

# CASSINI/HUYGENS

A PROBE TO TITAN

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 ric who came to fetch me.

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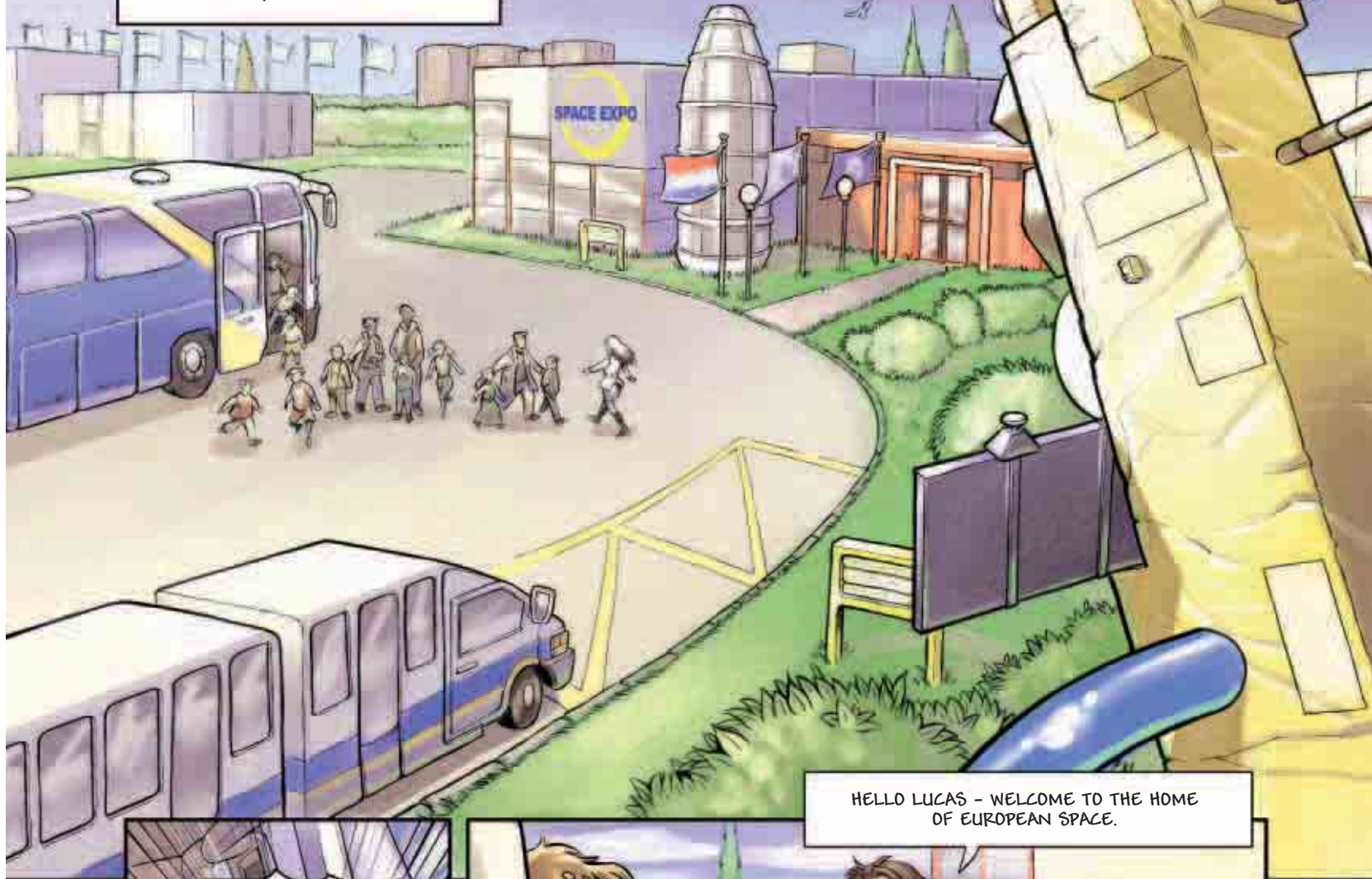
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NOORDWIJK, THE NETHERLANDS,  
25TH OF SEPTEMBER. VISITOR CENTRE.  
SPACE EXPO, THE SPACE MUSEUM.



HELLO LUCAS - WELCOME TO THE HOME  
OF EUROPEAN SPACE.



AUNTY ANN!  
AUNTY ANN!



COOL! I'VE BEEN  
WAITING FOR THIS  
VISIT FOR EVER!



GOOD! I'LL BE YOUR GUIDE. ASK ME WHATEVER YOU'D  
LIKE TO KNOW. WE'LL START WITH THE MUSEUM  
BEFORE CHECKING OUT  
THE ESA BUILDINGS  
NEXT DOOR.



HMMM ... WHAT DOES ESA MEAN?

ESA HEADQUARTERS ARE IN PARIS. THE TECHNICAL CENTRES ARE IN GERMANY, ITALY, SPAIN AND HERE IN THE NETHERLANDS AT ESTEC. YOU KNOW, THERE ARE 1900 PEOPLE SPEAKING 11 DIFFERENT LANGUAGES HERE.

AND YOU ALL UNDERSTAND EACH OTHER?

WE DON'T HAVE TO SPEAK ALL THE LANGUAGES. BUT EVERYONE WHO WORKS FOR ESA HAS TO SPEAK ENGLISH OR FRENCH.

IT'S THE EUROPEAN SPACE AGENCY. WE'RE IN CHARGE OF THE BIG EUROPEAN SPACE PROJECTS.

AND IS THAT A REAL SATELLITE?

NEARLY, IT'S A MOCK-UP OF ENVISAT ... OUR BIG SATELLITE THAT'S FLYING RIGHT NOW AROUND THE EARTH TAKING LOTS OF PICTURES OF OUR ENVIRONMENT.

DO YOU BUILD SATELLITES ON A PRODUCTION LINE LIKE CARS?

NO WAY! EVERY NEW SATELLITE HAS TO BE CUSTOM-BUILT FOR EVERY MISSION.

DO YOU SEE THE FLAGS? ALL OF THOSE COUNTRIES ARE MEMBERS OF ESA, AND CANADA IS A PARTNER.

WOW! WORKING AT ESA MUST BE GREAT!

WOULD YOU LIKE TO FOLLOW ALL THE STEPS OF A PROJECT WITH ME, FROM THE ORIGINAL IDEA TO LAUNCH?

