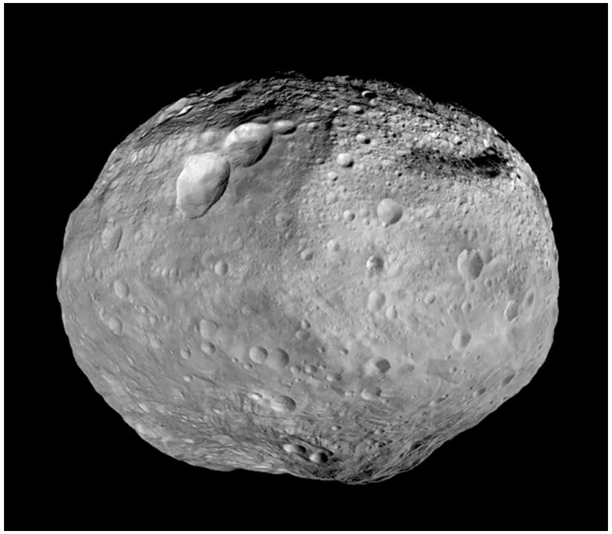
Asteroid Intervention and Collision Deterrence



We hear a lot in the media, usually "scary stuff".
Let's talk about the science, the engineering, and the implications including
many positives for our human species on Earth and (finally, soon)
Going Beyond this Third Rock

NASA MUREP @ Meharry
27.July.2022
Discussion Workshop Coordinator: Martin Dudziak, TETRAD Institute

Mentor-Facilitators

Dr. Martin Dudziak

TETRAD Institute of Complex System Dynamics; Director of ASTRIC Project in Astro-Terrestrial Robotics Control

[present via internet teleconferencing]

Dr. Yang Gao

University of Surrey (UK), Professor of Space Autonomous Systems; Wiley JFR Editor-in-Chief; United Nations Space4Women Mentor

Dr. Josep Trigo-Rodríguez

Consejo Superior de Investigaciones Científicas (CSIC); Director of the Meteorites, Minor Bodies and Planetary Science Group

Prof. Thomas Thundat

State University of New York at Buffalo, Professor of Chemical and Biological Engineering; Empire Innovation Professor of Research and Education in Energy, Environment and Water (RENEW)

What can (should) be our Objectives with Asteroids ?

Prevent Collisions with Earth, yes §
Mine them for metals, water, minerals, sure §
Learn how to use them in other ways, definitely §

What have we been doing ?

Telescopy, spectroscopy (Earth, Space) §
Contact, sampling, return (OSIRIS-REx, Hayabusa 1 & 2) §
Impact and deterrence experiments (DART) §

What are practical objectives now, 2022+ ?

Robotic missions for mining? §
Collision avoidance!!! §
Terraforming, use as a base, even as a spaceship? §

We've Actually Done A Lot, worldwide!

Current and Past Missions:

Double Asteroid Redirection Test (DART) - Kinetic Impact Test Mission to Asteroids Didymos and Dimorphos (2021)

OSIRIS-REx - Sample Return Mission to Asteroid Bennu (2016)

Hayabusa 2 - JAXA Sample Return Mission to Asteroid Ryugu (2014)

PROCYON - JAXA Small Satellite Asteroid Flyby Mission (2014)

Dawn - NASA Orbiter of Asteroids Ceres and Vesta (2007)

Rosetta - ESA Comet Mission, flew by asteroids Steins and Lutetia (2004)

Hayabusa (Muses-C) - ISAS (Japan) Sample Return Mission to Asteroid 25143 Itokawa (2003)

Genesis - NASA Discovery Solar Wind Sample Return Mission (2001)

Stardust - NASA Comet Coma Sample Return Mission, flew by asteroid AnneFrank (1999)

Deep Space 1 - NASA Flyby Mission to asteroid Braille (1998)

Cassini - NASA/ESA Mission to Saturn through the Asteroid Belt (1997)

NEAR - NASA Near-Earth Asteroid Rendezvous with 433 Eros

Galileo - NASA Mission to Jupiter via asteroids Gaspra and Ida

Future Missions:

Lucy - Flyby Mission to Multiple Trojan Asteroids (2021)

NEA Scout - Flyby CubeSat Mission to Near Earth Asteroid (2021)

Psyche - Orbital Mission to Main Belt Asteroid 16 Psyche (2022)

Hera - Follow-up Mission to Asteroids Didymos and Dimorphos(2024)

Some Details of Great Foundations (1)

Some Early First Encounters:

NASA's Galileo mission was the first spacecraft to fly past an asteroid. It flew past asteroid Gaspara in 1991 and Ida in 1993.

NASA's Near-Earth Asteroid Rendezvous (NEAR-Shoemaker) mission studied asteroids Mathilde, and Eros.

The European Space Agency's Rosetta mission to comet 67P/Churyumov-Gerasimenko also flew by asteroid (2867) Steins in 2008, and asteroid Lutetia in 2010.

Deep Space 1 and Stardust both had close encounters with asteroids.

Hayabusa:

Hayabusa, formerly known as MUSES-C for Mu Space Engineering Spacecraft C, was launched on 9 May 2003 and rendezvoused with Itokawa in mid-September 2005. After arriving at Itokawa, Hayabusa studied the asteroid's shape, spin, topography, color, composition, density, and history. In November 2005, it landed on the asteroid and collected samples in the form of tiny grains of asteroidal material, which were returned to Earth aboard the spacecraft on 13 June 2010.

Dawn:

NASA's Dawn spacecraft was launched in 2007 to explore asteroid Vesta, the second most massive body in the main asteroid belt. Dawn arrived at Vesta in 2011, then orbited and explored Vesta for over a year before leaving in September 2012 to explore dwarf planet Ceres.

Some Details of Great Foundations (2)

Hayabusa 2:
Japan's Hayabusa2 was launched in December 2014 on a six-year voyage to study asteroid Ryugu, and to collect samples to bring back to Earth for analysis. Hayabusa2 arrived at the asteroid in June 2018. The spacecraft deployed rovers and landers onto Ryugu's surface, and collected a sample. Hayabusa2 delivered the asteroid sample to Earth on Dec. 6, 2020.

OSIRIS-Rex:
Launched on Sept. 8, 2016, NASA's OSIRIS-REx arrived at near-Earth asteroid Bennu in 2018, and collected a sample of dust and rocks. On April 9, 2021, the spacecraft took one last look at Bennu before beginning its journey back to Earth. It's on track to deliver the asteroid sample to Earth on Sept. 24, 2023.

NEOWISE:
NASA's NEOWISE spacecraft is orbiting Earth to improve on the most accurate survey of near-Earth objects ever undertaken.

DART:
DART launched on 24 November 2021) and it is enroute to the binary S-type asteroid system 65803 Didymos, consisting of a primary, Didymos (formerly Didymos A), roughly 780 meters in diameter, and a secondary, Dimorphos (formerly Didymos B), approximately 163 meters across. En route to the system it may fly by the 578 meter diameter asteroid 2001 CB21 on about 6 March 2022. ...

Some Details of Great Foundations (3)

DART (continued):
It will reach the Didymos system in late September 2022, taking images during approach to constrain the size and shape of Didymos and Dimorphos.

Impact is planned for sometime in a window from 26 September to 1 October, 2022. The LICIA Cube will be released about two days before impact. In the last 4 hours before impact, DART will employ the DRACO and SMARTNav systems to target the asteroid. During this time it will also be returning detailed images of the surface (better than 20 cm/pixel at impact) of Dimorphos to pinpoint the exact impact site within one meter and to determine the local surface geology for later impact modelling.

The spacecraft will fly into Dimorphos at approximately 6.58 km/sec with an impact mass of 560 kg. The final images returned 2 seconds before impact will have a resolution of 3 cm/pixel.

The LICIACube will fly by about 3 minutes after impact, recording details of the impact plume and surfaces at resolutions up to 2 meters per pixel. After impact, Earth-based observations will continue in order to characterize the resulting change in orbit of Dimorphos induced by the impact. The distance to Earth at impact will be approximately 11.2 million km.

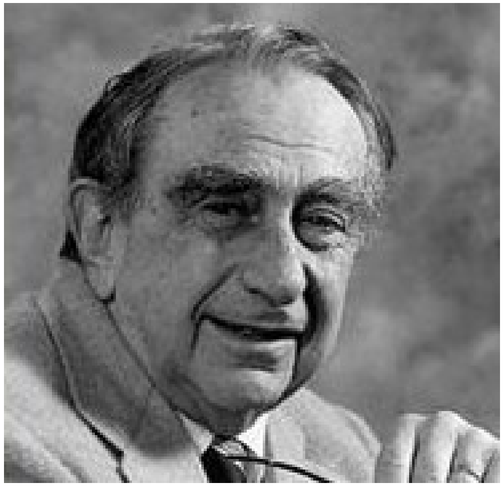
(The ESA Hera mission is planned to fly by Didymos in 2026 for followup observations.)

One approach with a long, rocky, roundabout history

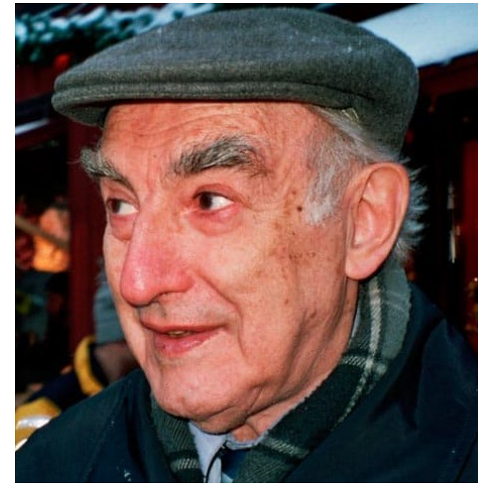
A S T R I C

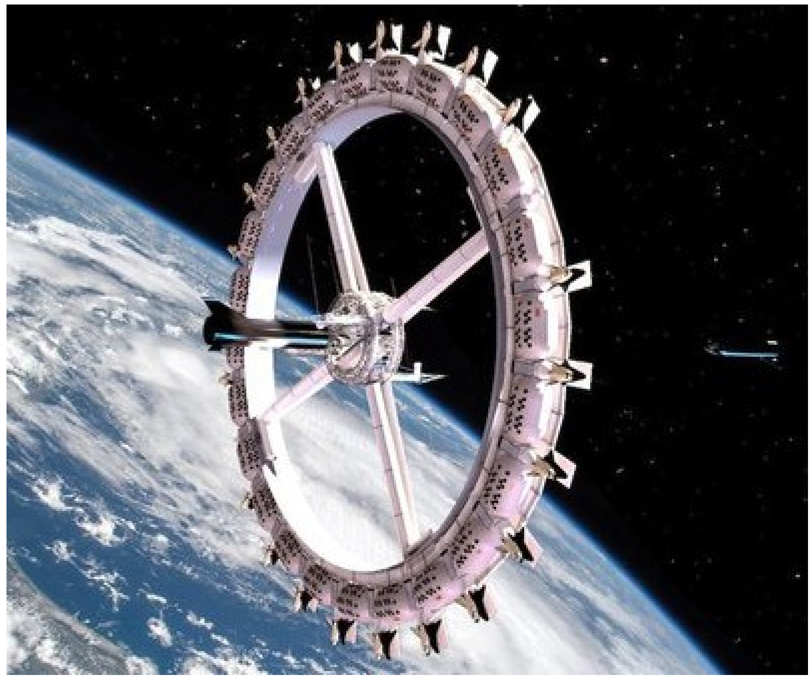
Astro Terrestrial Remote Interaction and Control
Asteroid Reconaissance Intervention and Control

It began in a very different era from today...



Planetary Remote Sensing
CBRNE Eyes in the Sky
Environment ~~ Climate Change
Disasters ~~ Rogue Operations





Planetary Defense
Asteroids ~~~ EMP?
Robots, space drone swarms
Multiple tools & techniques
Ready when needed

Motivations? Just "blue sky" dreaming?

