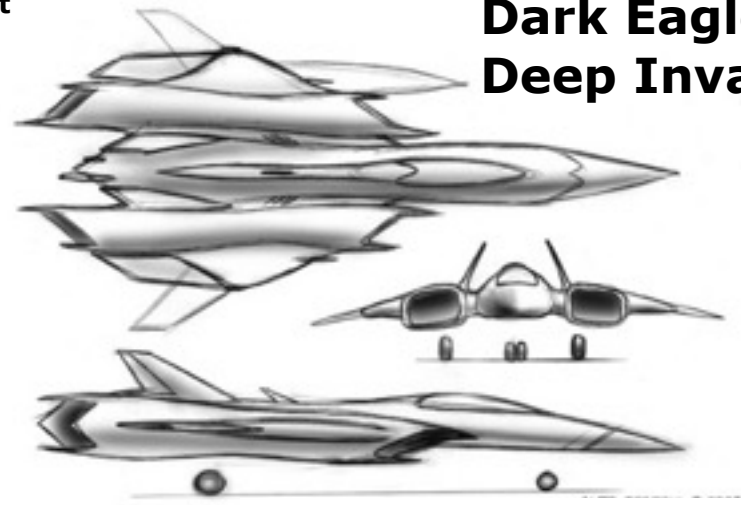
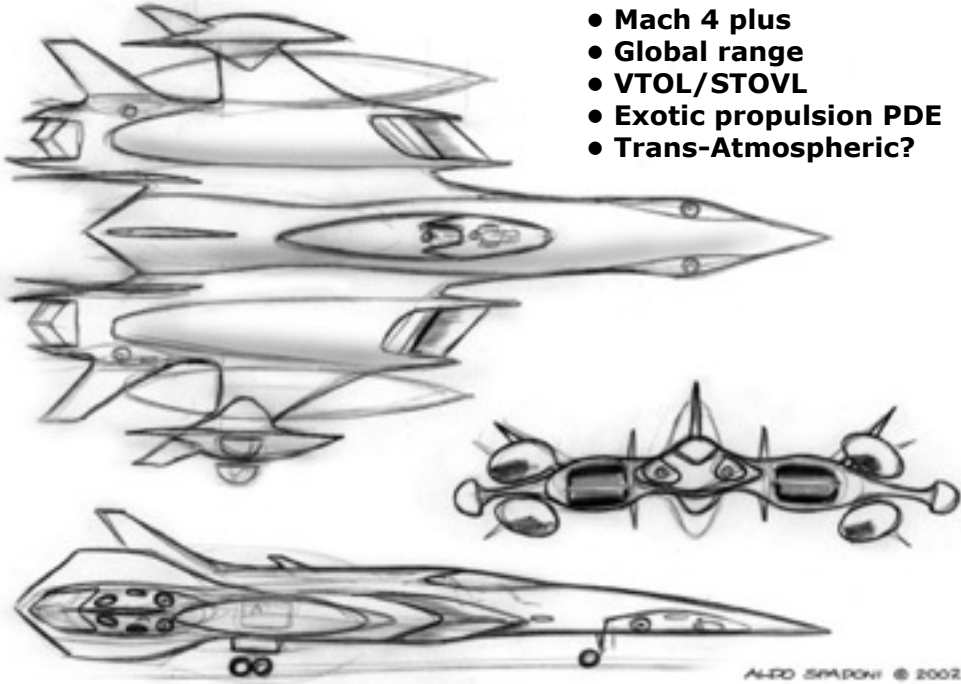
- Phase I with Digital Domain  
Phase II with Sony/Columbia Pictures

- Culture Clash

# STEALTH (2005)

- Carrier-based single-seat stealth strike fighter
- Near future
- Mach 4 plus
- Global range
- VTOL/STOVL
- Exotic propulsion PDE
- Trans-Atmospheric?