YOU BET!

SO LET'S ENTER THE FABULOUS WORLD OF SPACE!



BERGEN, NORWAY.

YOU KNOW, LUCAS, IT OFTEN STARTS WITH A SIMPLE IDEA ...

WHAT A SCORCHER FOR THE FIRST DAY OF FEBRUARY! I HAVE THE FEELING THE CLIMATE HAS BEEN WARMING UP RECENTLY. WHAT DO YOU THINK?



ROME, ITALY.

OH, NO! THE WEATHER'S NEVER BEEN SO COLD. IT'S SNOWING HERE!



THEY MEET A FEW MONTHS LATER ...

WE MUST CHECK OUR CALCULATIONS ABOUT THE CHANGING CLIMATE BY MEASURING THE CHEMICALS IN THE ATMOSPHERE.

OVER THE WHOLE WORLD?! IT'LL TAKE YEARS!

WE HAVE TO ORGANISE TEAMS IN EVERY COUNTRY ...

OR USE PLANES.

SO HOW ARE WE GOING TO DO IT?

HOW ABOUT A SATELLITE?

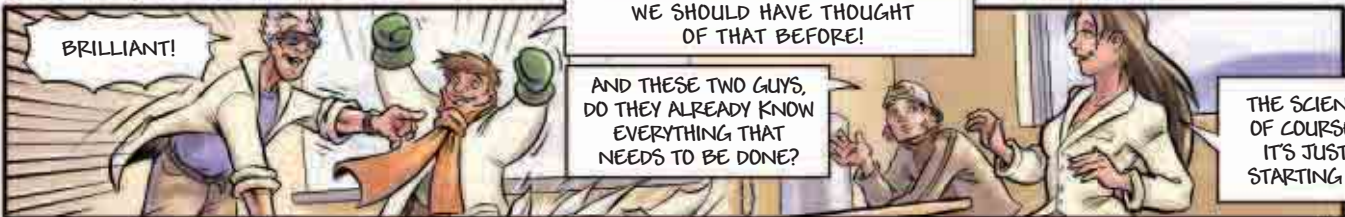


BRILLIANT!

WE SHOULD HAVE THOUGHT OF THAT BEFORE!

AND THESE TWO GUYS, DO THEY ALREADY KNOW EVERYTHING THAT NEEDS TO BE DONE?

THE SCIENTISTS? OF COURSE NOT, IT'S JUST THE STARTING POINT.



WHO CAN HELP US TO BUILD THIS SATELLITE?

MEETING WITH THE INDUSTRY, CHECKING IF THE PROJECT IS POSSIBLE ...

ESA! IT'S OUR JOB TO ACT AS A GO-BETWEEN FOR THE SCIENTISTS AND THE COMPANIES AND LABORATORIES WHO WILL DESIGN AND BUILD THE SATELLITE.

WE MUST MAKE THIS MEASUREMENT, IT'S FUNDAMENTAL!

YOU SHOULD UNDERSTAND THAT LARGE INSTRUMENTS NEED LARGE SATELLITES TO CARRY THEM. AND THE LARGER THE SATELLITE, THE MORE EXPENSIVE IT IS TO BUILD AND LAUNCH ...



ESA FIRST DECIDES IF A MISSION IS POSSIBLE ...

AND THE MISSING 5%, ARE WE GOING TO FORGET THEM?

WAIT! WE CAN USE THE MEASUREMENTS FROM OUR PREVIOUS OBSERVATIONS TO FIND THEM...

LET'S IMAGINE A FEW YEARS LATER ...

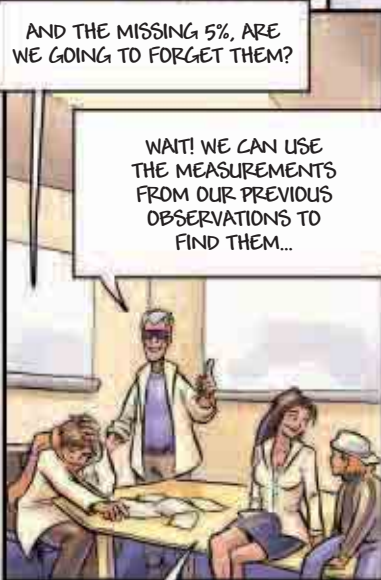
AT LAST, HERE'S THE PROTOTYPE OF YOUR SATELLITE, LUCAS.

LUCASAT - READY FOR LIFT-OFF!

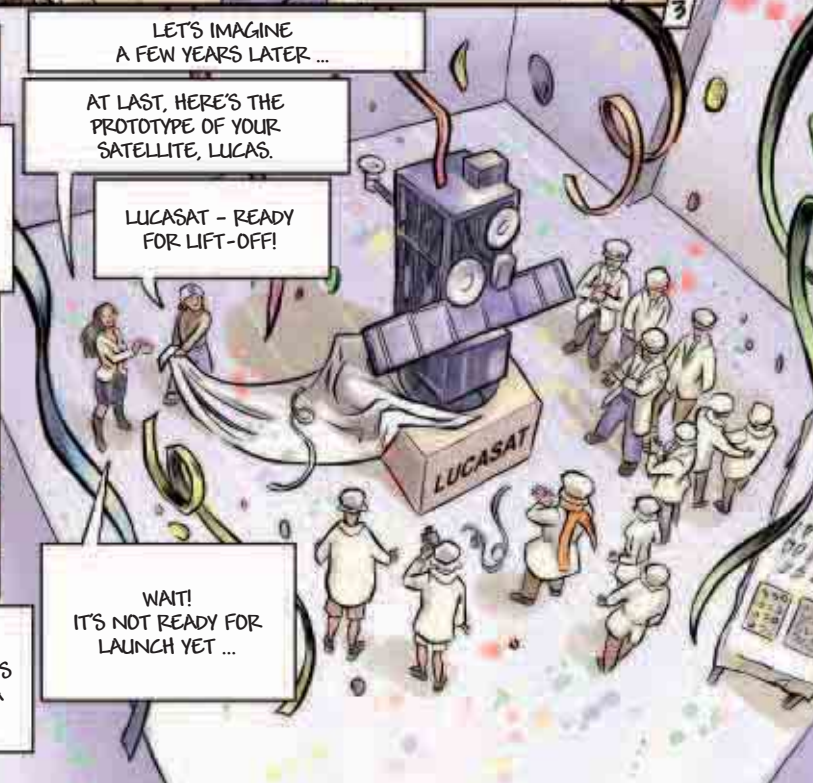
WAIT! IT'S NOT READY FOR LAUNCH YET ...