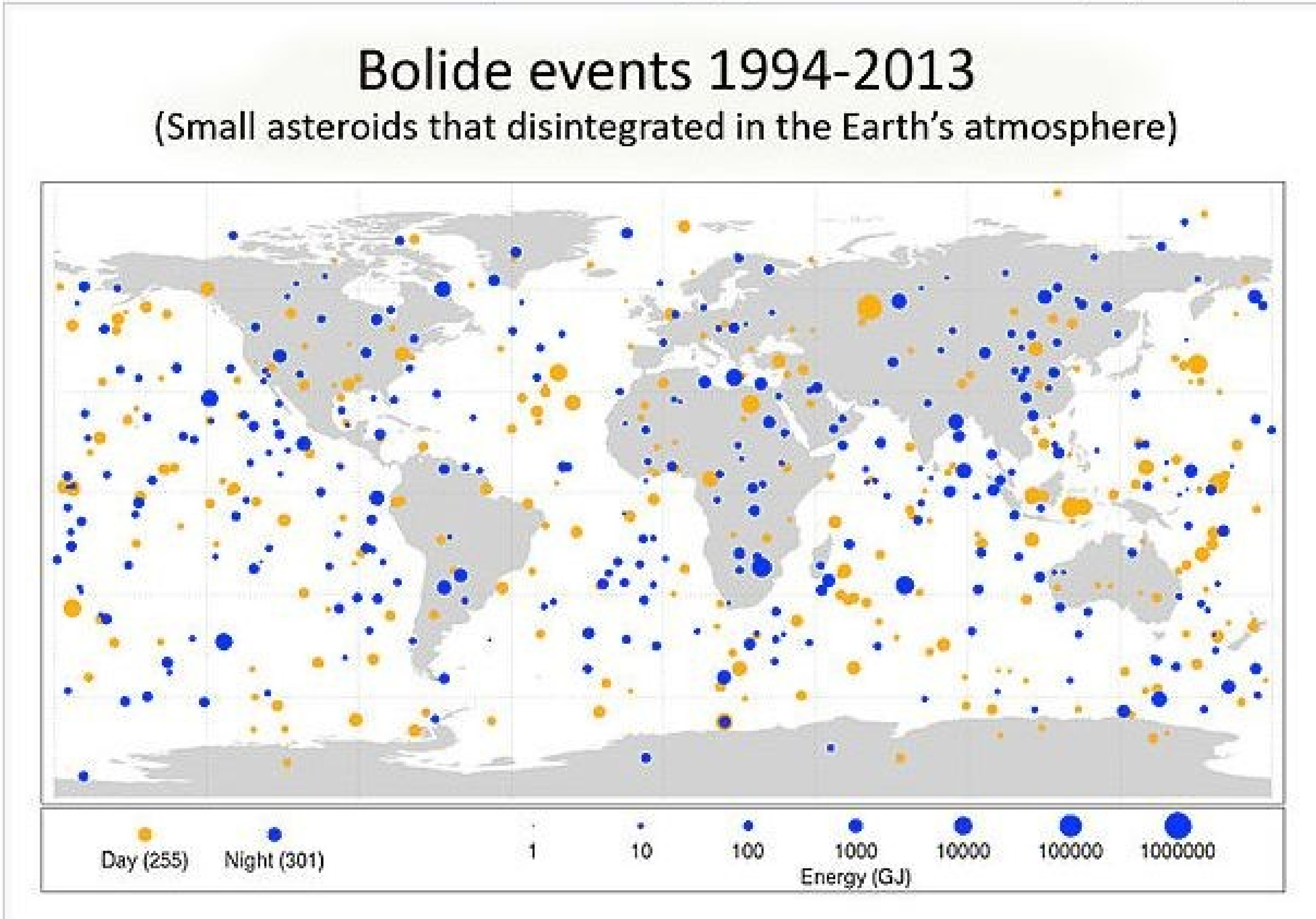
Plenty of Reasons

Some of us saw Climate Change Coming

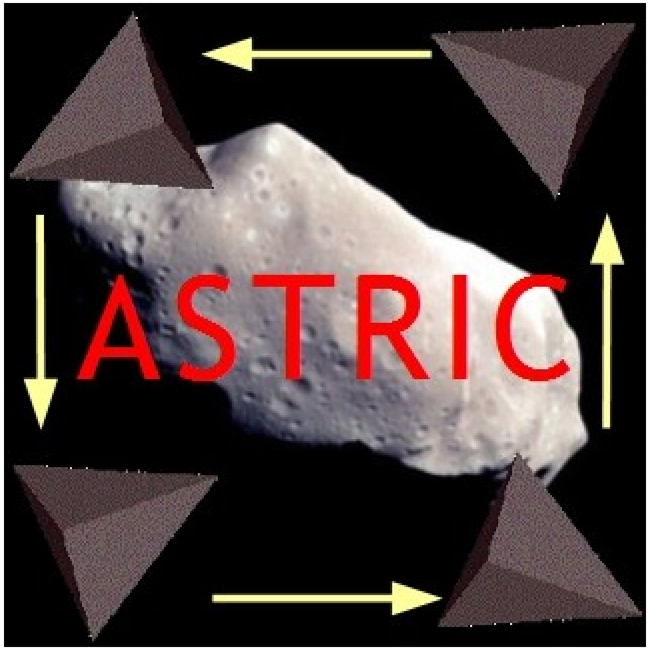
We saw CBRNE becoming a state-sponsored threat to global security and peace

The Need for Planetary Defense was Clear

The Opportunities for Space Exploration, Industry and Colonization were Evident



Frequency of small asteroids roughly 1 to 20 meters in diameter impacting Earth's atmosphere.



Precedents and Parallels

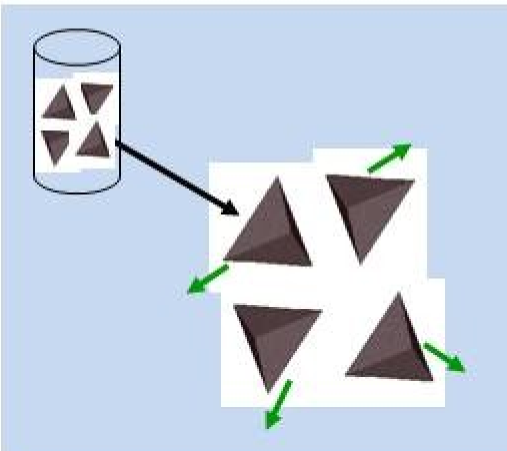
Studying the wind, the sea, learning from civil engineers and miners…

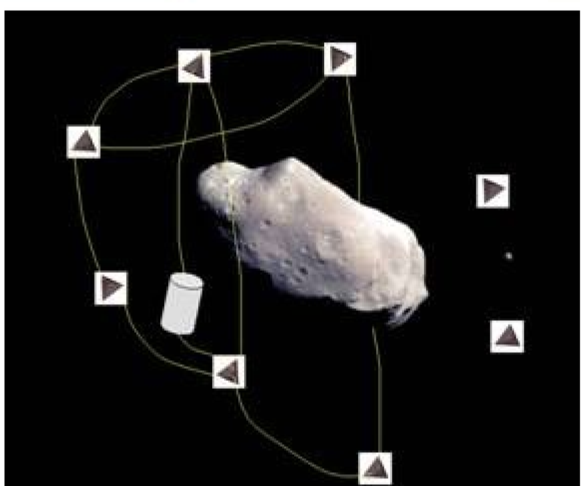
Space garbage collection

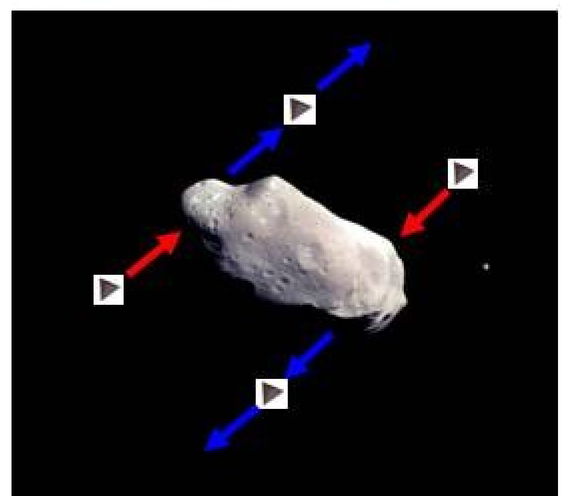
Collaboration and consortium people in the TETRAD team - interactive research over the years in this Project ASTRIC – an international and now growing family of minds:

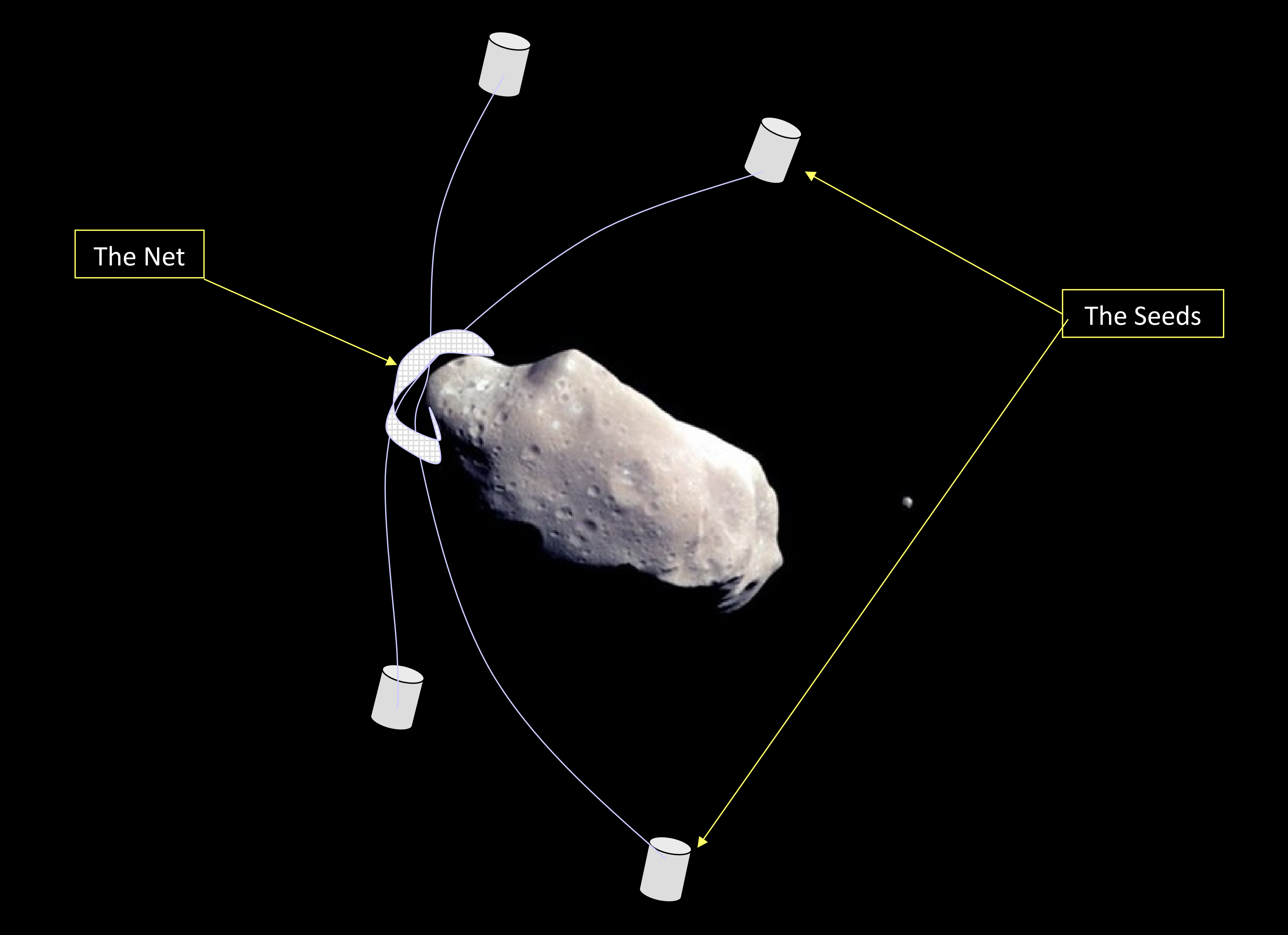
Copyright © 2022 TETRAD Institute

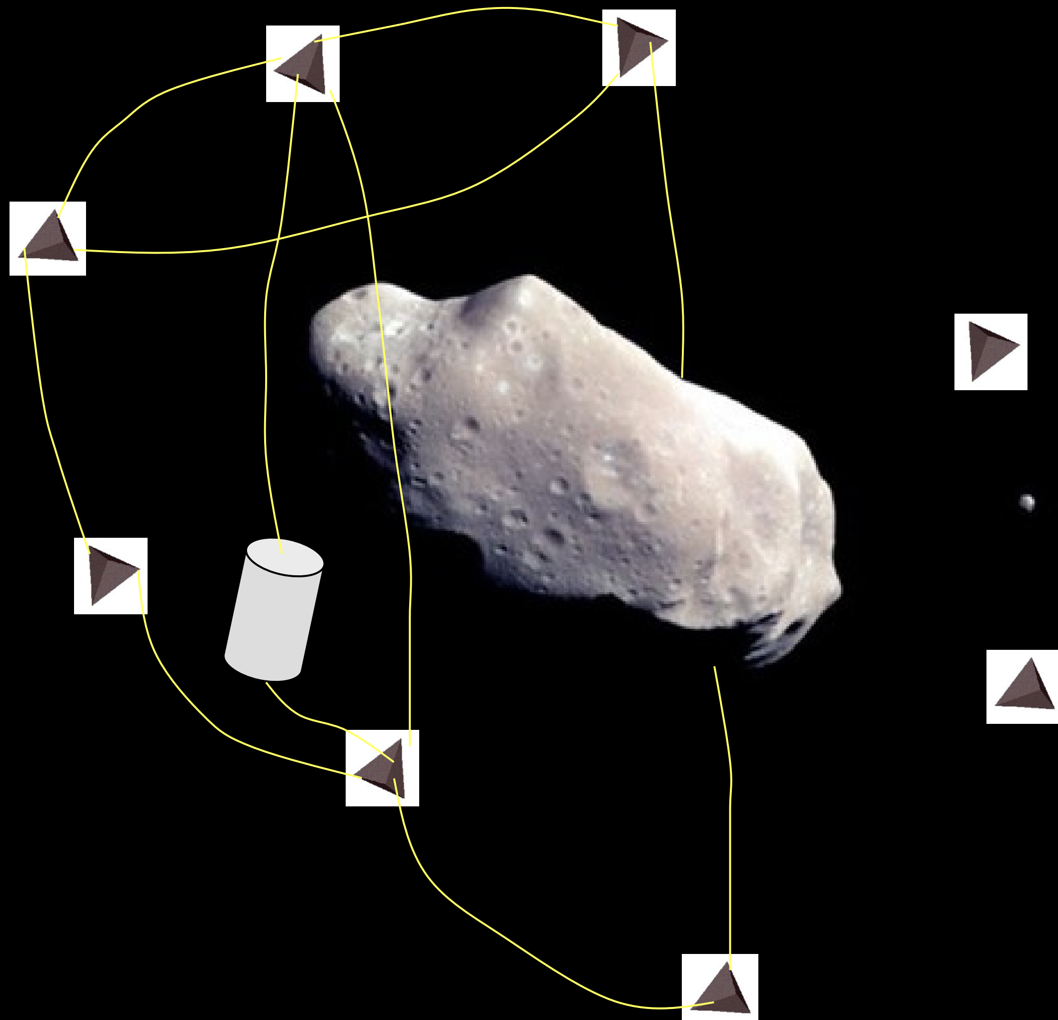
Root conceptual foundations and some other illustrations re: ASTRIC
(not only for collision-risk asteroids but for many other space-based engineering applications):