# Dark Eagle Deep Invader

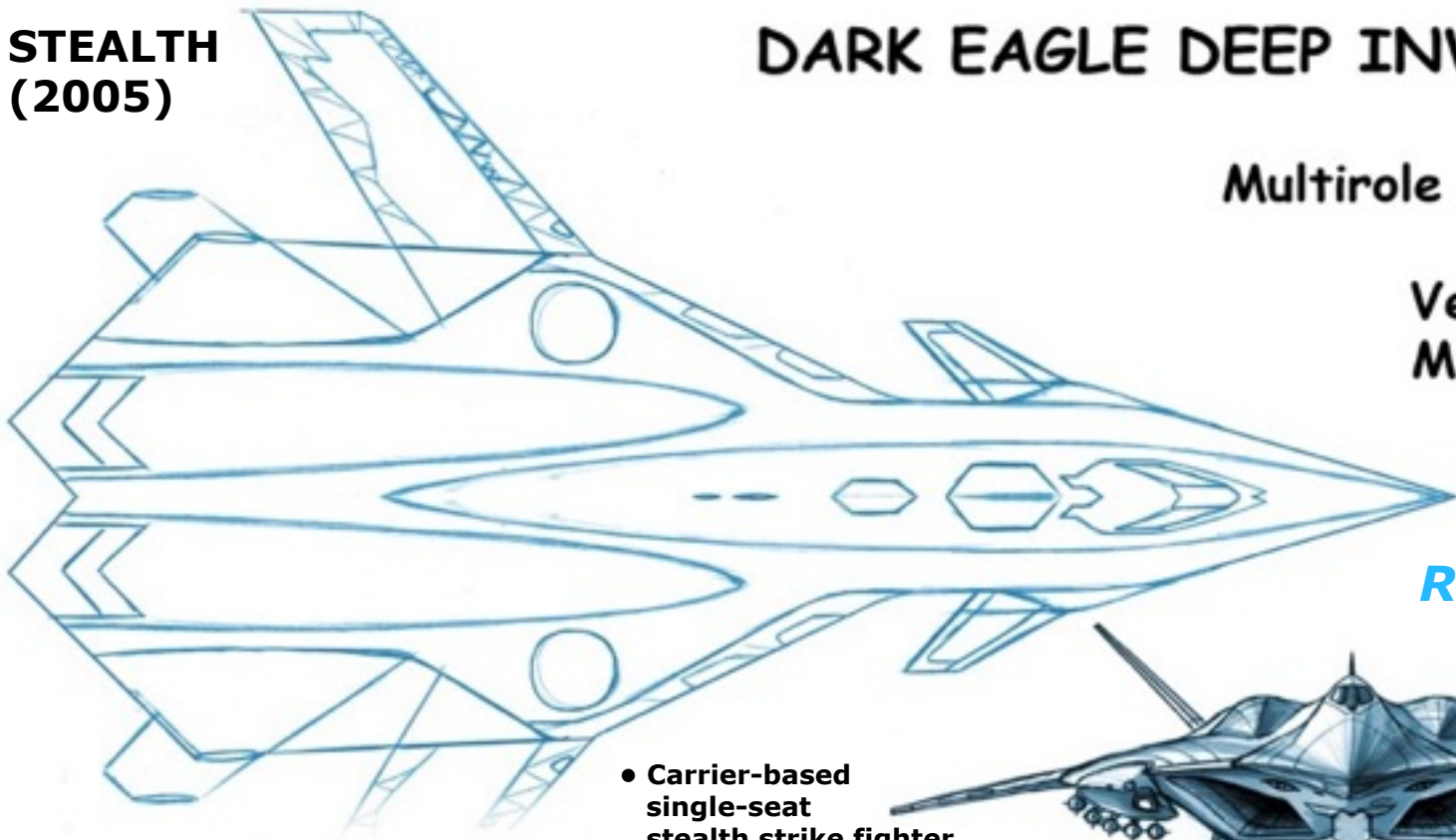




**STEALTH  
(2005)**

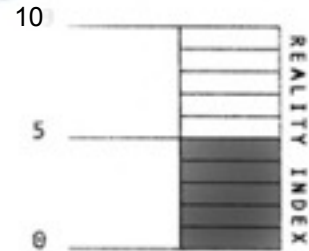
# DARK EAGLE DEEP INVADER - V4

**Multirole Strike Fighter  
Swing Wing  
Vectored Thrust  
Missionized Pods  
VTOL**



**REALITY INDEX**

- Carrier-based single-seat stealth strike fighter
- Near future
- Mach 4 plus
- Global range
- VTOL/STOVL
- Exotic propulsion PDE
- Trans-Atmospheric?



10: BLUE SKY  
5: NEAR FUTURE  
0: CURRENT TECH

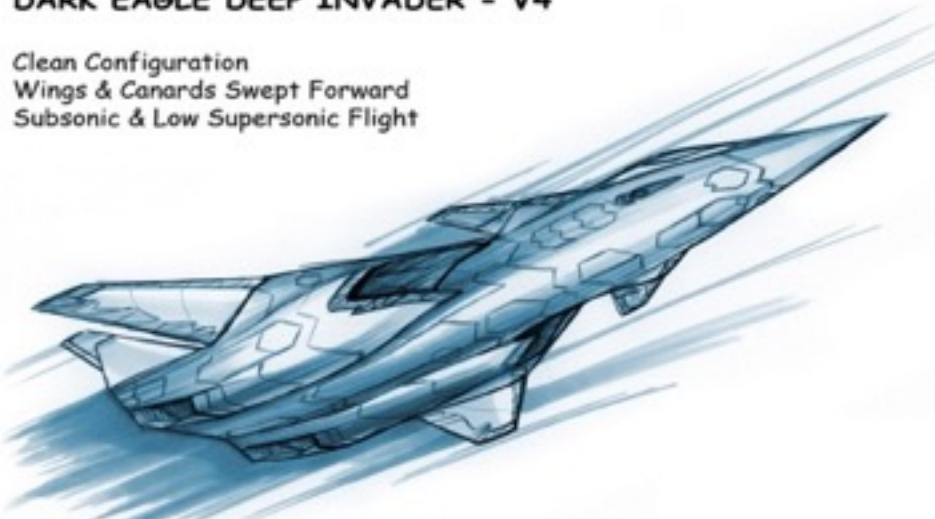
ALDO SPADONI © 2002

DATE



### DARK EAGLE DEEP INVADER - V4

Clean Configuration  
Wings & Canards Swept Forward  
Subsonic & Low Supersonic Flight



Clean  
Landing Gear & Tailhook Down  
Vertical Takeoff & Landing  
With Thrust Vectoring