THIS DESIGN FOR THE SATELLITE IS MUCH CHEAPER BUT STILL MAKES 95% OF ALL THE MEASUREMENTS.



NEW IDEAS HAVE TO BE FOUND AND AGREED ON AS THE PROJECT DEVELOPS YEAR BY YEAR FROM THE SIMPLE IDEA INTO THE FINAL SATELLITE.







WE NEED TO CHOOSE THE ROCKET BEST SUITED TO YOUR SATELLITE AND ITS ORBIT.

WHAT? THERE ARE DIFFERENT TYPES OF LAUNCHERS?

OF COURSE, THE HEAVIER THE SATELLITE AND THE HIGHER ITS ORBIT, THE BIGGER THE ROCKET AND THE ENGINES!



THIS ONE LOOKS BIG ENOUGH!

SURE, BUT IT'S MOSTLY GIANT FUEL TANKS WITH THE SATELLITE SITTING ON TOP.

DON'T BE STUBBORN, IT CAN'T FIT INSIDE!

NO - YOU CAN'T REMOVE THIS PART, IT'S REALLY IMPORTANT!

TO AVOID THIS PROBLEM, THE SATELLITE'S DESIGN TAKES INTO ACCOUNT THE SIZE OF THE ROCKET.

DON'T WORRY, I WILL REPLACE IT WITH SOMETHING SMALLER THAT'LL DO THE SAME JOB.

IN THE END, IT WASN'T THAT COMPLICATED. CAN WE START THE COUNTDOWN NOW?



SOON! BUT BEFORE TAKE-OFF, WE MUST CHECK THAT EVERYTHING WILL STILL WORK IN SPACE.



HERE ARE ESA'S  
TEST FACILITIES.

THEY'RE HUGE! WHAT  
DO YOU DO HERE?

THE ENTIRE  
SATELLITE IS  
TESTED BY  
ALL THESE  
MACHINES.

DURING LAUNCH, THE SATELLITE IS SHAKEN HARD IN  
ALL DIRECTIONS. WE HAVE TO CHECK THAT NOTHING  
BREAKS BECAUSE OF THE VIBRATIONS.

WAHOO, IT'S LIKE  
A GIANT MIXER!

HEY!  
IT'S FALLING APART!

IT'S FAR WORSE!  
WATCH AS I INCREASE  
THE SPEED ...

BECAUSE IT WASN'T STRONG  
ENOUGH. IT'S BETTER WE  
KNOW NOW - IT'S TOO LATE  
AFTER LIFT-OFF!

WHAT ARE THEY  
DOING NOW?

WE'RE GOING TO TEST  
IT AGAINST NOISE.

IS SPACE NOISY?

NO, BUT DURING TAKE-OFF,  
THE NOISE OF THE LAUNCHER  
IS LIKE 1000 JET ENGINES ALL  
SCREAMING TOGETHER! WE  
HAVE TO CHECK THAT LUCASAT  
CAN WITHSTAND THAT NOISE.

READY?

OK!

DON'T WORRY, OUTSIDE  
THE CHAMBER, WE CAN  
HEAR NOTHING.





WHAT A PITY!



NOW WE HAVE TO TEST IF THE SATELLITE CAN SURVIVE IN SPACE.

HOW ARE YOU GOING TO DO THAT?

IN A BIG VACUUM CHAMBER. IN SPACE, THERE'S NO AIR TO SMOOTH OUT THE TEMPERATURES. WHAT IS ON THE WARM SIDE WILL SCORCH AND WHAT IS ON THE COLD SIDE WILL FREEZE. TO PROTECT LUCASAT, IT'S COVERED WITH GOLD THERMAL INSULATION - JUST LIKE A SURVIVAL BLANKET!



PART OF THE TEST RAISES THE TEMPERATURE.



HEY, I THOUGHT SPACE WAS COLD?

ON THE OTHER HAND, PARTS OF THE SATELLITE IN SHADOW CAN COOL DOWN TO  $-180^{\circ}\text{C}$ , MUCH COLDER THAN THE NORTH POLE!



SURE! BUT PARTS OF THE SATELLITE EXPOSED TO THE SUN CAN EXCEED  $120^{\circ}\text{C}$  - HOTTER THAN BOILING WATER!



OK, THE MAIN TESTS HAVE BEEN SUCCESSFUL. I THINK YOUR SATELLITE IS READY AT LAST TO FLY!



YAHOO! BUT WHAT HAPPENS IF IT GOES WRONG IN ORBIT?



CAN SOMEBODY GO UP THERE TO REPAIR IT?

NO, THAT'S USUALLY IMPOSSIBLE. WE ALWAYS PLAN FOR FAILURES, SO THE SATELLITE INCLUDES BACK-UP EQUIPMENT ...

SATELLITE CONTROL CENTRE ...

YOU SEE, IF SOMETHING FAILS ...

THE BACK-UP EQUIPMENT IS SWITCHED ON BY REMOTE CONTROL FROM HERE.

WHY IS THE SATELLITE MOVING?

ALL ITS MOVING PARTS - MAYBE A ROTATING MIRROR - ENCOURAGE THE SATELLITE TO MOVE IN THE OPPOSITE DIRECTION.

IN FACT, EVEN THE TINY PUSH FROM SUNLIGHT IS ENOUGH TO DISTURB IT. IT'S ALSO ATTRACTED BY THE EARTH, MOON AND SUN, SO IT'S MOVING ALL THE TIME.

TO KEEP ON THE RIGHT TRACK, WE MUST CORRECT ALL THESE MOVEMENTS. THE SATELLITE'S SMALL ROCKETS TAKE CARE OF THAT, AND THE MISSION COMES TO AN END WHEN ALL THE FUEL IS USED UP!

WHAT ARE THE WINGS USED FOR?

THEY'RE NOT LIKE AIRCRAFT WINGS, LUCAS! THEY'RE SOLAR-CELL WINGS TO GENERATE ELECTRICITY FROM SUNLIGHT. ALL THE SATELLITE EQUIPMENT NEED ELECTRICITY TO WORK!

HOW HIGH DO THE SATELLITES FLY?



