RoPACS Conference, MPE, 12-16 Nov 2012

Mission Preparation at Astrium

an ExoPlanet Flavour

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UK Lead, Earth Observation and Science, Future Programmes

All the space you need

ASTRIUM

AN EADS COMPANY

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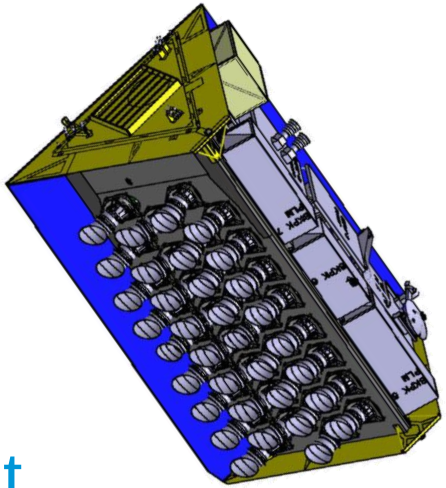
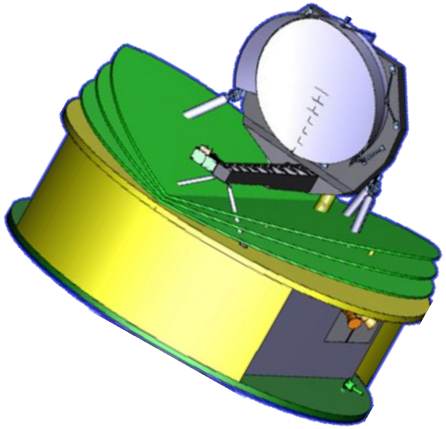
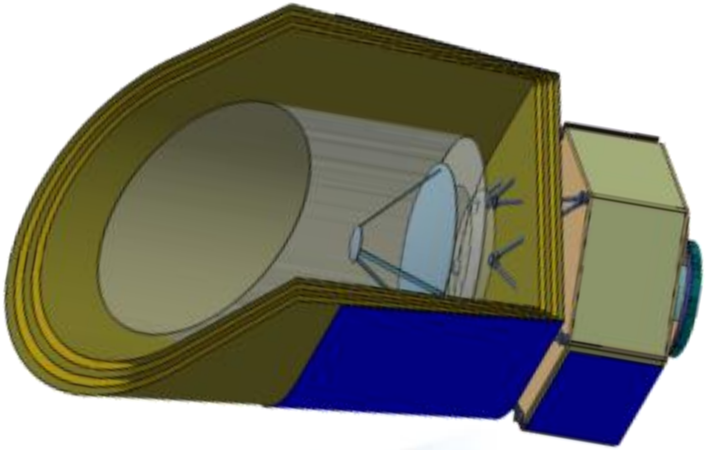