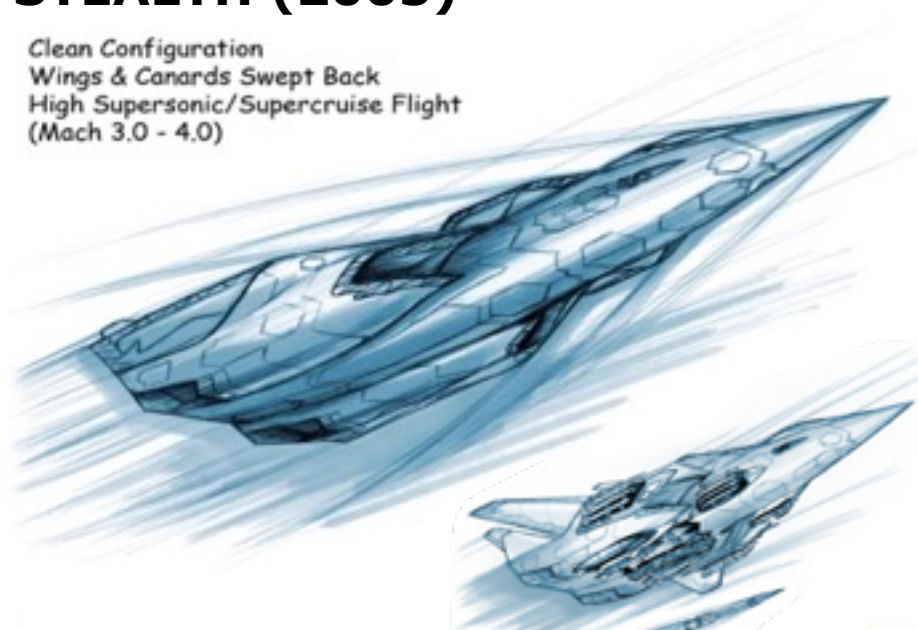


F-35B STOVL  
Lift + Lift/Cruise

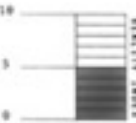
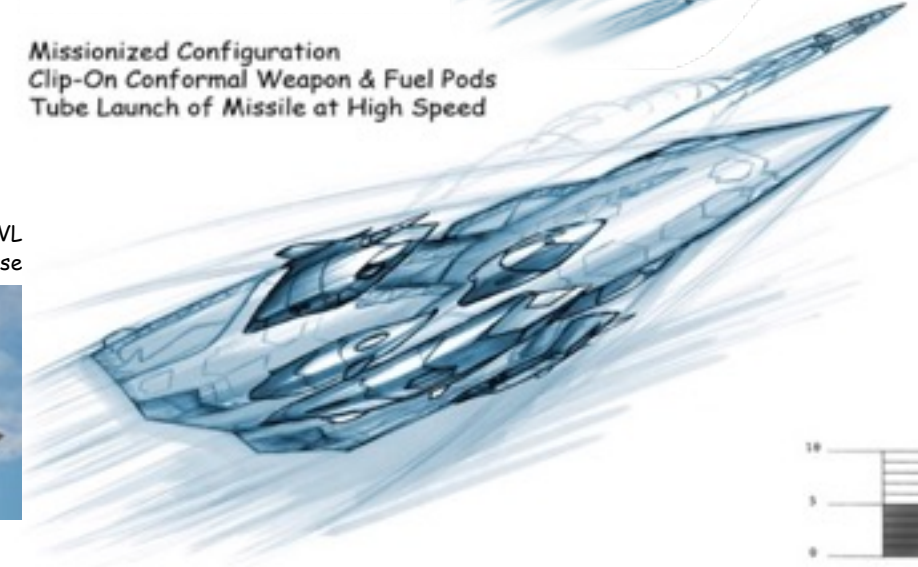


### STEALTH (2005)

Clean Configuration  
Wings & Canards Swept Back  
High Supersonic/Supercruise Flight  
(Mach 3.0 - 4.0)



Missionized Configuration  
Clip-On Conformal Weapon & Fuel Pods  
Tube Launch of Missile at High Speed





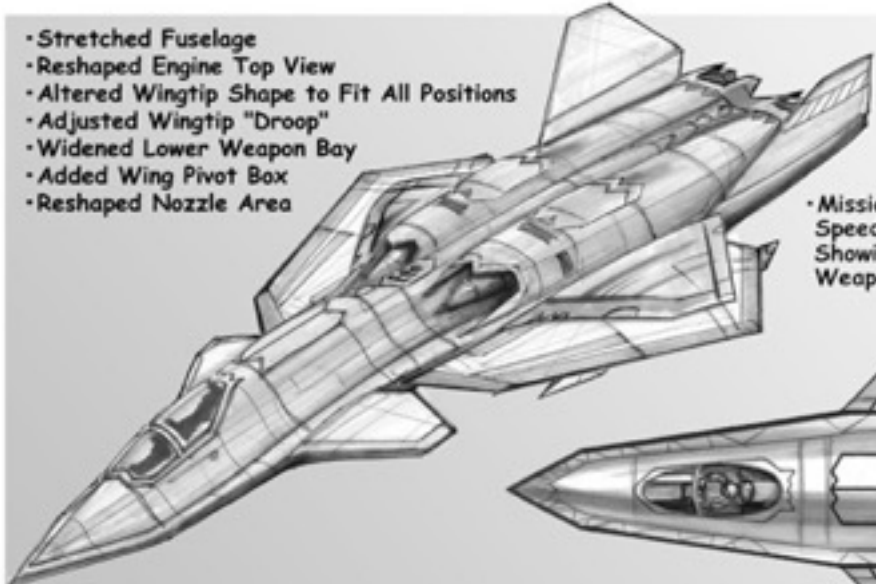
# STEALTH (2005)