IF THEY STUDY THE EARTH, LIKE LUCASAT, THEY USUALLY ORBIT AT HEIGHTS BETWEEN 400 KM AND 1400 KM. THEY TRAVEL VERY FAST AND CIRCLE THE EARTH POLE-TO-POLE. THEY EVENTUALLY COVER THE WHOLE EARTH, BUT AT ANY MOMENT THEY SEE ONLY A SMALL PART.



LOOK AT THE GREAT PICTURES THEY TAKE!

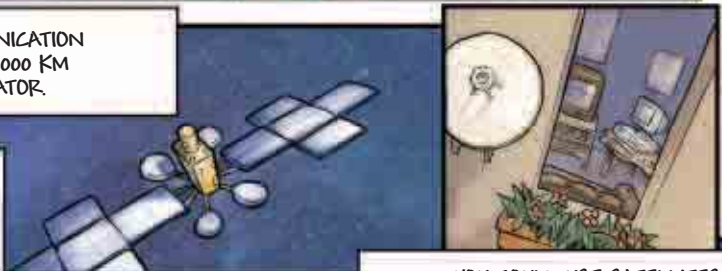


AND SOME FLY EVEN HIGHER?

SURE. MOST COMMUNICATION SATELLITES FLY 36,000 KM ABOVE THE EQUATOR.

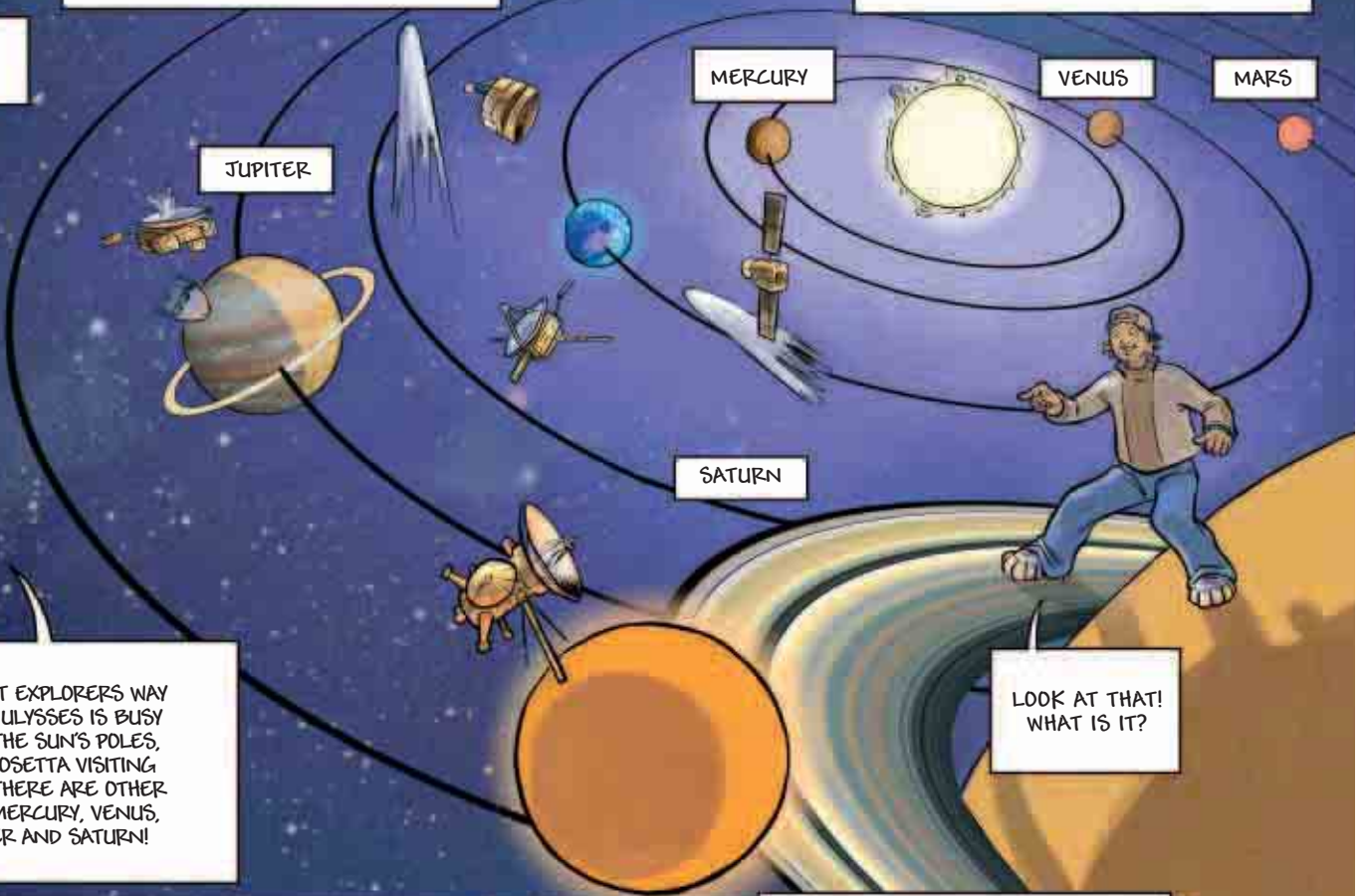


THERE, THEY CIRCLE AS FAST AS THE EARTH TURNS, SO THEY ALWAYS HOVER OVER THE SAME SPOT - THEY ARE CALLED GEOSTATIONARY. SO THEY CAN BROADCAST TV PROGRAMMES ALL THE TIME TO THE SAME REGION.



YOU COULD USE SATELLITES FOR YOUR TV, YOUR TELEPHONE AND EVEN THE INTERNET!

AND HIGHER STILL?



WE HAVE ROBOT EXPLORERS WAY OUT IN SPACE. ULYSSES IS BUSY FLYING OVER THE SUN'S POLES, GIOTTO AND ROSETTA VISITING COMETS, AND THERE ARE OTHER MISSIONS TO MERCURY, VENUS, MARS, JUPITER AND SATURN!

LOOK AT THAT! WHAT IS IT?