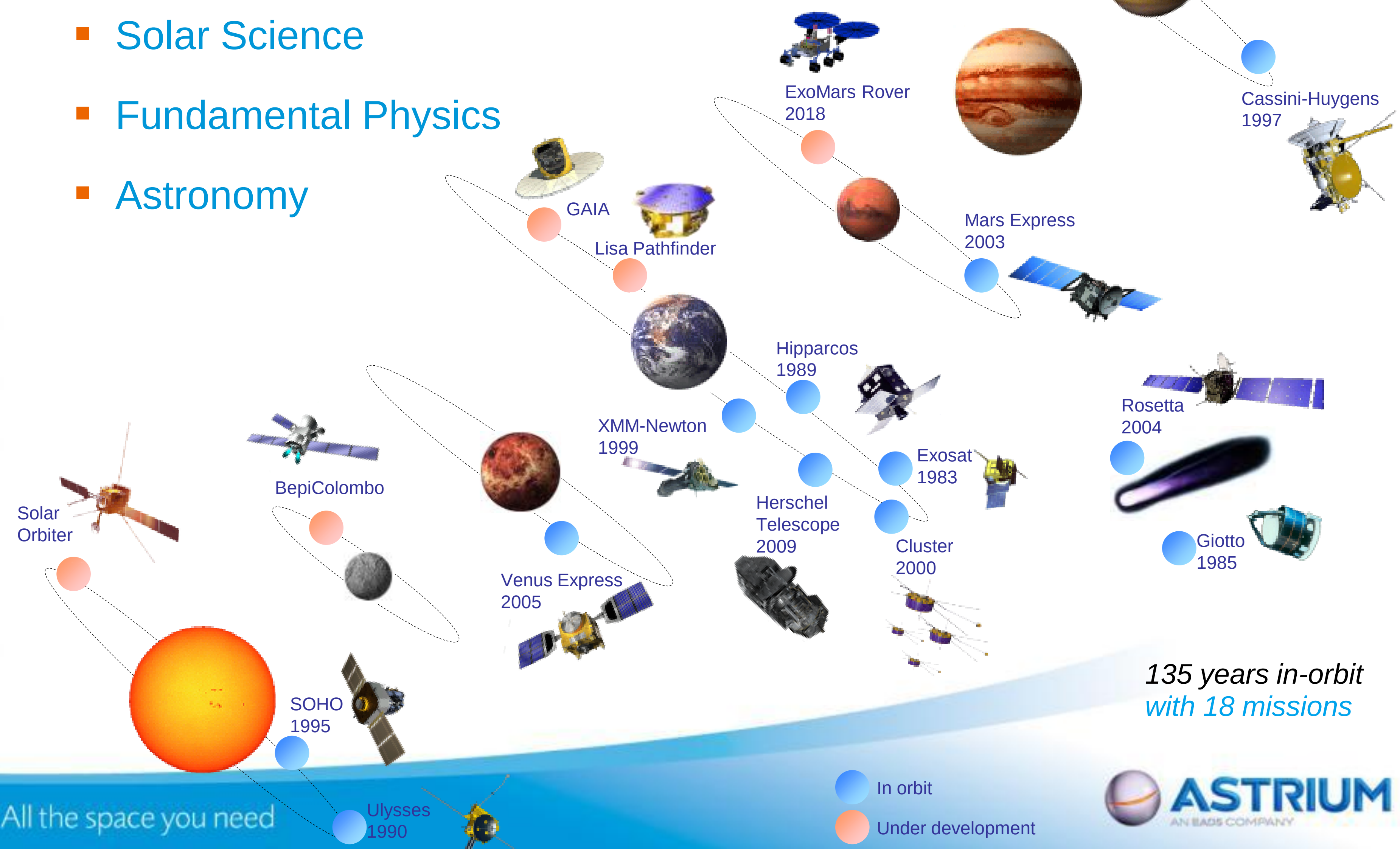


Astrium & RoPACS

- RoPACS
  - Astrium is the RoPACS industrial partner
  - Co-supervision and hosting of James Frith during his PhD with the UoH
    - James helped with EChO science proposal during his visit
  - Hosted the RoPACS team for a training day
  - Assessment of undergraduate projects relating to ExoPlanet missions
  - Excellent relationship built up between Astrium and RoPACS partners!

Science Heritage – Prime Contracts

- Planetary Science
- Solar Science
- Fundamental Physics
- Astronomy



135 years in-orbit
with 18 missions

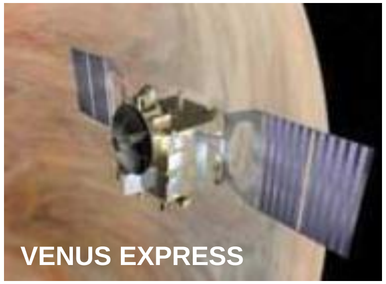
Science platforms: recurring vs bespoke

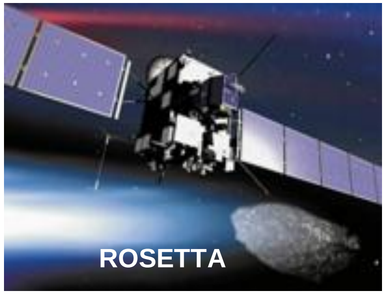
Many space science missions require development of bespoke platforms

e.g. GAIA, XMM

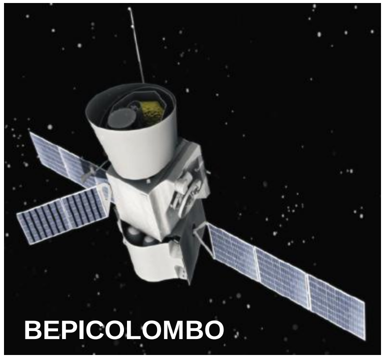
It is faster and lower cost to adapt existing platforms if possible

e.g. Mars Express -> Venus Express

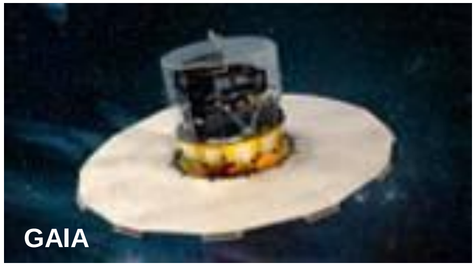




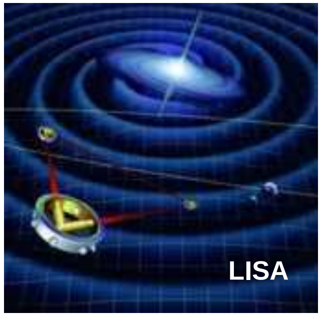
Interplanetary



High Temperature



Telescopes



Fundamental Physics

Technology for Space Science

in-depth understanding of science needs of a mission is required to develop the supporting technologies successfully