## Northrop YF-23 ATF

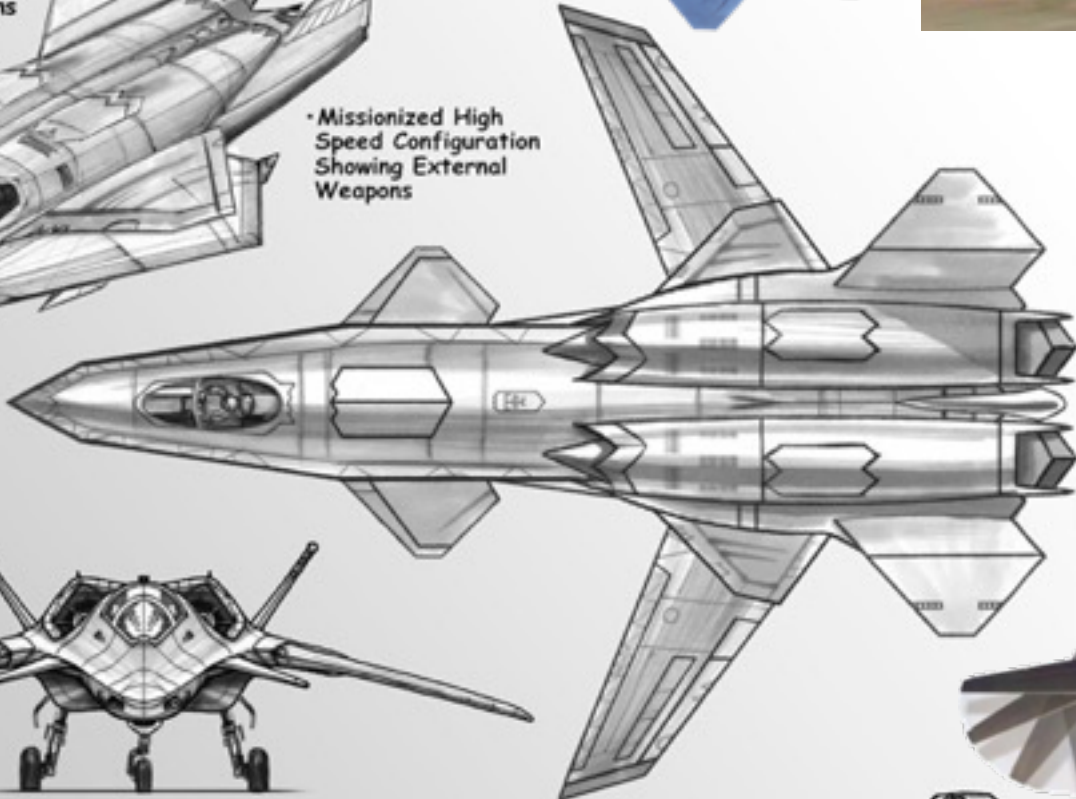


Russian S-37

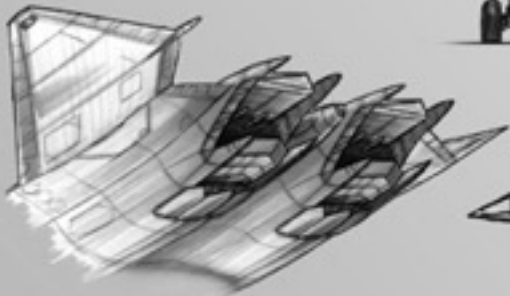
- Stretched Fuselage
- Reshaped Engine Top View
- Altered Wingtip Shape to Fit All Positions
- Adjusted Wingtip "Droop"
- Widened Lower Weapon Bay
- Added Wing Pivot Box
- Reshaped Nozzle Area



- Missionized High Speed Configuration Showing External Weapons



- Rear View Showing Engine Nozzle Detail. Nozzle Blades are in Horizontal High Powered Flight Configuration
- Rear Countermeasures Pod Visible Between Engines



Northrop "Switchblade"





# F/A-37 Talon

# STEALTH (2005)



"... Designed in Collaboration With Northrop Grumman "Stealth" Experts."

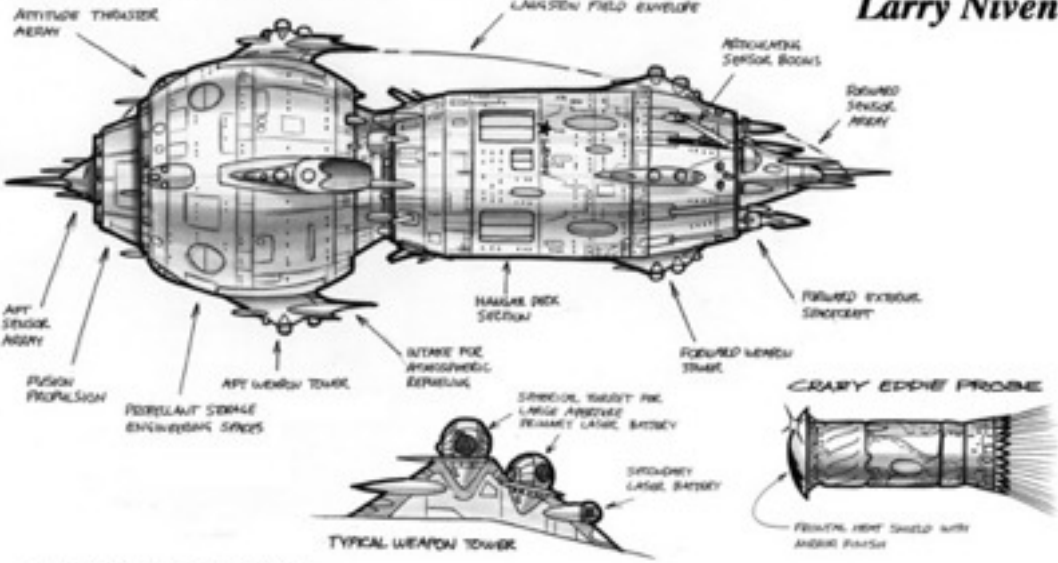


EDI

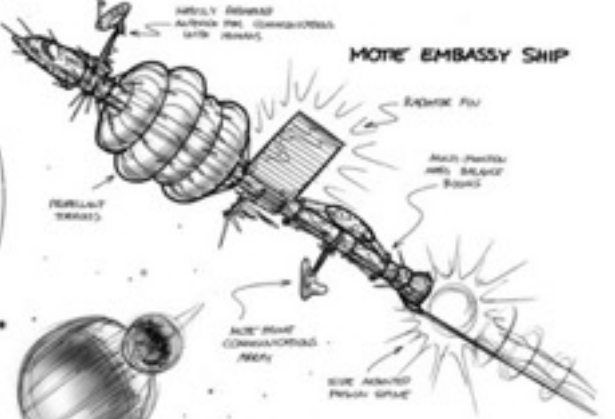


# The Universe of Larry Niven

## LENIN ... HIS MAJESTY'S PRESIDENT CLASS BATTLE SHIP PREFERRED SYSTEM CONCEPT (PSC)



GENERAL PRODUCTS #1 HULL  
30 CM DIAMETER SPHERE...