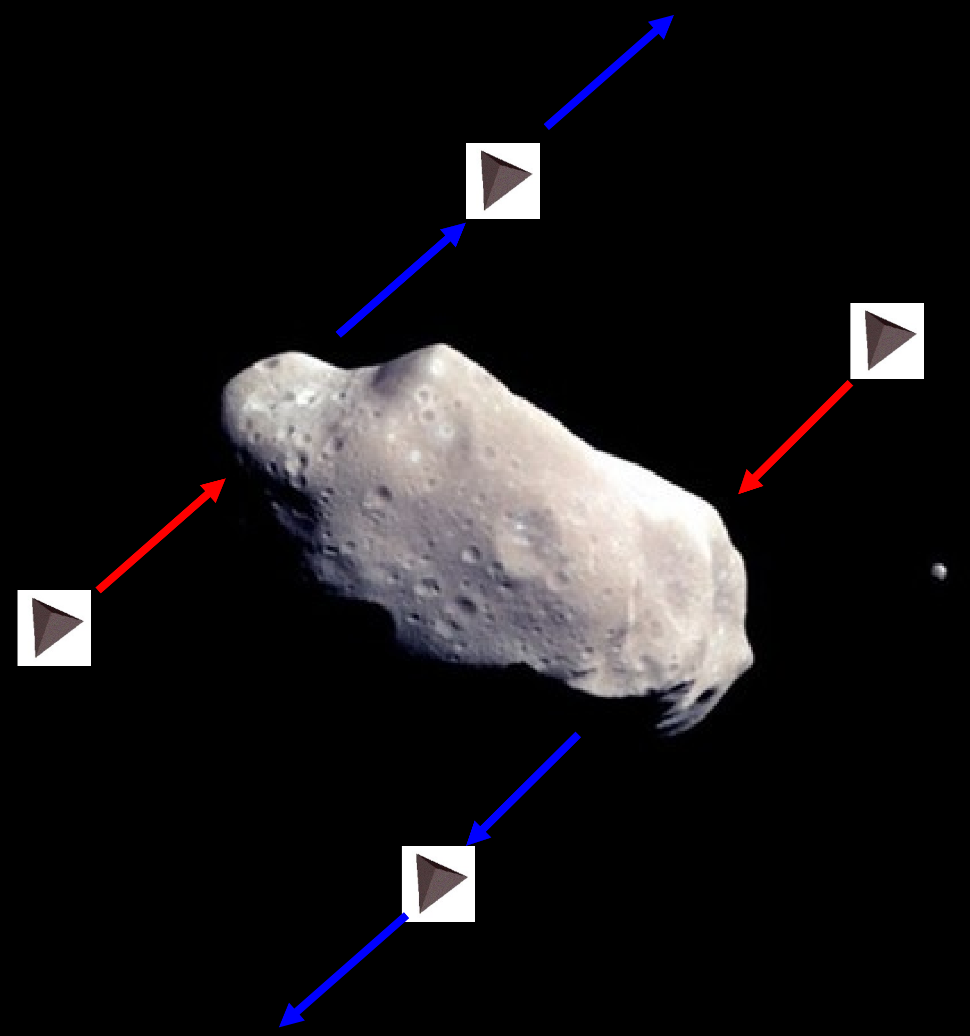




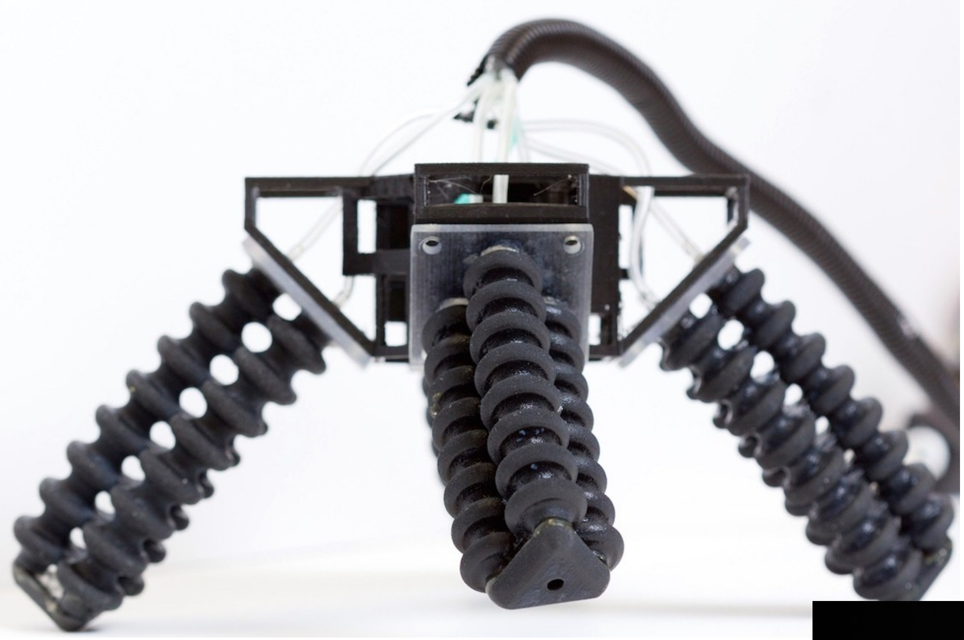



The Net
The Seeds



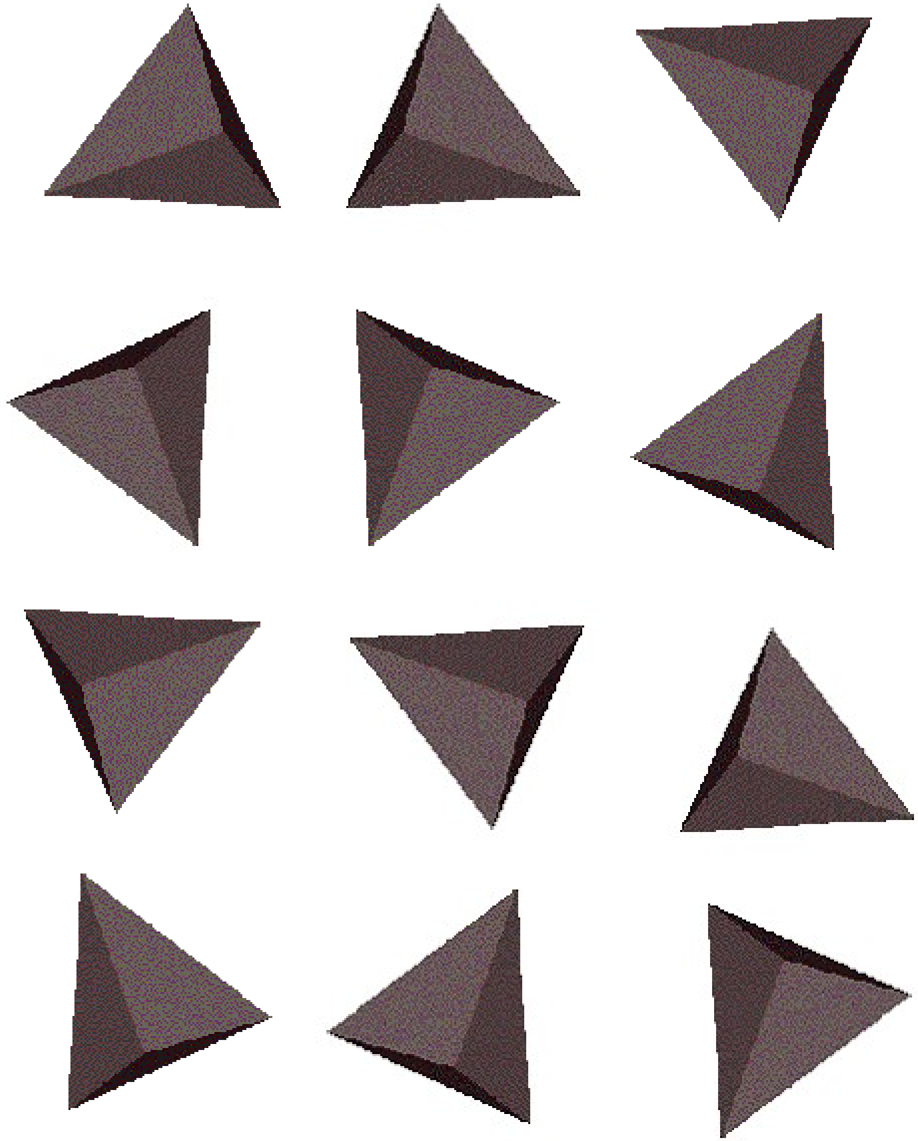


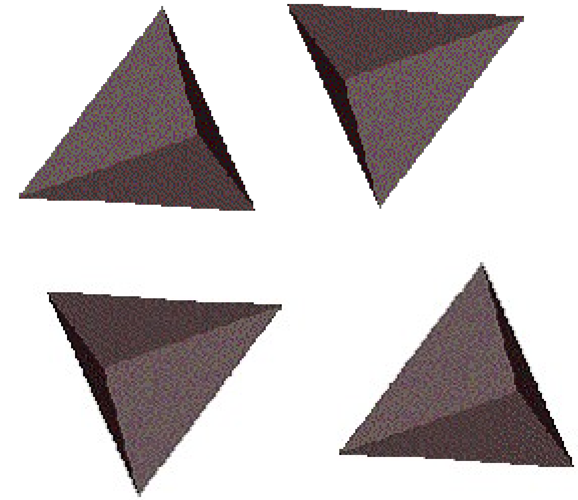
Real robots, some built for space (ISS), applied to remote self-controlling tasks with asteroids



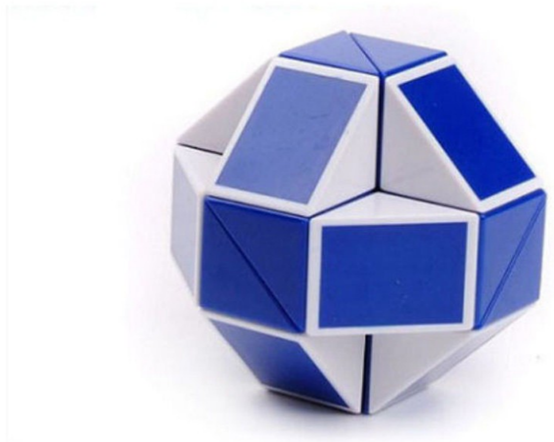
Cecilia Laschi, Professor of Biorobotics
Sant'Anna School of Advanced Studies, Pisa, Italy

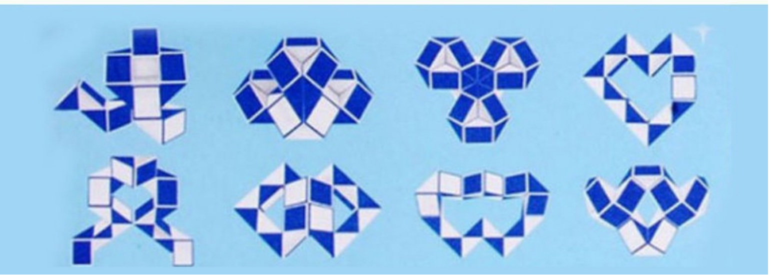
When you need a few arms and hands and flexibility, dexterity, and fault-tolerance, Think like an Octopus...