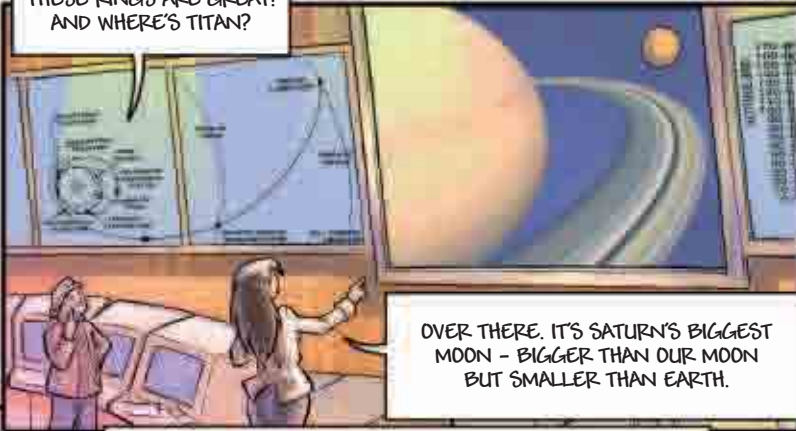
IT'S ONE OF OUR GREAT PROJECTS!



CASSINI/HUYGENS IS A JOINT PROJECT WITH NASA, THE AMERICAN SPACE AGENCY. IT TOOK OFF IN OCTOBER 1997 AND FINALLY JUST ARRIVED AT SATURN TO EXPLORE THE BEAUTIFUL RINGED PLANET AND ITS MOONS, PARTICULARLY TITAN.



THESE RINGS ARE GREAT!  
AND WHERE'S TITAN?



OVER THERE. IT'S SATURN'S BIGGEST  
MOON - BIGGER THAN OUR MOON  
BUT SMALLER THAN EARTH.

VERY FEW! ONCE ON TITAN, HUYGENS WILL HOLD  
THE DISTANCE RECORD FOR MAN-MADE  
LANDERS. CAN YOU IMAGINE, SATURN IS ABOUT  
1500 MILLION KILOMETRES FROM THE SUN, TEN  
TIMES FURTHER THAN THE EARTH.

MERCURY VENUS EARTH MARS

JUPITER

SATURN

URANUS

NEPTUNE

PLUTO

ESA'S HUYGENS PROBE WAS BUILT  
ESPECIALLY TO LAND ON TITAN,  
AFTER SEPARATING FROM CASSINI.

CASSINI



THAT'S REALLY DIFFICULT  
BECAUSE IT HAS TO SURVIVE  
THE HIGH-SPEED ENTRY INTO  
THE ATMOSPHERE.

HUYGENS

ARE THERE MANY PROBES  
LANDING ON OTHER MOONS  
AND PLANETS?

WOW, THE ROCKET YOU USED  
MUST HAVE BEEN GIGANTIC!

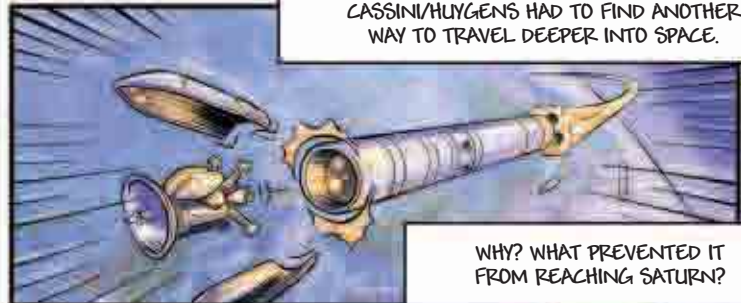
YOU'RE RIGHT, WE USED  
A TITAN-IVB, THE  
BIGGEST IN THE WORLD.  
IT'S FUNNY THAT IT HAS  
THE SAME NAME AS  
SATURN'S MOON ...  
THE SPECTACULAR  
LAUNCH TOOK PLACE  
FROM CAPE CANAVERAL  
IN FLORIDA, USA, ON 15  
OCTOBER 1997.



AND EVEN THIS LAUNCHER WAS  
NOT ENOUGH TO REACH SATURN!



ONCE THE ROCKET HAD DONE ITS JOB,  
CASSINI/HUYGENS HAD TO FIND ANOTHER  
WAY TO TRAVEL DEEPER INTO SPACE.



WHY? WHAT PREVENTED IT  
FROM REACHING SATURN?

ONCE ITS BOOSTER TORE IT FREE OF EARTH,  
CASSINI/HUYGENS HAD TO FIGHT AGAINST THE SUN'S  
INTENSE GRAVITATIONAL PULL. NOT SO EASY FOR A  
SPACECRAFT THAT WEIGHS MORE THAN FIVE TONNES.

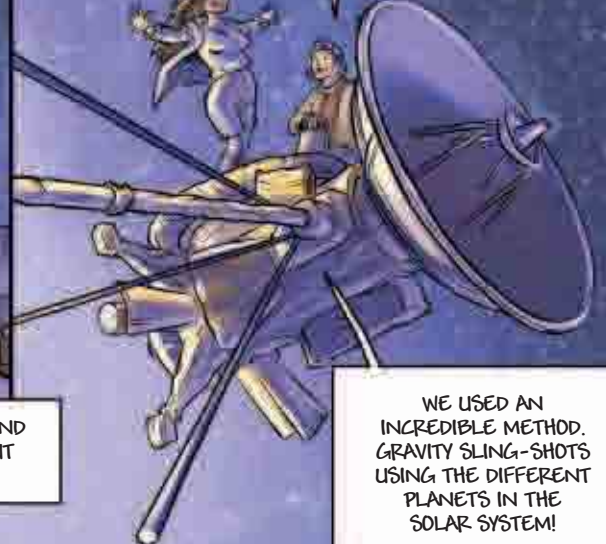


THERE MUST BE AN  
ENGINE SOMEWHERE  
ONBOARD!



THERE IS A SMALL ENGINE AND  
THREE TONNES OF FUEL, BUT  
THEY AREN'T ENOUGH ...

WHAT DID YOU  
DO THEN?



WE USED AN  
INCREDIBLE METHOD.  
GRAVITY SLING-SHOTS  
USING THE DIFFERENT  
PLANETS IN THE  
SOLAR SYSTEM!



HOW DOES IT WORK???

IT'S LIKE THE PLANET CATCHES CASSINI/HUYGENS WITH A LASSO AND FLINGS IT AWAY AT EVEN HIGHER SPEED.

AND IF IT FAILS?



IT'S TRICKY BUT WE PLAN IT VERY CAREFULLY.

HEY! I HAVE TO GO THIS WAY!



NO PROBLEM, BUT BECAUSE YOU'RE ATTACHED TO ME, YOU HAVE TO FOLLOW ME A BIT!

THE SPEED IS FANTASTIC - IT'S BETTER THAN SURFING!

SURE! YOU'VE PICKED UP SOME OF MY SPEED!