ALDO SPADONI  
© 1996



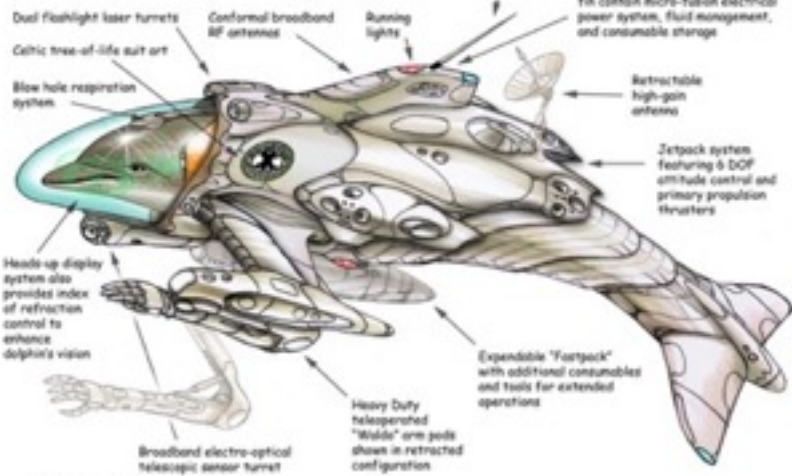


# VIDEO GAME DEVELOPMENT - LARRY NIVEN'S FREEFALL



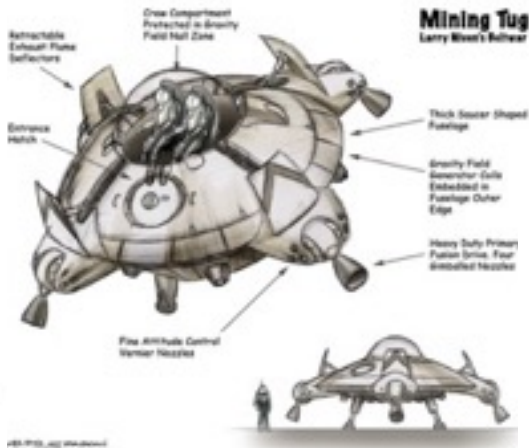
## Dolphin EVA Spacesuit

Extended Duration Expeditionary Configuration



ALPQ & PADONI  
© 2008 Aerospace Engineering  
All Rights Reserved

06/01/08



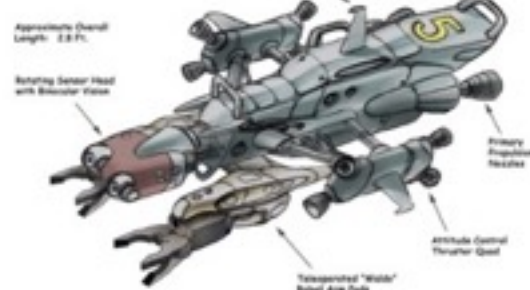
## Mining Tug

Larry Niven's Beltwar



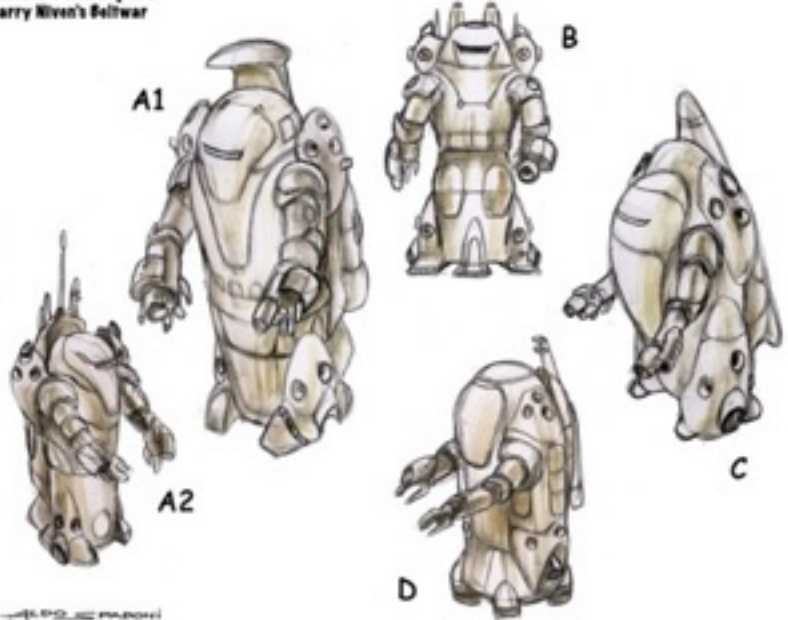