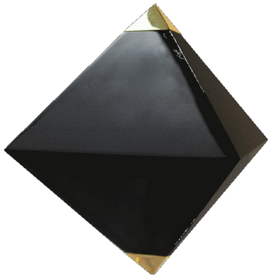


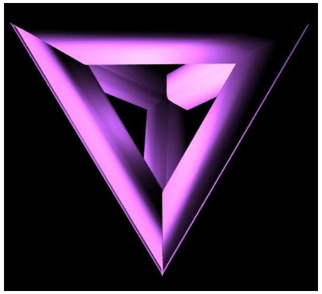


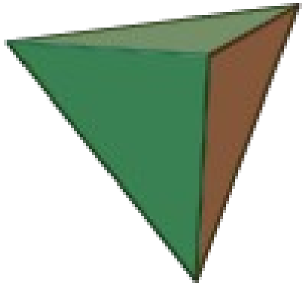
We paid special attention to the geometry of how to design the "drones" and how to pack them into a variety of launch and post-orbit transport cargo containers



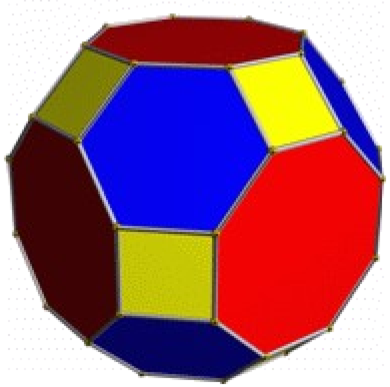


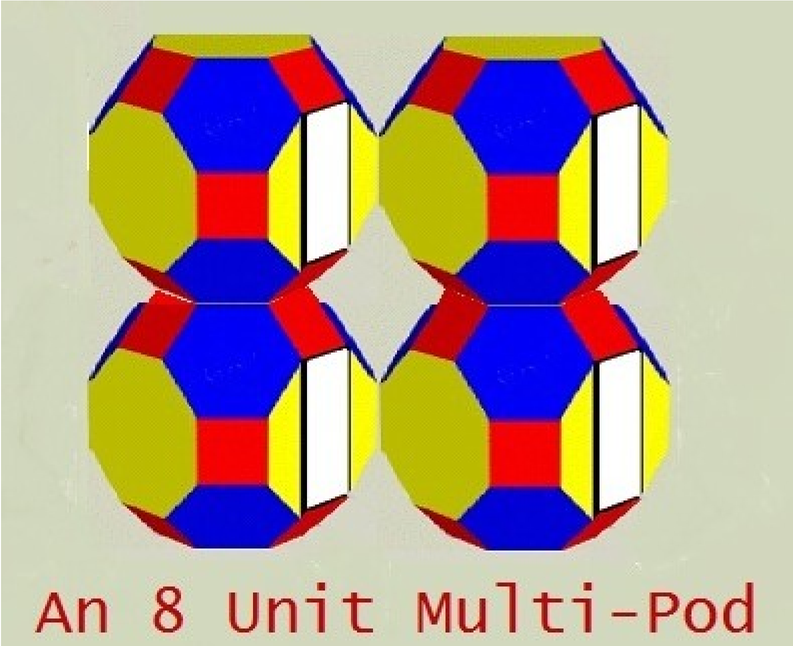


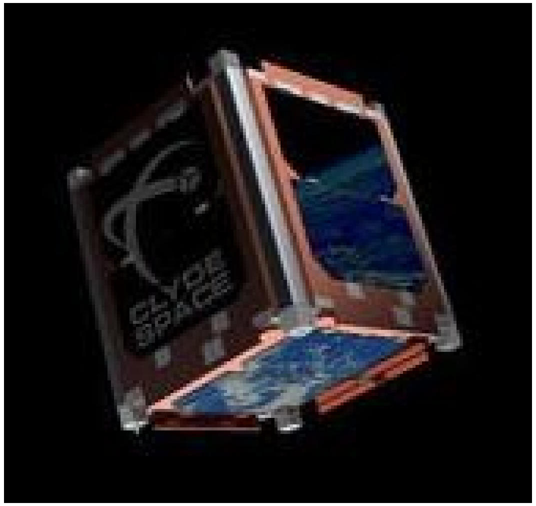




Many possibilities emerged for satisfying all the additional requirements and fail-safe needs beyond simple launch-into-orbit







We designed and made efforts to get a CubeSat launched as a simple, early-stage but useful prototype for certain cybernetic (control) tasks, and for modeling, for visibility in the world community – And for the education and experience of Students

We proposed constructive teaming to the Skylon developers as well as to Virgin Galactica and a few other more-well-knowns In the space industry

Even only a few years ago, things looked potentially ominous, given the calculations then for a certain asteroid, 99942 Apophis

We knew that any proper Planetary Defense Will require Multinational Cooperation

ASTRIC Global Laboratory Consortium Team Members

Fortunately, there is also a huge long-term open-ended

POSITIVE

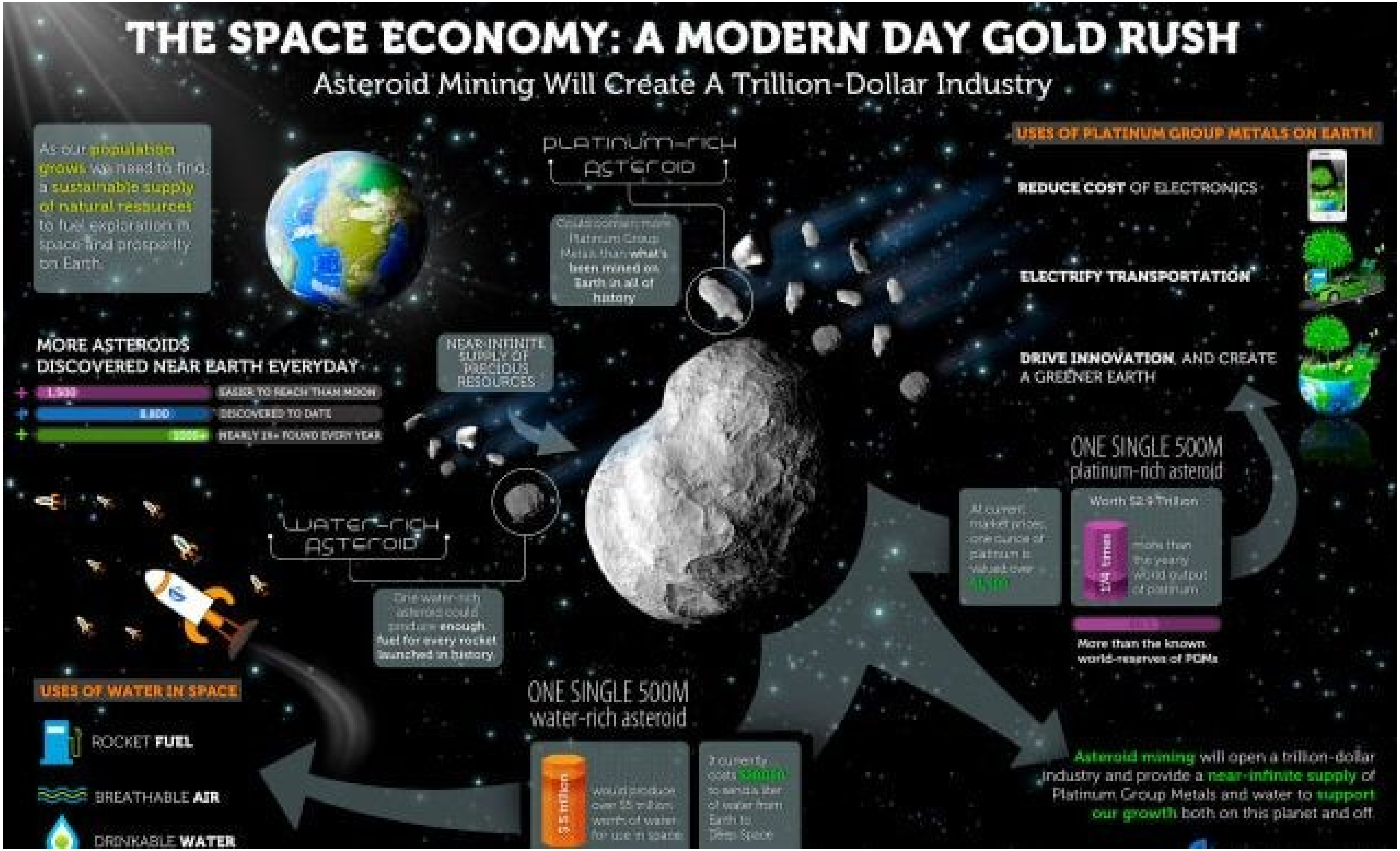
About engineering and deploying

A S T R I C

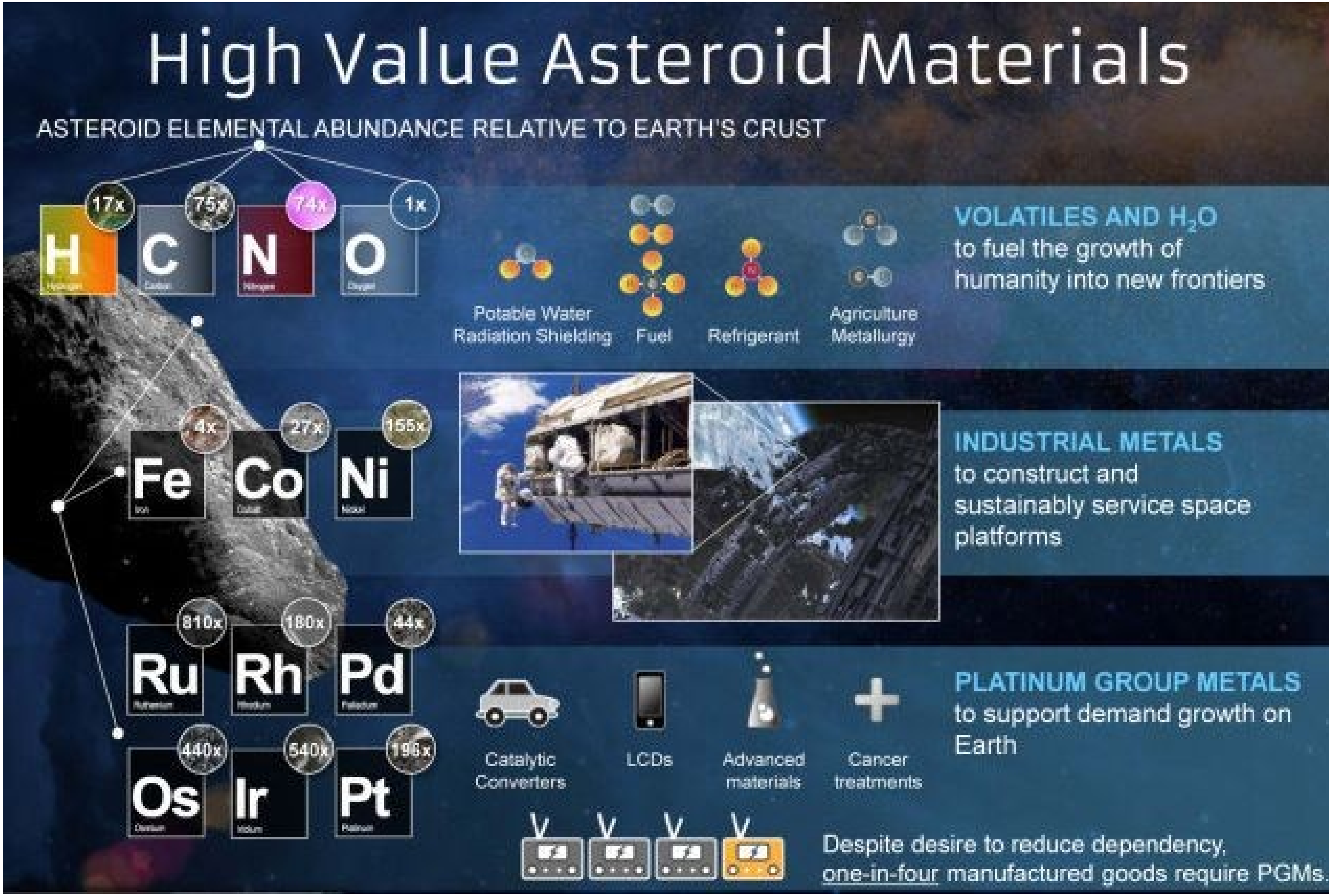
Astro Terrestrial Remote Interaction and Control

Asteroid Reconaissance Intervention and Control

and it has very positive economical and social dimensions



THE SPACE ECONOMY: A MODERN DAY GOLD RUSH
Asteroid Mining Will Create A Trillion-Dollar Industry
As our population grows we need to find a sustainable supply of natural resources to fuel exploration in space and prosperity on Earth.
PLATINUM-RICH ASTEROID
Could contain more Platinum Group Metals than what's been mined on Earth in all of history
NEAR INFINITE SUPPLY OF PRECIOUS RESOURCES
MORE ASTEROIDS DISCOVERED NEAR EARTH EVERYDAY
EASIER TO REACH THAN MOON
DISCOVERED TO DATE
WATER-RICH ASTEROID
One water-rich asteroid could produce enough fuel for every rocket launched in history
USES OF WATER IN SPACE
ROCKET FUEL
BREATHABLE AIR
DRINKABLE WATER
ONE SINGLE 500M
water-rich asteroid
USES OF PLATINUM GROUP METALS ON EARTH
REDUCE COST OF ELECTRONICS
ELECTRIFY TRANSPORTATION
DRIVE INNOVATION, AND CREATE A GREENER EARTH
ONE SINGLE 500M
platinum-rich asteroid
More than the known world-reserves of PGMs
Asteroid mining will open a trillion-dollar industry and provide a near-infinite supply of Platinum Group Metals and water to support our growth both on this planet and off.


High Value Asteroid Materials
ASTEROID ELEMENTAL ABUNDANCE RELATIVE TO EARTH'S CRUST
17x
H
75x
C
74x
N
1x
O
4x
Fe
27x
Co
155x
Ni
810x
Ru
180x
Rh
44x
Pd
440x
Os
540x
Ir
196x
Pt
Potable Water
Radiation Shielding
Fuel
Refrigerant
Agriculture
Metallurgy
VOLATILES AND H_2O
to fuel the growth of humanity into new frontiers
INDUSTRIAL METALS
to construct and sustainably service space platforms
Catalytic Converters
LCDs
Advanced materials
Cancer treatments
PLATINUM GROUP METALS
to support demand growth on Earth
Despite desire to reduce dependency, one-in-four manufactured goods require PGMs.