Herschel

Cryo-technology

GAIA

Video chain electronics and focal planes

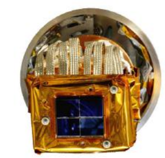
HERSCHEL MIRROR

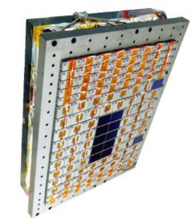
Silicon Carbide for structure and mirrors

GAIA

Advanced platform avionics and test bench

Gaia Demonstrator





High resolution optical spectrometry

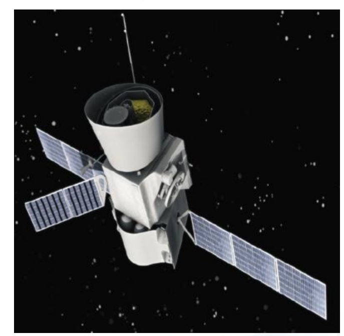
NIRSpec for JWST

Building complex instruments

Robotics & locomotion

Sample handling & manipulation

BepiColombo



High temperature missions

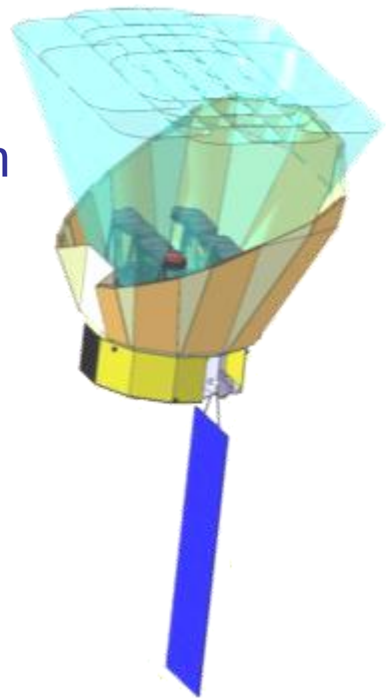
Technology Development

The International X-ray Observatory

- All science missions require technology development
- Technology development is one of the largest risks that a space agency must take into account and manage if a mission is to be successful
  - Expensive
  - Time-consuming
  - Often unpredictable
  - Mistakes/negative outcomes can lead to mission slip
    - = ++TIME
    - = ++MONEY
- Technology Readiness Levels are used to help us monitor the maturity of technology during the design and build process

Technology Readiness Levels (TRLs)

- ESA and NASA use Technology Readiness Levels (TRLs) to measure how mature a technology is
  - Helps determine the risk of including certain technologies on a mission
  - Space Agencies consider TRL when evaluating mission proposals –> so do not ignore this!
- TRLs go from very immature technology (level 1) to well established, off-the-shelf, space-flown technology (level 9)
  - Level 1-4: Creative, innovative technologies before or during mission assessment phase
  - Level 5-9: Mission definition and implementation phase



The Original PLATO

TRL	ESA Definition
1	Basic principles observed and reported
2	Technology concept or application formulated
3	Analytical and experimental critical function proof-of-concept
4	Component or breadboard validation in lab environment
5	Component or breadboard validation in relevant environment
6	System prototype/model demo’d in relevant environment (ground or space)
7	System demonstration in a space environment
8	Actual system completed and flight qualified through test and demo (ground or space)
9	Actual system ‘flight proven’ through successful mission operations

Astrium's TRL Assessment Tool - Minos

Astrium Technology Readiness Level

TRL Assessment Title:	de	**TRL Assessment Subtitle:**		**TRL Level**
Project/Product Code:	e	**Component/System Level:**	Component	1
Technology Area:	Mission & Trajectory Analysis	**Status:**	In progress	
Technology Expert:	Stephen Kemble	**Author:**	Craig Brown	
Reference No:	e141112114216			

Comments relevant to the TRL:

Technology Readiness Level Navigator

I | R | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

The TRL assessment data has been saved.