YOUR SPEED HAS SHOT UP BECAUSE THE PLANET HAS GIVEN YOU PLENTY OF ENERGY.

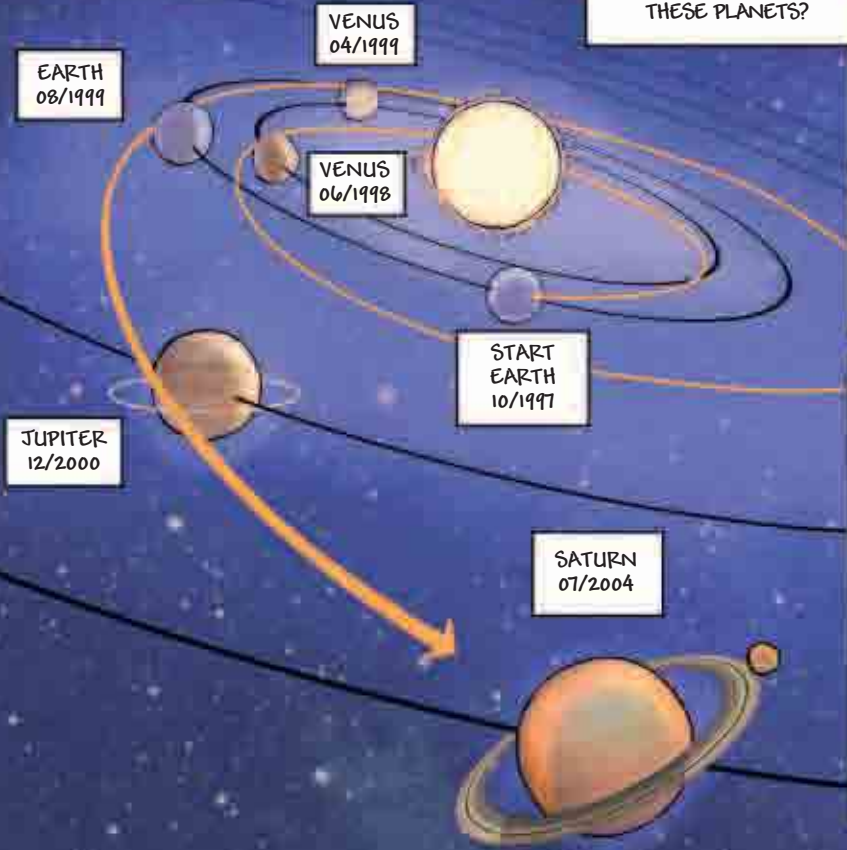


TO GET TO SATURN, CASSINI/HUYGENS USED THIS SLING-SHOT EFFECT TWICE WITH VENUS, ONCE WITH EARTH AND ONCE WITH JUPITER.

WE HAD TO GET ENERGY FROM ALL THESE PLANETS?

YES, WE WOULDN'T HAVE GOT TO SATURN WITHOUT IT.

HOW LONG DOES IT TAKE TO REACH SATURN?

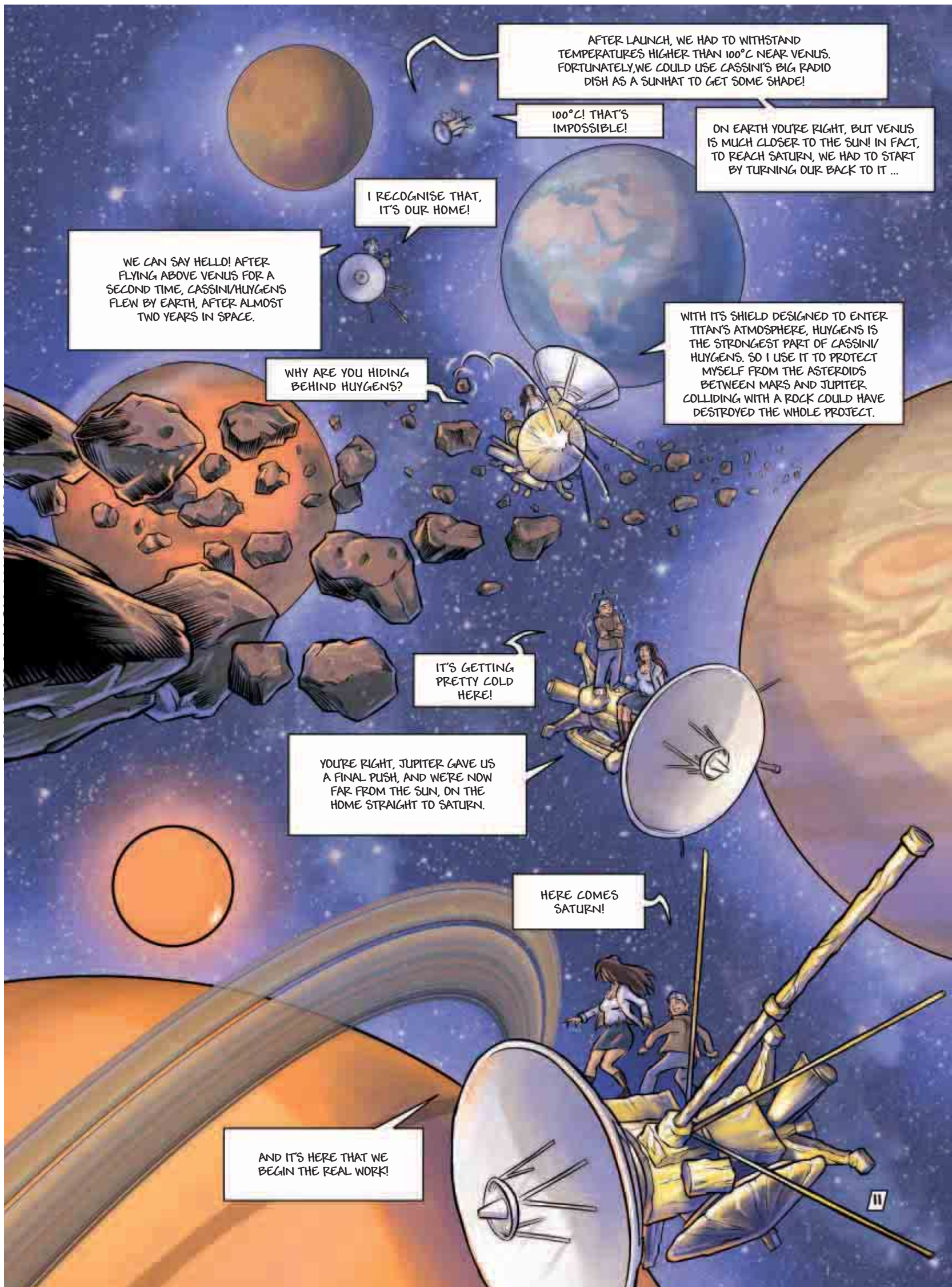


I'LL LET YOU CALCULATE ...