The key to Asteroid Defense =

Asteroid Operations = Asteroid Industry.

The key to that is in Intelligent Control of Cooperative Robots operating under Extreme Conditions, with fault-tolerance and fail_safe.

The key to that is "AI" based upon Natural, Biologically-based, Mathematically-proven Models. "Cybernetics for and with Swarms." Not so different from swarms of UAV drones that dance in the sky.

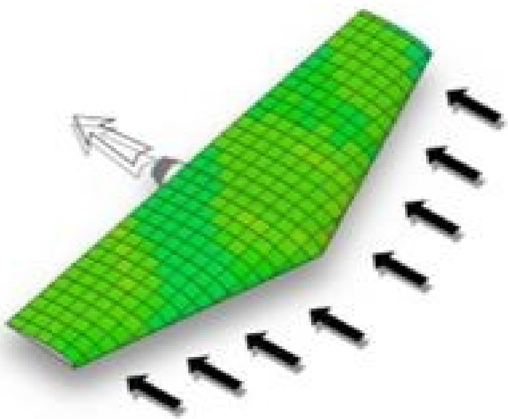
But also: Having the Business Model that fits and accompanies the Science and Technology is what creates Real Success.

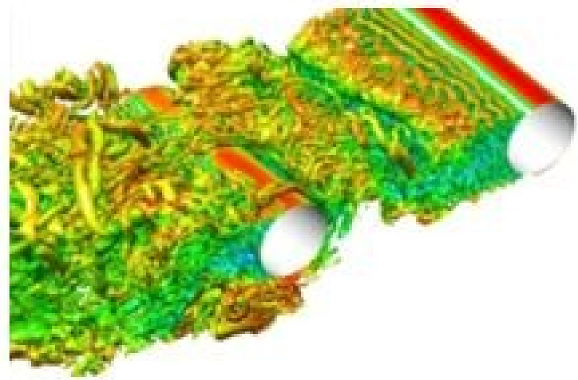
This is demonstrated and proven by others, repeatedly, in technology business sectors (e.g., Airbus, SpaceX).

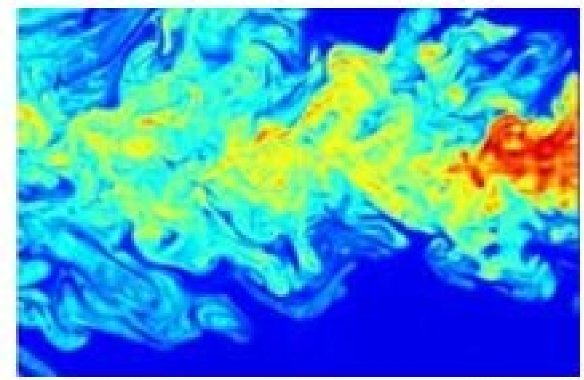
ASTRIC will accomplish the same successes.

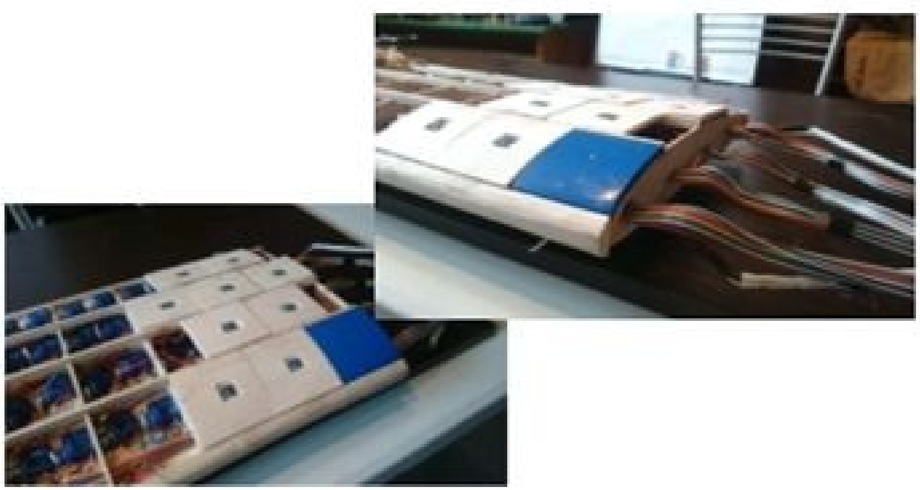
More Intelligent =

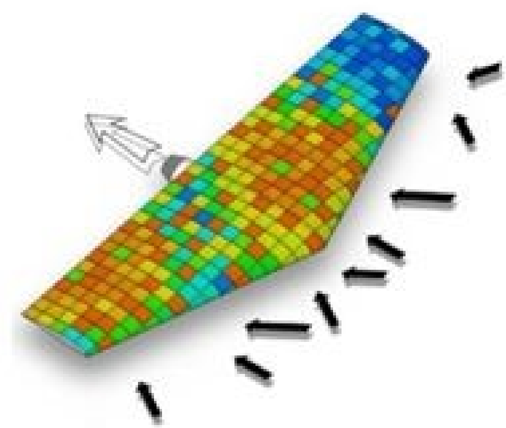
Responsive Adaptive Multi-Agent CONTROL Systems That Learn and Self-Modify Behavior





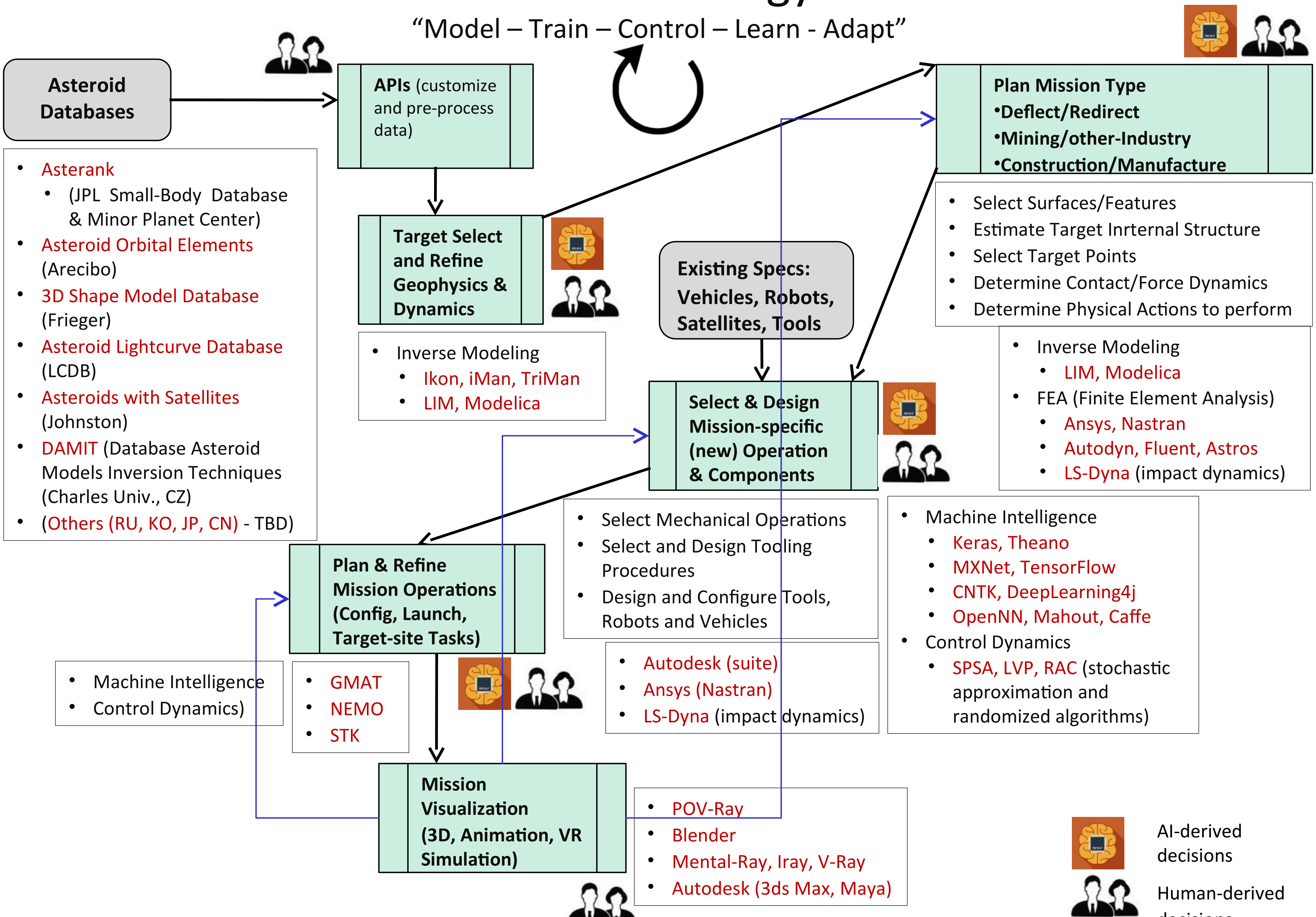






ASTRIC Technology Plan

"Model – Train – Control – Learn - Adapt"



Some Detail ---ASTRIC Technology Plan

"Model – Train – Control – Learn - Adapt"

Asteroid Databases

- Asterank
  - (JPL Small-Body Database & Minor Planet Center)
- Asteroid Orbital Elements (Arecibo)
- 3D Shape Model Database (Frieger)
- Asteroid Lightcurve Database (LCDB)
- Asteroids with Satellites (Johnston)
- DAMIT (Database Asteroid Models Inversion Techniques (Charles Univ., CZ)
- (Others (RU, KO, JP, CN) - TBD)

APIs (customize and pre-process data)

Target Select and Refine Geophysics & Dynamics

- Inverse Modeling
  - Ikon, iMan, TriMan
  - LIM, Modelica

Tasks:

Interactive computer-based model for asteroid selection

Definition of idealized asteroid dataset – the parameters required for designing a mission and the robot/satellite components

Methodology for estimating and simulating parameters for which data is sparse or not available

Methodology for generating one or more simulation representations of the target asteroid

What can we know from existing databases? From new observations that are possible? What can we estimate and simulate, in order to have a reasonable model of asteroid X in order to design how to make a rendezvous and how to perform tasks with that asteroid?

ASTRIC Technology Plan

"Model – Train – Control – Learn - Adapt"

Tasks:
Plan the precise Mission for the given target asteroid

Interactive AI-assisted tool for defining processes and sequences of actions for the specified mission

Identification and description of specific geometries and dynamics of the asteroid – the places to be manipulated, impacted, drilled, lasered, tethered, or otherwise operated-upon by ASTRIC unit(s)

Visualization models for all steps in asteroid approach, contact and mechanical manipulation

Identification of all critical-step points and modeling of fault-tolerance procedures to avoid or to recover from system failure

What will we do with the specified asteroid? (Objectives can be to deflect it from Earth by changing its trajectory, using one of several methods, or to break it up into smaller fragments, or to perform mining operations, or some other constructive task.) What are the positions on the asteroid that must be used in the operation? How will the ASTRIC devices (robot-satellites) make contact with the asteroid surface and perform their tasks?

Plan Mission Type
- **Deflect/Redirect**
- **Mining/other-Industry**
- **Construction/Manufacture**

- Select Surfaces/Features
- Estimate Target Inrternal Structure
- Select Target Points
- Determine Contact/Force Dynamics
- Determine Physical Actions to perform

- Inverse Modeling
  - LIM, Modelica
- FEA (Finite Element Analysis)
  - Ansys, Nastran
  - Autodyn, Fluent, Astros
  - LS-Dyna (impact dynamics)

- Machine Intelligence
  - Keras, Theano
  - MXNet, TensorFlow
  - CNTK, DeepLearning4j
  - OpenNN, Mahout, Caffe
- Control Dynamics
  - SPSA, LVP, RAC (stochastic approximation and randomized algorithms)

AI-derived decisions

Human-derived decisions

ASTRIC Technology Plan

“Model – Train – Control – Learn - Adapt”

Tasks:

Interactive computer-based model for modeling of mission operation steps and components (including those components selected from among other device designs; e.g., ESA, DLR, GMV, NASA, JAXA, etc.)

“Mapping” function – from the abstract operation to the instrument (device) hardware and electronics: given device (“d”) with complement of arms, grippers, sensors, tools (“t”), define the algorithm for each step to be performed in order to accomplish that procedure of the mission.

Visualization including VR (virtual/augmented reality) environment for performing each step in a mission.

How will device d perform its tasks using its toolset t on the target asteroid? How will the system recover from a subsystem failure or something like a “crash” event?

Compare devices d1 and d2, with different toolsets t1 and t2. What are the trade-offs? Which can do the job best and most reliably?

How will all the mission components be packaged into the launch vehicle and transported?