Colour Key

75%
50%
R
I

TRL Assessment

ESA/Astrium	Type	Category	Question	Level of completion %	Evidence Comment	Reference link
ESA [1.1]	Hardware	Describe Tech	What is the newly discovered scientific fact or principle that suggests some potentially useful new capabilities?	0 25 50 75 100		
ESA [1.1]	Hardware	Describe Tech	What are the suggested new capabilities?	0 25 50 75 100		
ESA [1.2]	Hardware	Mission Requirements	How can the new capabilities be technically implemented?	0 25 50 75 100		
ESA [1.3]	Hardware	Experimental Evidence	Have conceptual studies confirmed the newly discovered scientific fact or principle?	0 25 50 75 100		
ESA [1.4]	Hardware	Future Viability	For the scientific phenomena involved, is further scientific research possible in the foreseeable future?	0 25 50 75 100		
ESA [1.4]	Hardware	Future Viability	Does it appear likely that technology R&D will be viable?	0 25 50 75 100		
Astrium [1.1]	Software	Describe Tech	Is there a basic concept which could be realized in software (e.g. basic principles for an algorithm)?	0 25 50 75 100		

ESA Mission Timeline – M/L Class

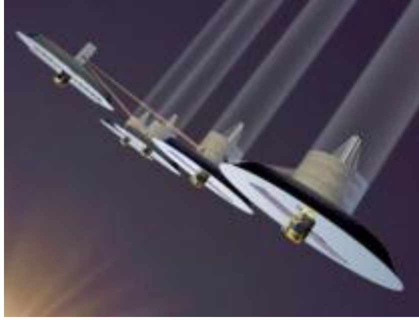
- **Pre-phase A: Assessment Phase**
  - Lasts ~ 12 months
- **Phase A + Phase B1: Definition Phase**
  - Lasts 12 months + 6 Months
    - ~1 month gap between end of Phase A and start of Phase B1
    - B1 is where Industry prepares the spacecraft specification and Invitations to Tender for building parts of the spacecraft
- **Phase B2 + Phase C + Phase D: Implementation**
  - Lasts 1 year + 4 years (+)
- **Phase E: Launch**
- **Phase F: Operations**
- **TOTAL: <u>~8.5 – 10 </u>(+) years from Mission proposal to launch**

ESA's TRL Requirements

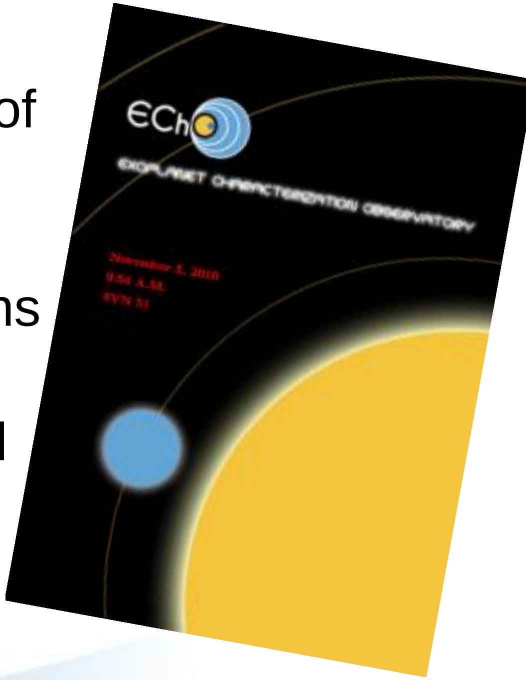
- Medium-class missions should require little technology development in order to qualify.
- Large-class missions require significant technology development.
- All technologies baselined on a mission should reach, as a minimum, TRL = 4 by end of the assessment phase and TRL = 5 by end of phase B1
  - i.e. Once a mission is selected for assessment, ~1 year spent in Pre-Phase A (Assessment) so must reach TRL 4 (lab breadboard) in ~1 years
  - Phase A/B1 lasts ~ 1.5 years so just a year and a half to test the breadboard in a relevant environment (TRL 5)

Qualification Testing at TRL 6 and above

Astrium & EPRAT



- EPRAT: ExoPlanet Roadmap Advisory Team
  - Astrium took part in the London EPRAT workshop
    - EPRAT produced a document for ESA making recommendations on how to implement the vision for future exoplanet missions
  - Astrium made significant contribution to the output of the workshop
    - stressed the need for early technology development programme for exo-planet missions
    - ensured emphasis on missions capable of meeting M-class requirements for schedule and cost