## Remote Waldo

Larry Niven's Free Fall



## ARM Battlepod

Larry Niven's Beltwar

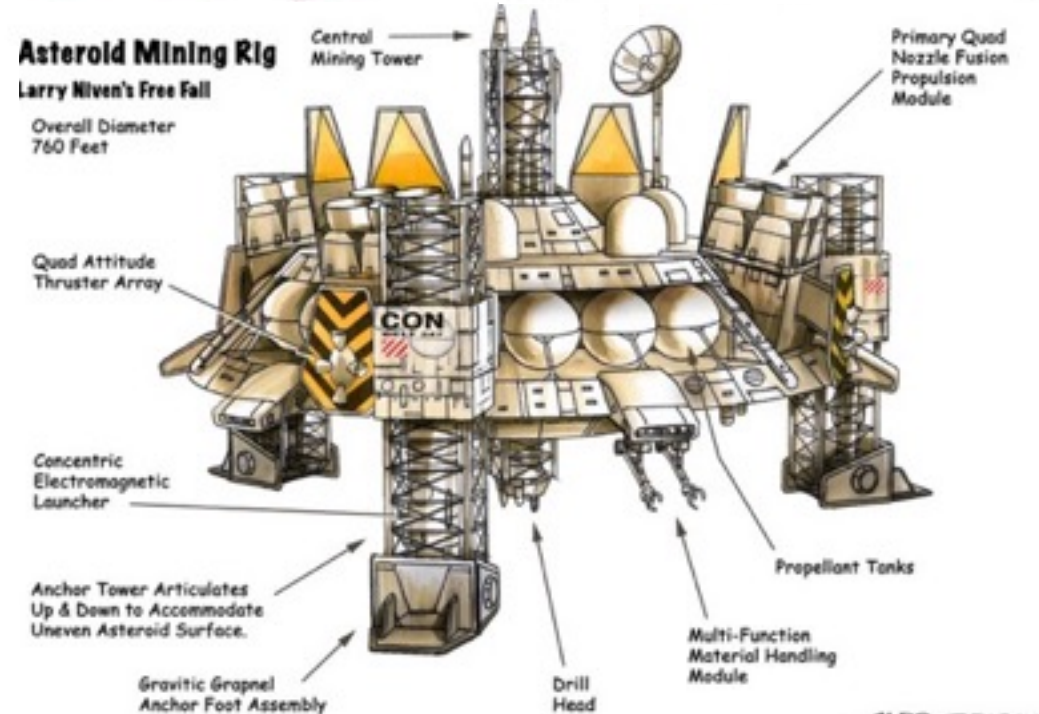


ALPQ & PADONI  
© 2008 Aerospace Engineering  
All Rights Reserved

## Asteroid Mining Rig

Larry Niven's Free Fall

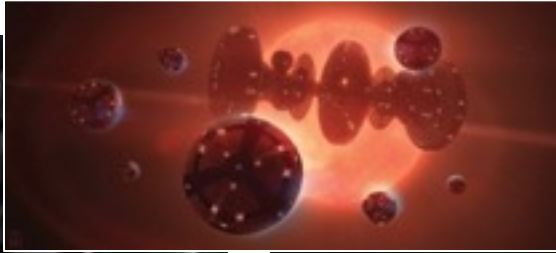
Overall Diameter 760 Feet



02/20/08

ALPQ & PADONI  
© 2008 Aerospace Engineering  
All Rights Reserved