Select & Design Mission-specific (new) Operation & Components

- Select Mechanical Operations
- Select and Design Tooling Procedures
- Design and Configure Tools, Robots and Vehicles

- Autodesk (suite)
- Ansys (Nastran)
- LS-Dyna (impact dynamics)

- Inverse Modeling
  - LIM, Modelica
- FEA (Finite Element Analysis)
  - Ansys, Nastran
  - Autodyn, Fluent, Astros
  - LS-Dyna (impact dynamics)

- Machine Intelligence
  - Keras, Theano
  - MXNet, TensorFlow
  - CNTK, DeepLearning4j
  - OpenNN, Mahout, Caffe
- Control Dynamics
  - SPSA, LVP, RAC (stochastic approximation and randomized algorithms)

AI-derived decisions

Human-derived decisions

ASTRIC Technology Plan

“Model – Train – Control – Learn - Adapt”

Tasks:

Given a test-set of mission components, model the overall mission steps involved in configuration of the launch vehicle(s), launch and transportation to the target asteroid destination, and all operational steps.

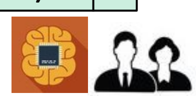
Prepare the project schedule for each component and each step in preparation, launch, transit and final operations.

What must be completed and delivered by whom and by what time? What are the backups and recovery methods?

Plan & Refine Mission Operations (Config, Launch, Target-site Tasks)

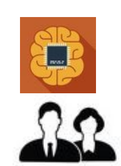
- Machine Intelligence
- Control Dynamics)

- GMAT
- NEMO
- STK



- Autodesk (suite)
- Ansys (Nastran)
- LS-Dyna (impact dynamics)

- Machine Intelligence
  - Keras, Theano
  - MXNet, TensorFlow
  - CNTK, DeepLearning4j
  - OpenNN, Mahout, Caffe
- Control Dynamics
  - SPSA, LVP, RAC (stochastic approximation and randomized algorithms)



AI-derived decisions

Human-derived decisions

ASTRIC Technology Plan

"Model – Train – Control – Learn - Adapt"

Tasks:
Produce refined visualization and animation models for all steps of the mission production.

Using 3D rendering tools, prepare visualizations that can be logically mapped to each sequence of the mission.

Using interactive tools, enable the visual simulations to be modified in such a manner so that modifications in the animations can be reflected into mission operational databases, and vice versa, changes to the object database for mission components and target asteroid parameters can be reflected in the visualizations.

What can be learned by seeing and manipulating animated robots performing tasks on the asteroid, which can be transformed into changes within those devices and their procedures? How can we expedite and economize the entire process of designing multiple devices that can be economically launched, travel to a location in space, rendezvous with an asteroid, and perform physical tasks – and have the overall mission recover from different operational failures and still complete its main tasks?

- Machine Intelligence
- Control Dynamics)

- GMAT
- NEMO
- STK

Mission Visualization (3D, Animation, VR Simulation)

- POV-Ray
- Blender
- Mental-Ray, Iray, V-Ray
- Autodesk (3ds Max, Maya)

AI-derived decisions

Human-derived decisions

Scaling-Up (Fractally) from Local Cellular Networks to Logical/Semantic Fields, Surfaces, Volumes of Control-focus Spaces (Systems)

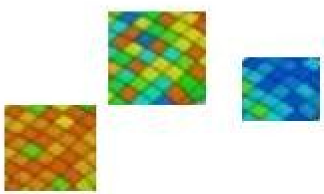
Example system: a highly flexible “soft” robot - No image Here because it does not yet exist, and there is nothing – Nothing! – else like it anywhere yet in the world

It shares some points in common with “wings with feathers” but we are thinking here about the whole system and all its behaviors. It may have 4 or 8 arms/legs and need to operate a drill or grab onto a rocky surface, or tighten a tether around an asteroid.

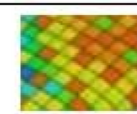
Internal objectives are multiple, and may be in conflict – just as in biology and psychology! How do humans decide in walking, holding, thowing?

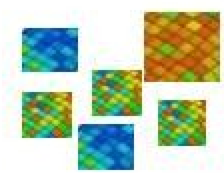
There are some overriding system constraints – called “instincts” and also “purposes” – and the decision processes each step of the way from identification of target to action is multi-agent and multi-scale!

[1] Different local cellular neighborhoods are selected and evaluated randomly in terms of local size, geometry, relationship with others and with prior measurements



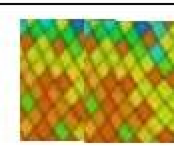
[2] Encompassing larger neighborhoods that include contiguous local-net sets, or that are composed on basis of functional or geometrical relationships among different sets

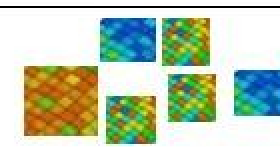




[1](a) Local-nets are considered as sets and their geometry matters as well as the values of their parameters being measured

[3] Encompassing still larger neighborhoods that are created by grouping that may be on basis of geometry or semantic relationships – which may also be randomly selected and measured!





We know about the severe threat from asteroids

This is often neglected and downplayed. People lose interest. Investors want tangible short-term returns, profits. *"Saving the world is not profitable!"*
But other things about asteroids – and ASTRIC – are very profitable.

The economic benefits and financial returns of asteroid mining and other industrial uses are immense. Even more so are the returns and profits from AI, control of turbulence, social media forecasting, and other "XCS" analytics – *ALL of which come from the Core Technology Required for ASTRIC !*

Our Strategy will help attract stronger, larger, easier sponsors and funding sources – because we offer real and practical technologies that have short-term, near-term, broad applications and usefulness.

The science and technology for optimal asteroid defense is precisely what is required for commercial, industrial space-applications – for not only Asteroid utilization but Moon and Mars missions.

What ASTRIC is developing and will provide in research, education, and technology transfer, is (*very important!*) useful and required not only for Space but for many other "earthbound" applications.

ASTRIC uses, builds-upon, integrates, and improves upon what is in several groups and labs

- ♦ Existing knowledge-bases and data for asteroids (orbits and astro-geology)
- ♦ Simulation, modeling and visualization tools (including VR - virtual/augmented reality)
- ♦ Unique cybernetic and AI models (e.g., SPSA, randomized, local-voting, cellular-automata)
- ♦ Innovations in mechanics, robotics, materials, lasers, ion propulsion
- ♦ Integration of supercomputing (plus new architectures; e.g., "Real" quantum computing)
- ♦ Advances in ballistics and kinetic impact technologies
- ♦ Innovations in "smart materials" for space construction robots

ASTRIC necessarily brings together multiple technologies because the problems to be solved demand New Thinking from conventional space programs/agencies

This is the Opportunity for an International Team to Lead in the Most Significant and Important Scientific and Technology Project of History Pioneering and Integrating Space, Computing, AI and Intelligent Systems, Planetary Defense and Security, Solutions for 21st Century Critical Problems

(Explicit) **Mission of the Laboratory:**
Asteroid Defense and Space-Based Industrial Engineering

These two areas are interdependent, mutually supportive and *necessarily must proceed together* in order for the research and development required (for each) to be properly supported and to succeed

Engineering Emphasis:

- Cooperative Autonomous Robotics
- Multi-Agent, Multi-Tasking Technologies
- Composite "Smart" Materials
- Flexible joints, extenders, grippers
- Reconfigurable modular satellite and robot components
- Innovative propulsion (especially ion thrusters)
- Innovative ballistics and kinetics

AI (artificial intelligence)
SI (synthetic intelligence)
Machine Learning

The key to success is in the Implicit Task and Goal of the Laboratory:
Correct, practical, focused development of

Adaptive Intelligent Control Systems

appropriate for "XCS" (Extreme Complex Systems – high uncertainty, non-linearity, noise, "NP-hard" models, inverse modeling requirements, etc.)

(Implicit and Extended) **Mission of the Laboratory:**

Adaptive Intelligent Control Technology for Extreme Complex Systems

A systems-oriented approach to inherently-non-deterministic systems in the natural and human-made worlds.

Information+Computing Emphasis:

Stochastic, randomized modeling and control
Inverse modeling methods
Multi-Agent parallel distributed computing
Biologically-inspired AI and Machine Learning
"Topological computing" (e.g., macromolecular arrays with graphene)
Quantum computing at high-temperatures (no cryogenics)
Constructive use of noise, error and uncertainty
Control that learns and adapts and expects future change

Biological and quantum-physical basis
Heterogeneity and asynchronous parallelism

The key to success is in the research and development is through linking Theory with clear, definite targets in

Applied Engineering System Problems

which will have immediate, near-term achievable Solutions as Verifiable Results

Here is how the landscape is envisioned starting Today

ASTRIC fits the interests, wants and needs of many organizations and programs in EU and western Europe, Asia, and also USA.

The Key First Steps are with places that already have activity, support, and relationships connected with multiple projects in:

Asteroid Defense and Mining
Cooperative Robotics
Artificial Intelligence
New Computing Architectures
Complex Systems

ASTRIC can help an Integrated Team (EU, UK, NO, RU, KO, JP, US, others) to achieve their goals better, by their teaming with and supporting us.

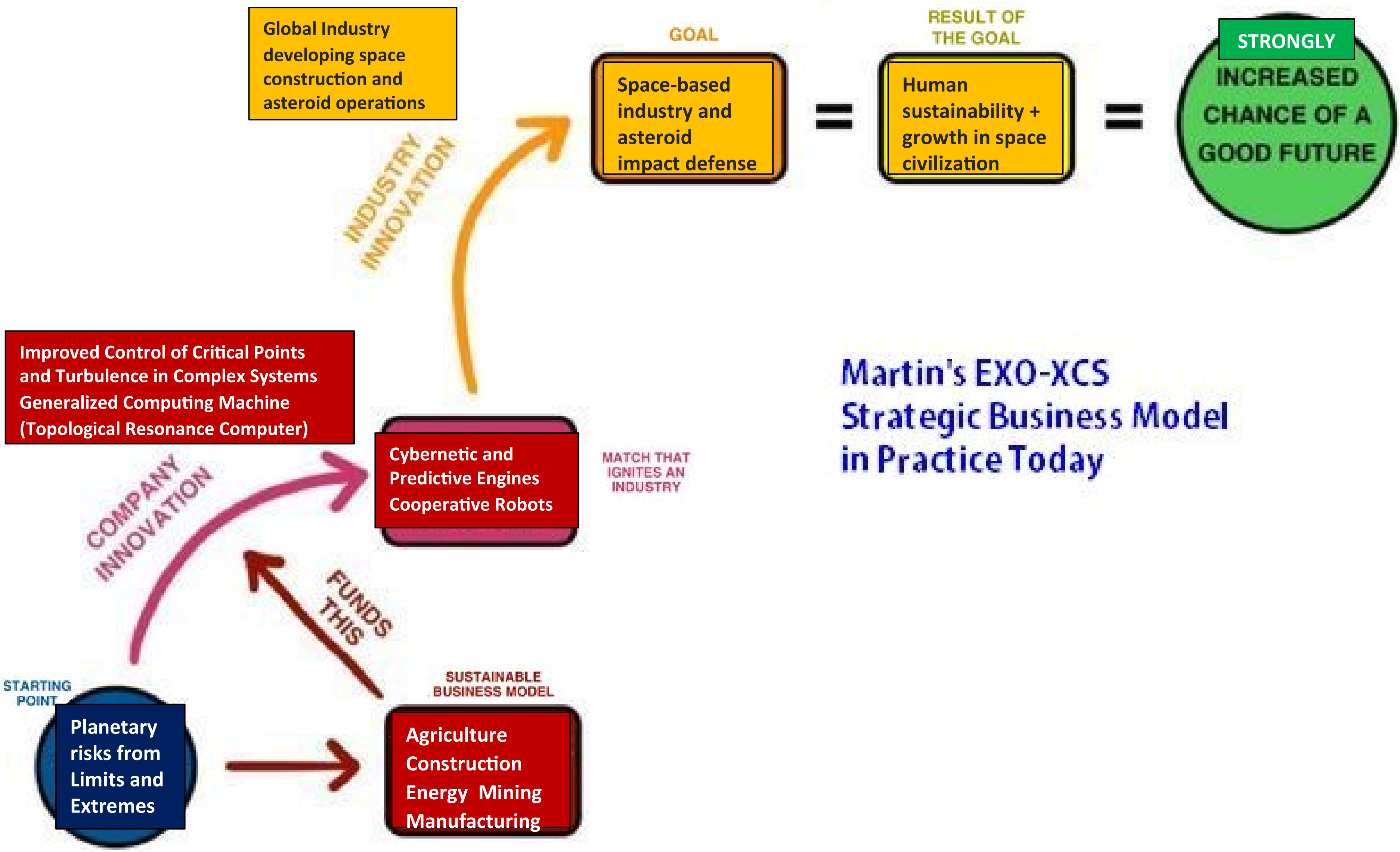
ASTRIC will provide the *major items missing and lacking in other programs* (e.g., NEOShield, AIM, ARM, DART) that are critical for any asteroid missions:

Systems Engineering **Intelligent Control Systems (Cybernetics)**
New Robotics **Reconfigurability and Reusability**
Real "AI" (artificial intelligence) and Machine Learning
New computing architectures ("heterogeneous computing")