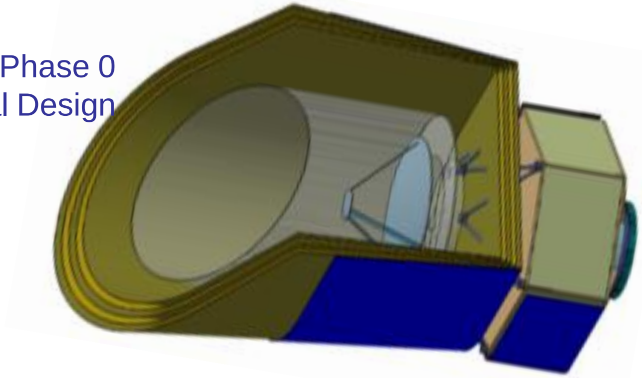


- The EPRAT roadmap led directly to the EChO mission proposal

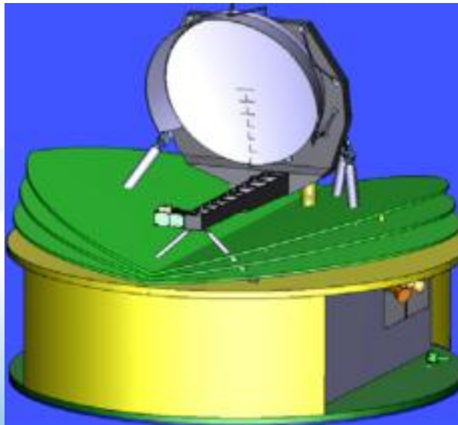
EChO Proposal for M3

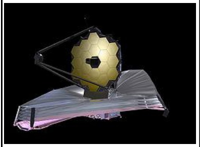
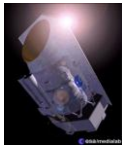
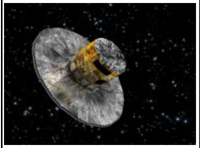
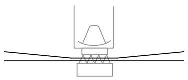
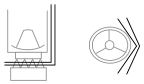
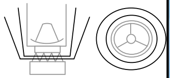
- Astrium assisted the EChO team in preparing it’s proposal to ESA for the M3 call
- PhD student from UoH (James Frith) worked with us on this during his secondment for RoPACS
- Again, ensured an emphasis on a technically achievable mission within the scope of M3

Science and Phase 0 Proposal Design



Phase A Design

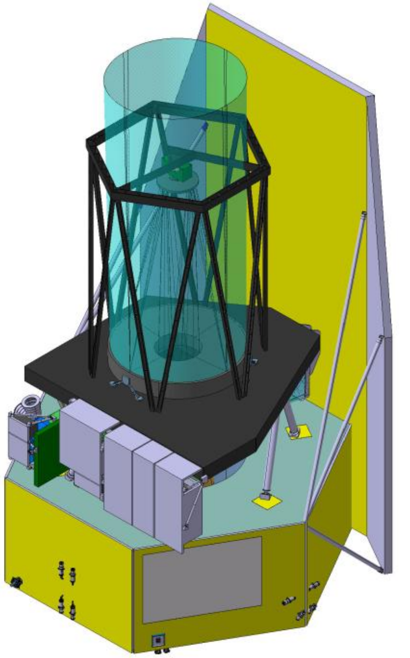


Sun Shield Type	Parasol	Side Sun Shield	V-groove Cone
Heritage	 JWST	 ISO	 Planck
	 GAIA	 Herchel	
Feature	Large deployable sun shield	Fixed to one side of the payload telescope baffle	Smaller fixed parasol
Note	Front sun facing layer of sun shield must shadow all subsequent layers.		
Potential Echo Config			

Thermal design trade-off. It was recognised early on that thermal stability and sky area were two important design drivers

Euclid

- Studying dark energy & dark matter
  - Mapping dark matter and dark energy by imaging gravitationa
    of galaxies
  - Red-shift spectroscopy of 1 billion galaxies to measure baryo
    oscillations
  - 100% sky coverage in 6 years



- ExoPlanet legacy survey using microlensing

- Selected for implementation as M2 -> Phase B2/C/D/E1
  - Separate prime contracts for
    - Payload module
    - Spacecraft
  - 2020 launch, 6.25 years in operation

- Astrium UK involvement so far:
  - Hybrid attitude and orbit control analysis
  - Propulsion system and mission analysis
  - Payload data handling analysis

Take home message: keep in contact !

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