# PERSEPHONE - Spacecraft Technical Advisor



FEATURE FILM ART + DESIGN

VISUAL JOURNEY JEFFREY MORRIS

ART DIRECTOR DYLAN HANSEN

## PERSEPHONE

### Key Contributors



NEIL DEGRASSE TYSON  
SCIENCE ADVISOR



ALAN STERN  
SCIENCE ADVISOR



KEVIN R. GRAZIER  
SCIENCE ADVISOR

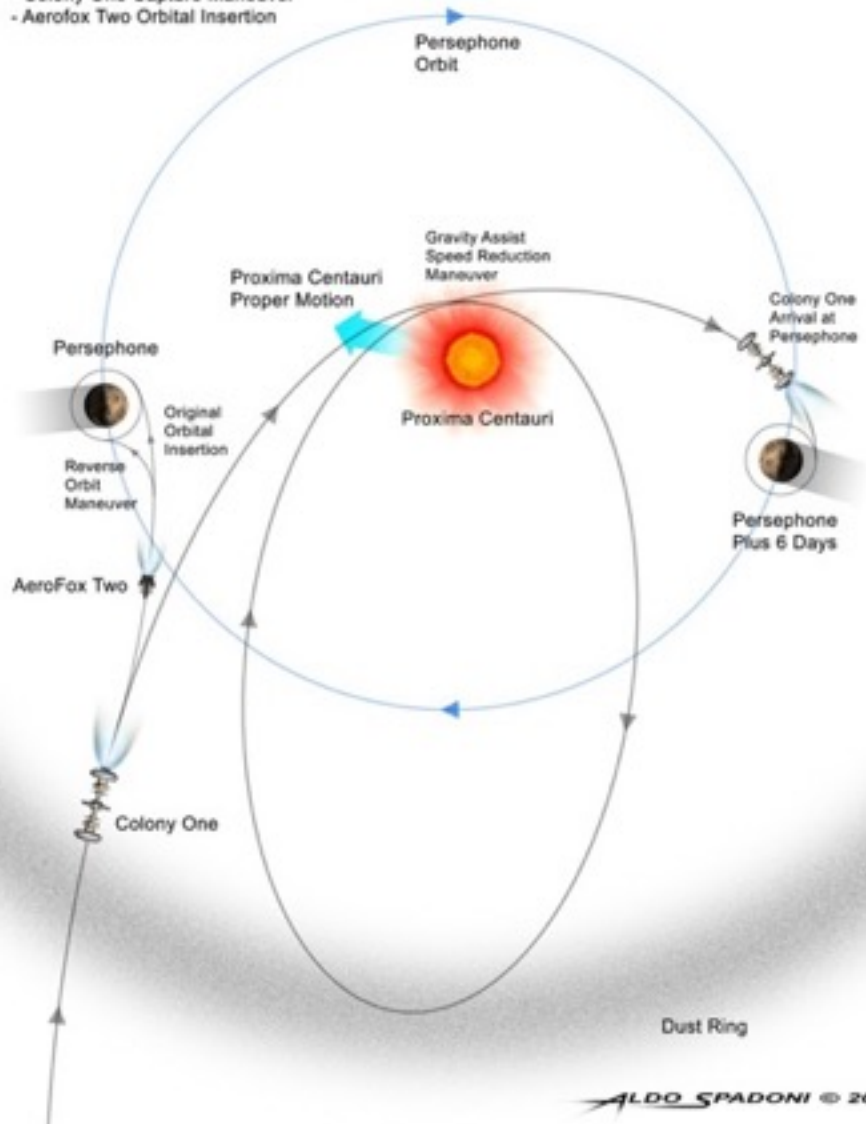




## PERSEPHONE

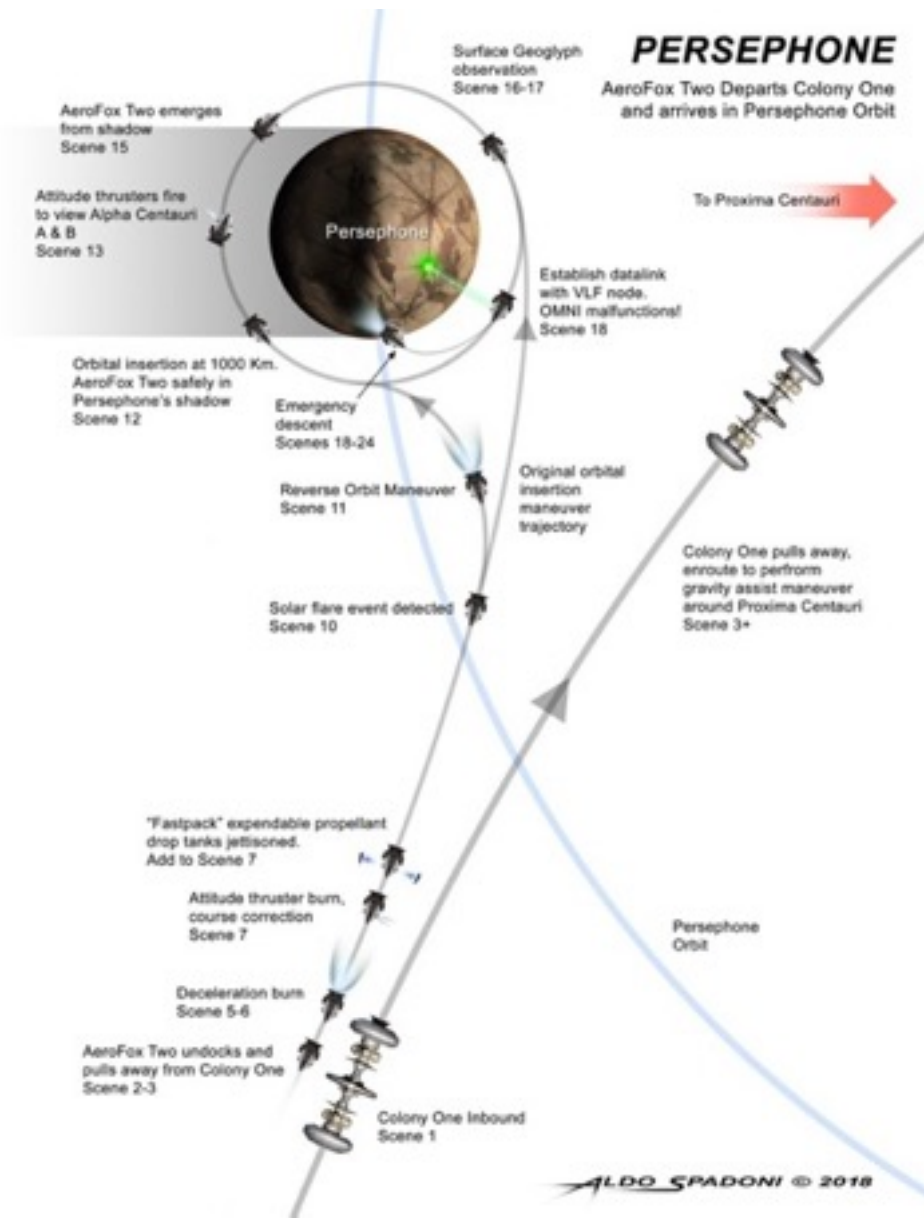
Proxima Centauri Capture & Mission Overview:

- Colony One Capture Maneuver
- Aerofox Two Orbital Insertion



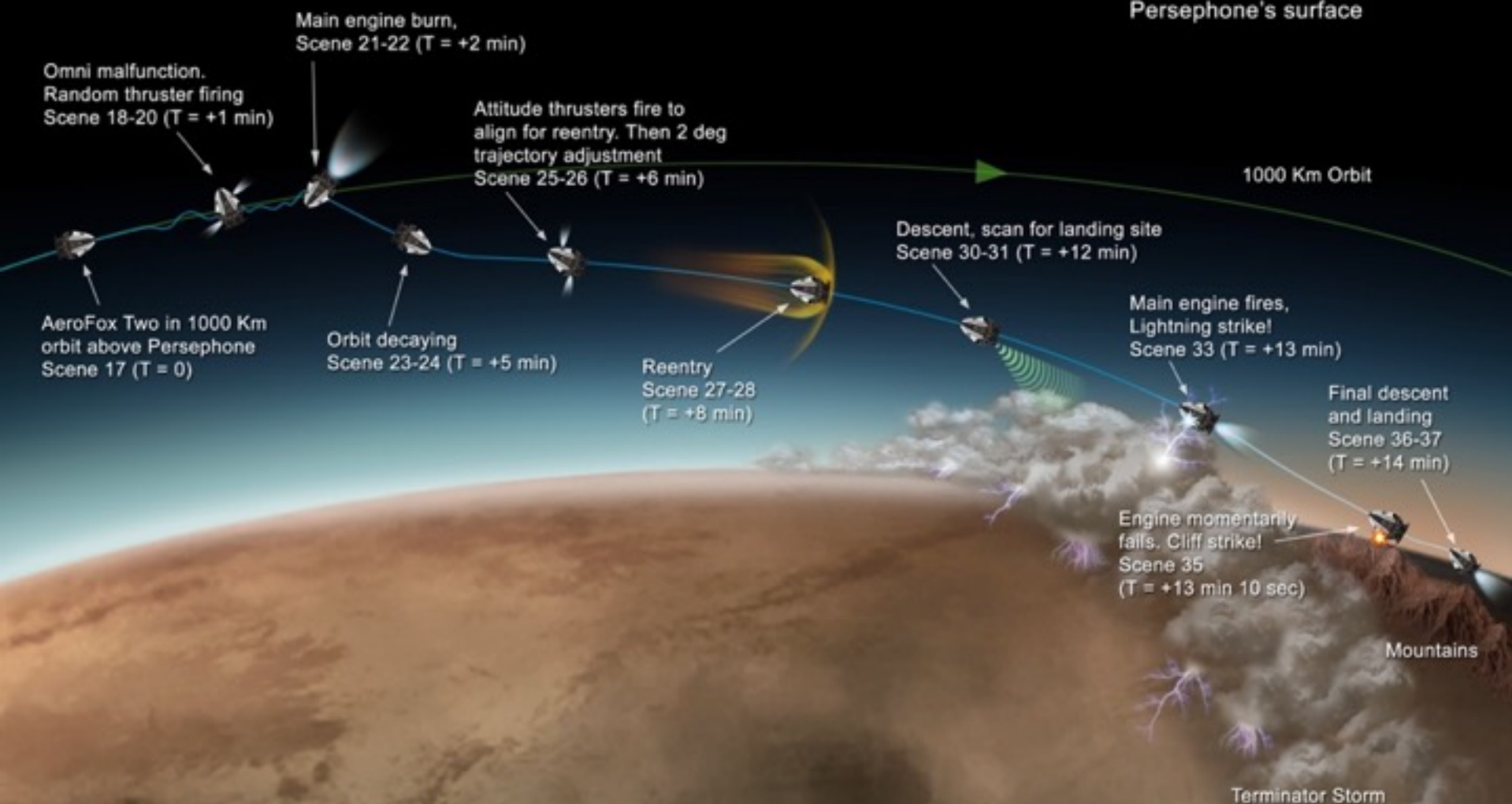
## PERSEPHONE

AeroFox Two Departs Colony One and arrives in Persephone Orbit



# PERSEPHONE

AeroFox Two is forced to make emergency descent to Persephone's surface







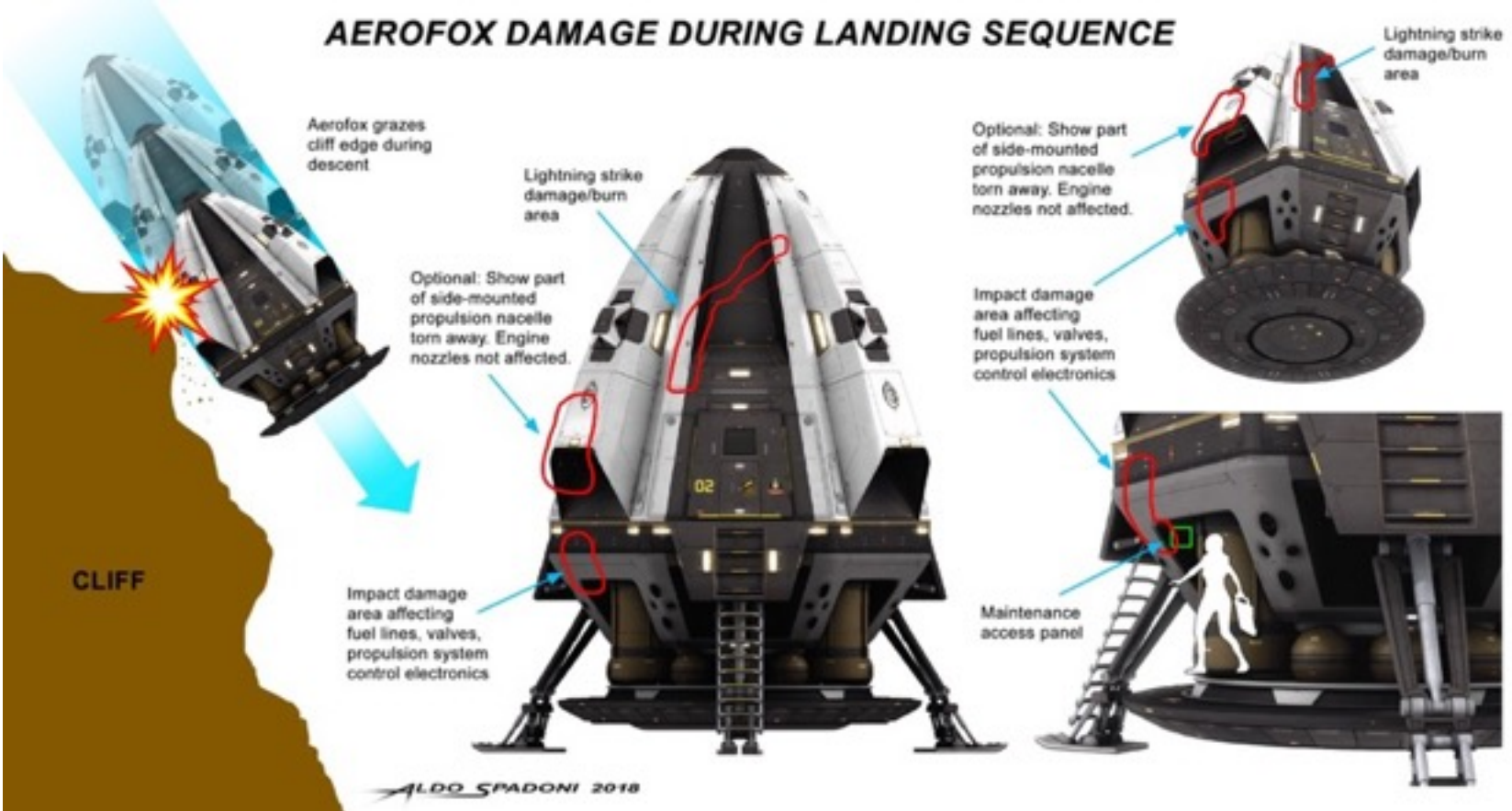
## AEROFOX

### "FAST PACK"

EXTERNAL EXPENDABLE PROPELLANT DROP TANK CONFIGURATION



## AEROFOX DAMAGE DURING LANDING SEQUENCE



## SUMMARY & LESSONS LEARNED

- **STEAM is good!**
- **Art and Illustration help communicate complex ideas and facilitate the systems engineering process.**
- **Don't shoot the technical advisor!**
- **Producers/Director must have the vision and the will to incorporate accurate science & technology.**
- **Accurate science & technology does enhance the story and can help educate.**
- **Hopefully your movie will actually be good!**





- **Keep Dreaming!**
- **Keep Envisioning!**
- **Keep Designing!**
  
- **Questions?**

**Aldo Spadoni**

President – Aerospace Imagineering  
Former Manager - Engineering Visualization  
Northrop Grumman Aerospace Systems