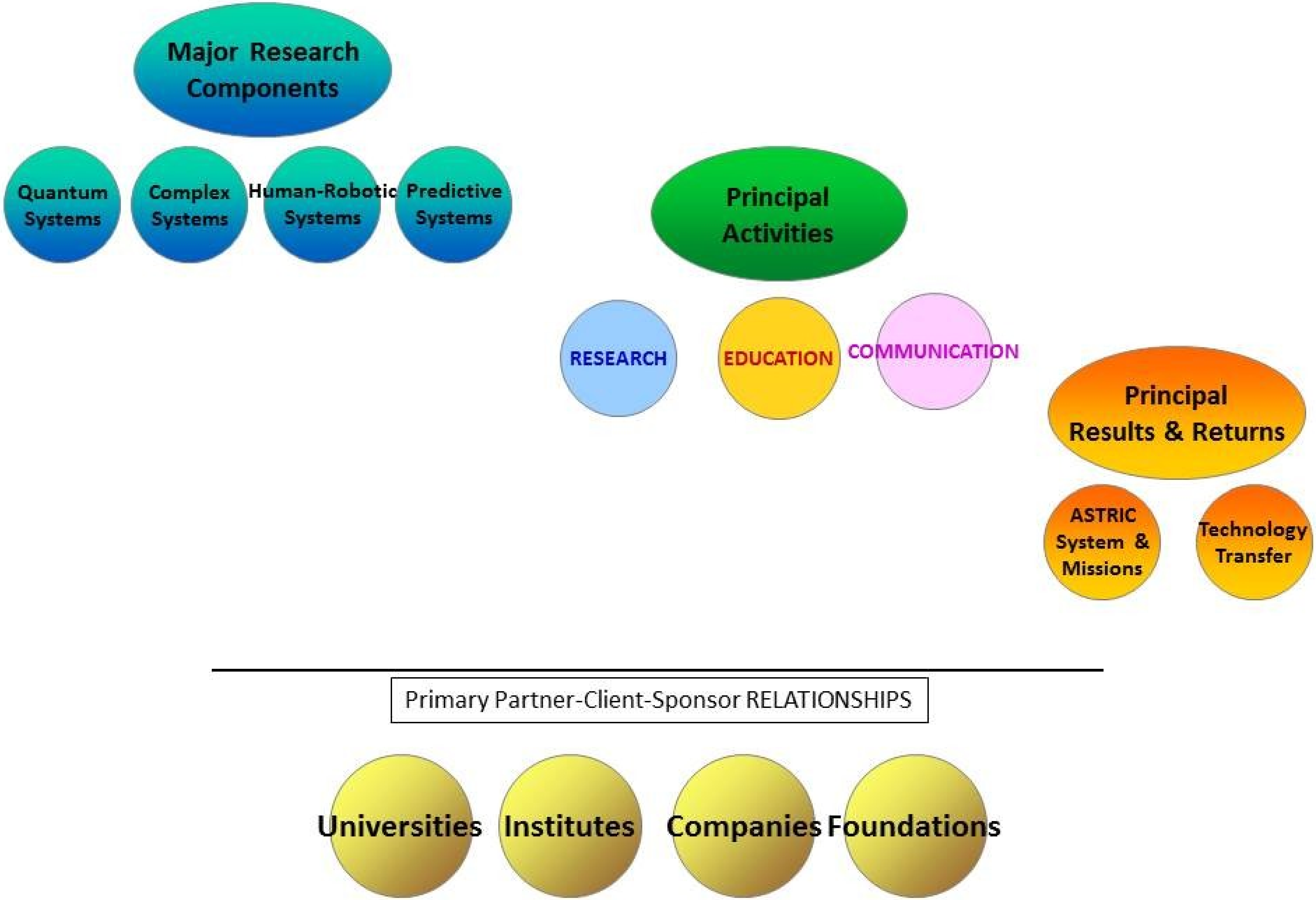
ASTRIC combine and creates things that are missing in other approaches. This will be recognized and bring strong support.

It is important to recognize the importance of **Control (Cybernetics)** and **Intelligence (AI)** for Space, for Cooperative Robots, and for Extreme Complex Systems.

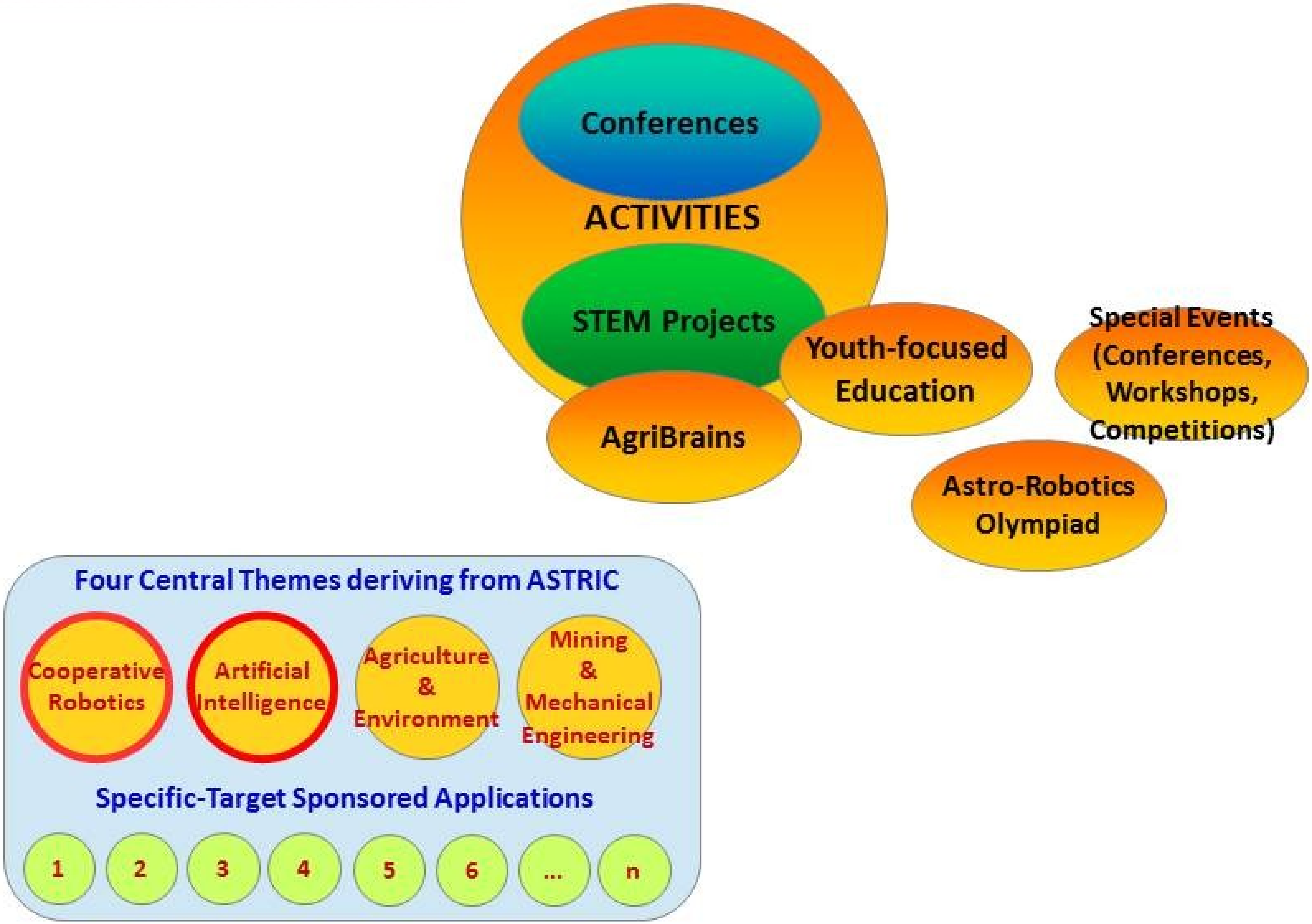
It is valuable that what ASTRIC produces can be applied easily to other fields and problems. This is the important "selling point."



Martin's EXO-XCS Strategic Business Model in Practice Today


Major Research Components
Quantum Systems
Complex Systems
Human-Robotic Systems
Predictive Systems
Principal Activities
RESEARCH
EDUCATION
COMMUNICATION
Principal Results & Returns
ASTRIC System & Missions
Technology Transfer
Primary Partner-Client-Sponsor RELATIONSHIPS
Universities
Institutes
Companies
Foundations

ASTRIC-derived
Educational and
Cross-Disciplinary Activities



"How Much and How Long?

ASTRIC can lead to a complete ASTRIC Mission System capable of rendezvous and construction or redirection (deflection) with an asteroid within 3 LD (Lunar Distance; 1 LD ~ 384,000 km) within 5 years. **(Let's not be 5 years too late for Earth!)**

The cost for design and development can certainly be significantly less than the estimated cost of the ARM (Asteroid Redirection Program) program (NASA, now terminated from new USA budget) – over $1.25B.

ASTRIC's expanded budget with Euro/Asian partners can surely be less than NEOShield (€ 5.5M, 3 years) and NEOShield-2 (€ 4M, 2.5 years)

ASTRIC's initial Phase 0 Budget is for SUSU to establish the ASTRIC Global Laboratory. Everything else builds upon that "foundation-stone."

?

Abilities

Choices

Decisions

Destinies

?

Here we are today,
Focusing on This,
the Human "Usual"

!

We

CAN

MUST

Do Better

!

"Ad Astra per Aspera" - To the Stars, Through Hard Work

Believing Makes Big Things Possible.
Working Harder Makes Them Real.

@ 2032

Consider just these three events.

Two are from the recent past. 20Th & 21st century events.

One is a near-miss and a future maybe.

But, depending on some *unpredictables*,
it might not be a "maybe" – even if our lifetimes.