UMMM...

A LITTLE BIT LESS THAN SEVEN YEARS - AND WHAT A FANTASTIC JOURNEY!





AFTER LAUNCH, WE HAD TO WITHSTAND TEMPERATURES HIGHER THAN 100°C NEAR VENUS. FORTUNATELY, WE COULD USE CASSINI'S BIG RADIO DISH AS A SUNHAT TO GET SOME SHADE!

100°C! THAT'S IMPOSSIBLE!

ON EARTH YOU'RE RIGHT, BUT VENUS IS MUCH CLOSER TO THE SUN! IN FACT, TO REACH SATURN, WE HAD TO START BY TURNING OUR BACK TO IT ...

I RECOGNISE THAT, IT'S OUR HOME!

WE CAN SAY HELLO! AFTER FLYING ABOVE VENUS FOR A SECOND TIME, CASSINI/HUYGENS FLEW BY EARTH, AFTER ALMOST TWO YEARS IN SPACE.

WHY ARE YOU HIDING BEHIND HUYGENS?

WITH ITS SHIELD DESIGNED TO ENTER TITAN'S ATMOSPHERE, HUYGENS IS THE STRONGEST PART OF CASSINI/HUYGENS. SO I USE IT TO PROTECT MYSELF FROM THE ASTEROIDS BETWEEN MARS AND JUPITER. COLLIDING WITH A ROCK COULD HAVE DESTROYED THE WHOLE PROJECT.

IT'S GETTING PRETTY COLD HERE!

YOU'RE RIGHT, JUPITER GAVE US A FINAL PUSH, AND WE'RE NOW FAR FROM THE SUN, ON THE HOME STRAIGHT TO SATURN.

HERE COMES SATURN!

AND IT'S HERE THAT WE BEGIN THE REAL WORK!



FIRST OF ALL, CASSINI HAS TO  
SEND HUYGENS TOWARDS TITAN.



WATCH OUT! WE'RE  
GOING TO MISS TITAN!



DON'T WORRY, WE ORBIT  
SATURN THREE TIMES BEFORE  
WE HAVE THE RIGHT POSITION  
TO RELEASE HUYGENS.

AFTER THREE CIRCUITS  
AROUND SATURN ...

CASSINI AND HUYGENS  
SEPARATE AT THE END OF  
DECEMBER 2004.



HEY, IT'S CHRISTMAS!  
WHAT WILL CASSINI  
DO NOW?

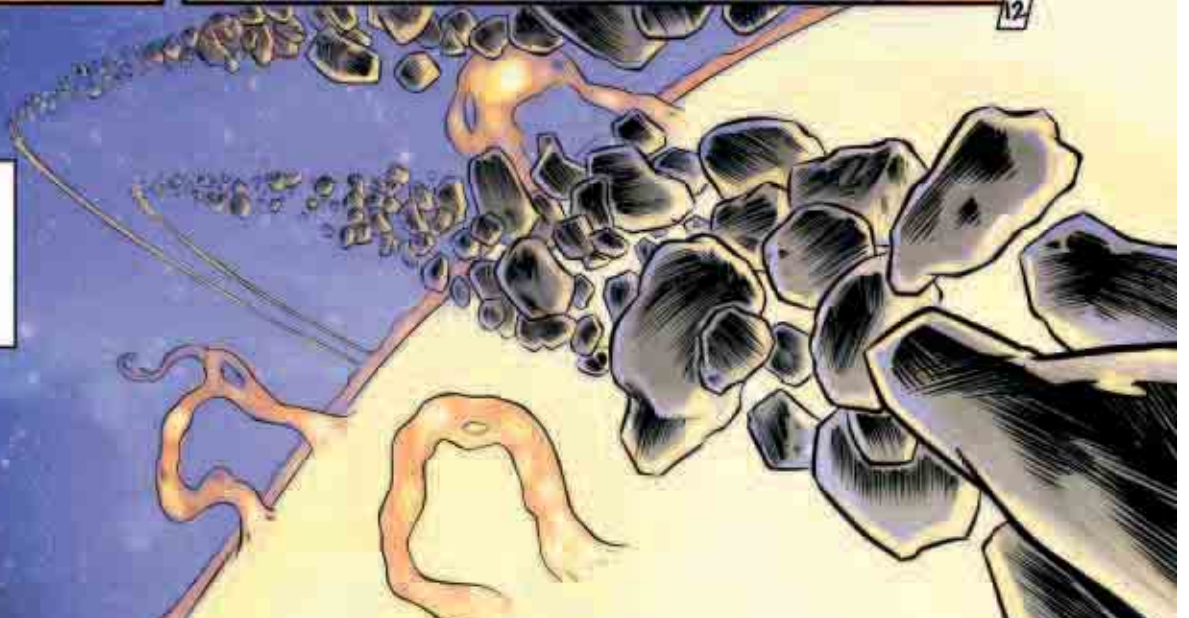
CASSINI WILL EXPLORE THE ICY AND  
DUSTY RINGS OF SATURN - HOW  
THEY'RE BUILT AND WHAT'S IN THEM.