June 30, 1908


OCEAN ARCTIQUE
NOR
SUEDE
FIN
POL
BELA
Moscou
RUSSIE
Sibérie
KAZAKHSTAN
CHINE
JAPON
MONGOLIE



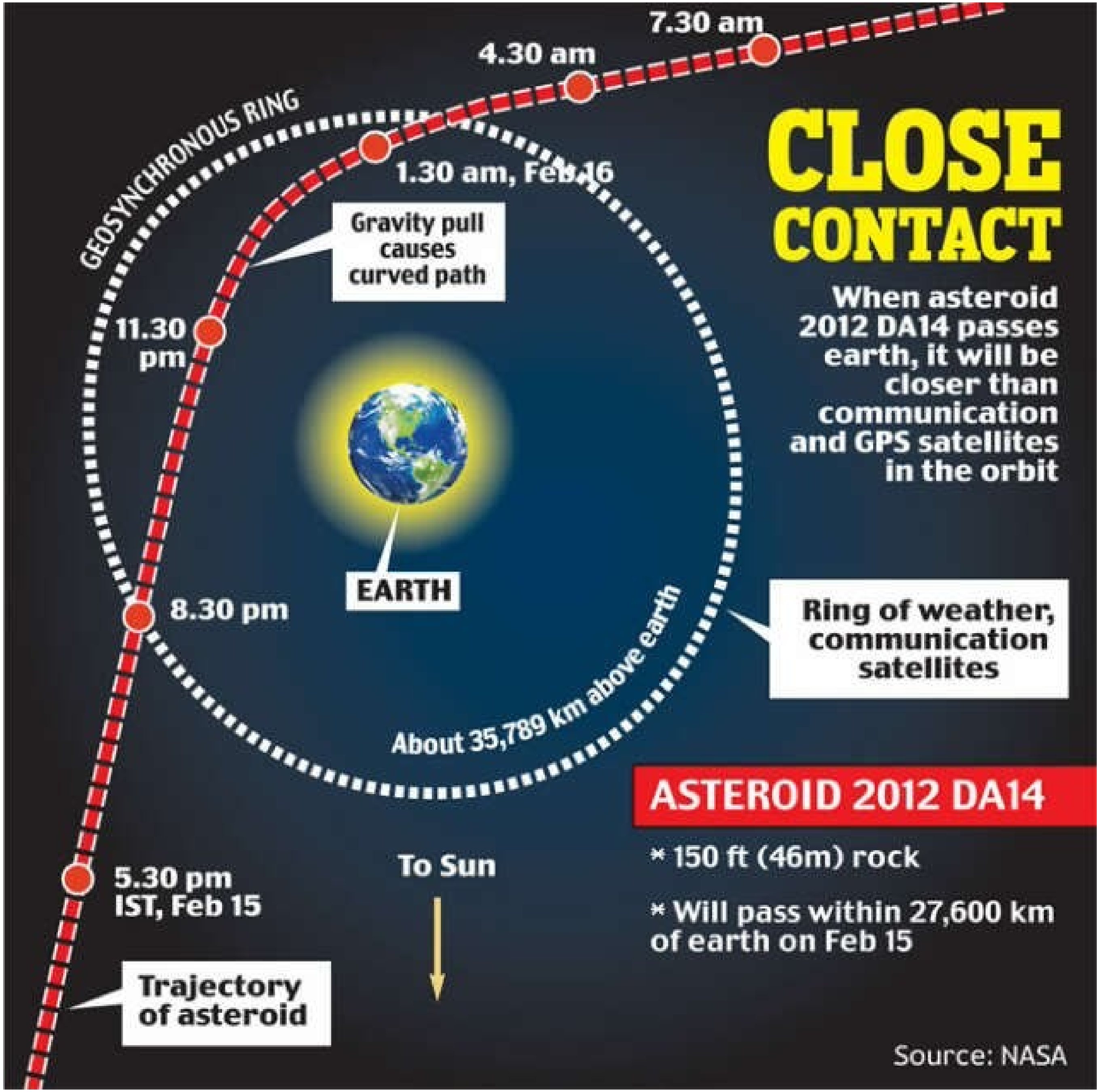

Shift forward
almost 105 years…

Advances in science and technology

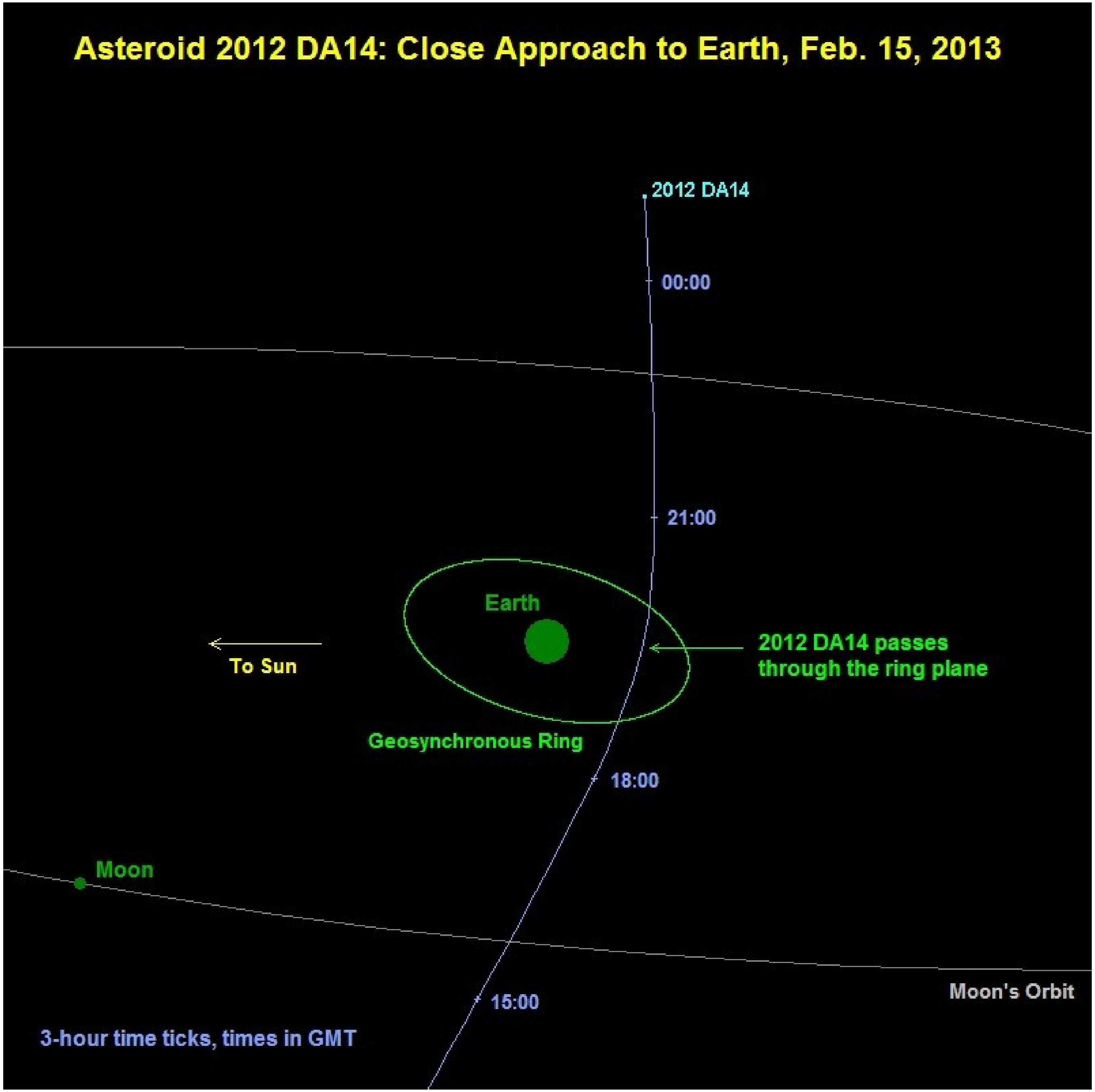
Several billion more people
Major cities everywhere
and a highly interdependent global society

Ability to track some asteroids…
But not all

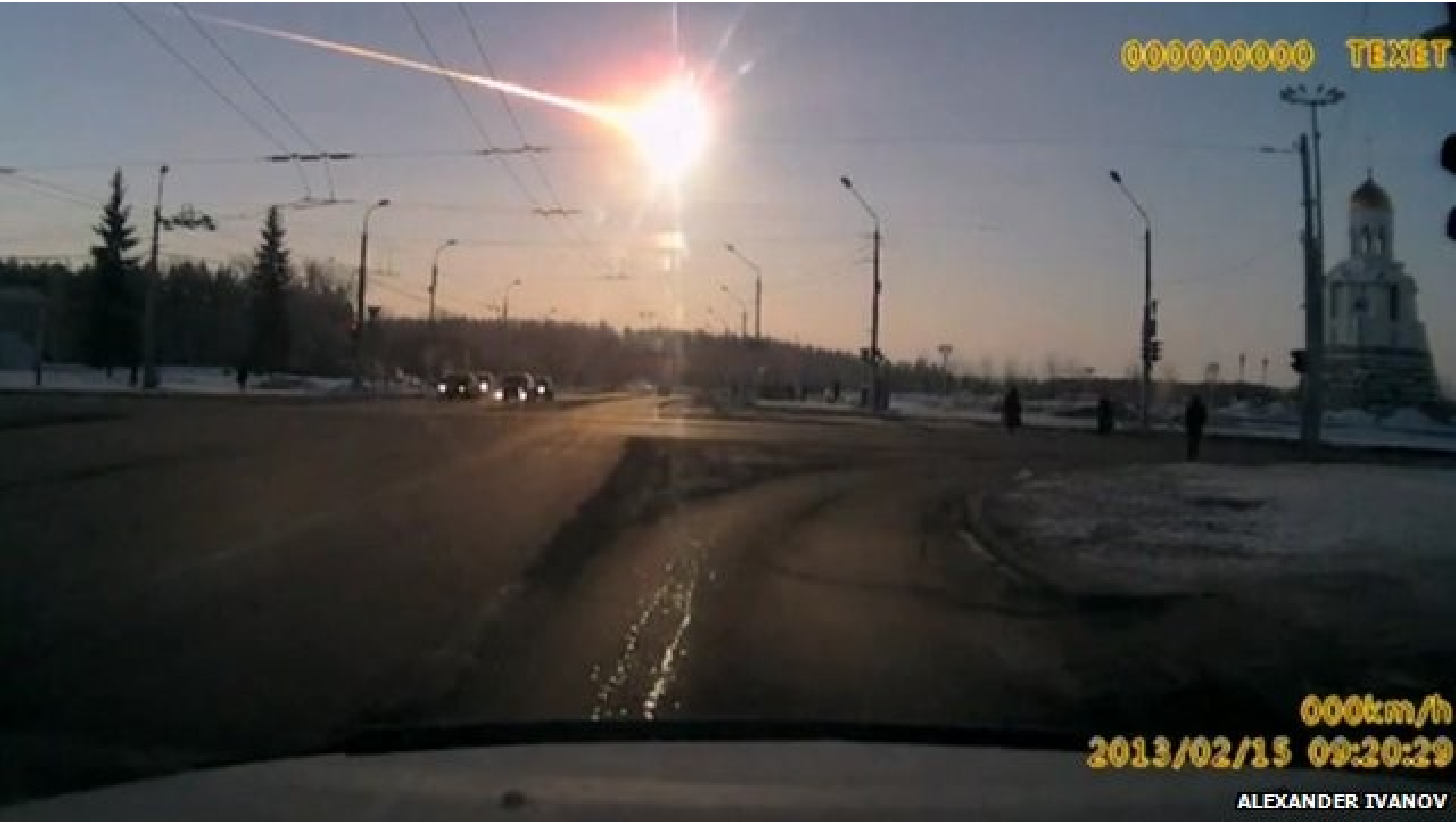
And what to do even if we track another like Tunguska?



CLOSE CONTACT
When asteroid 2012 DA14 passes earth, it will be closer than communication and GPS satellites in the orbit
7.30 am
4.30 am
1.30 am, Feb 16
GEOSYNCHRONOUS RING
Gravity pull causes curved path
11.30 pm
EARTH
8.30 pm
About 35,789 km above earth
Ring of weather, communication satellites
5.30 pm IST, Feb 15
To Sun
Trajectory of asteroid
ASTEROID 2012 DA14
* 150 ft (46m) rock
* Will pass within 27,600 km of earth on Feb 15
Source: NASA


Asteroid 2012 DA14: Close Approach to Earth, Feb. 15, 2013
2012 DA14
00:00
21:00
Earth
To Sun
2012 DA14 passes
through the ring plane
Geosynchronous Ring
18:00
Moon
Moon's Orbit
15:00
3-hour time ticks, times in GMT

Earthlings! This is a Wake-Up Call...



February 15, 2013


Published 2013

Sheer luck, this was all...

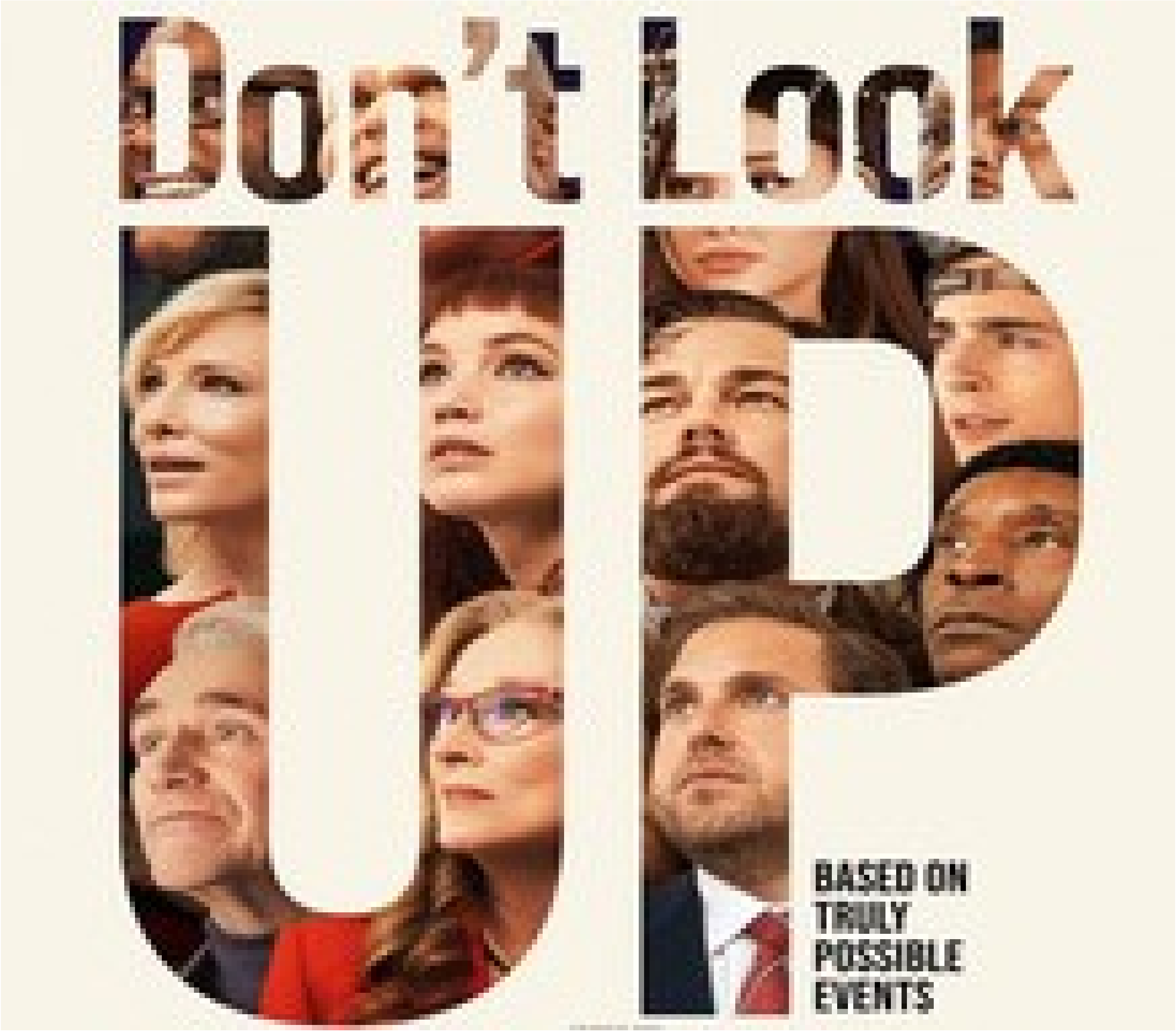
7812 days, 14 hours, 0 minutes, and 23 s

Sure glad we were Wrong
About this one…
I think we are pretty sure…
It won't hit Earth in
The next 100 years…
I hope...

7817 days, 21 hours, 25 minutes, and 26 seconds left
until Apophis - X-Day - ? 1 in 250,000 ? but what about All the
Other NEO's?
April 13, 2036


THE FATE OF THE WORLD
IS IN YOUR HANDS

We should be able to do better than this! ...



Thank You!

[Largest piece found from the Chelyabinsk meteorite]

Main contact:

Dr. Martin Joseph Dudziak

martinjoseph@tdyn.org, martin@intelrenaissance.com
martin.dudziak@gmail.com
+1 (231) 492-8301 cell, (505) 926-1399 internet