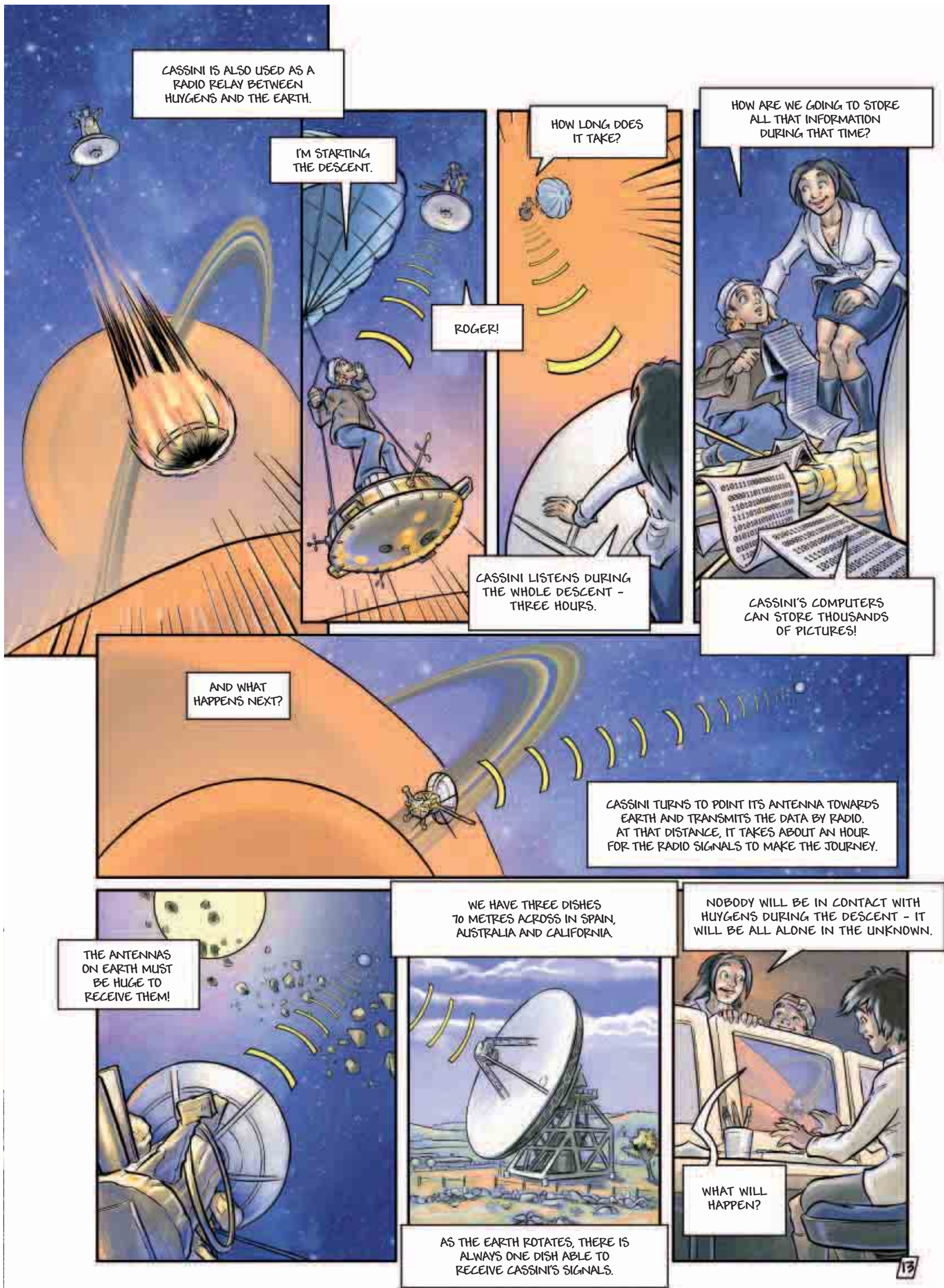
IT WILL ALSO STUDY THE  
WAY SOME RINGS CAN  
GROW INTO PLANETS!



IN THE SOLAR SYSTEM, MANY OF  
THE PLANETS AND THEIR MOONS  
MIGHT HAVE GROWN FROM  
RINGS CIRCLING THE SUN.







CASSINI IS ALSO USED AS A RADIO RELAY BETWEEN HUYGENS AND THE EARTH.

I'M STARTING THE DESCENT.

HOW LONG DOES IT TAKE?

HOW ARE WE GOING TO STORE ALL THAT INFORMATION DURING THAT TIME?

ROGER!

CASSINI LISTENS DURING THE WHOLE DESCENT - THREE HOURS.

CASSINI'S COMPUTERS CAN STORE THOUSANDS OF PICTURES!

AND WHAT HAPPENS NEXT?

CASSINI TURNS TO POINT ITS ANTENNA TOWARDS EARTH AND TRANSMITS THE DATA BY RADIO. AT THAT DISTANCE, IT TAKES ABOUT AN HOUR FOR THE RADIO SIGNALS TO MAKE THE JOURNEY.

THE ANTENNAS ON EARTH MUST BE HUGE TO RECEIVE THEM!

WE HAVE THREE DISHES 70 METRES ACROSS IN SPAIN, AUSTRALIA AND CALIFORNIA.

NOBODY WILL BE IN CONTACT WITH HUYGENS DURING THE DESCENT - IT WILL BE ALL ALONE IN THE UNKNOWN.

AS THE EARTH ROTATES, THERE IS ALWAYS ONE DISH ABLE TO RECEIVE CASSINI'S SIGNALS.

WHAT WILL HAPPEN?



WELL, YOU HAVE TO WAKE UP AND WARM UP JUST BEFORE ENTERING TITAN'S ATMOSPHERE ABOUT 1300 KM ABOVE THE SURFACE.

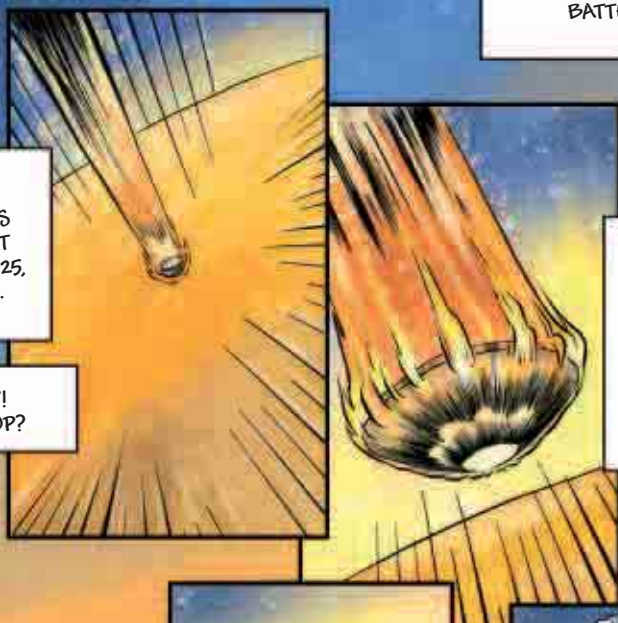


THAT DOESN'T GIVE US MUCH TIME!

WE'VE CHECKED HUYGENS EVERY 6 MONTHS. BUT NOW THINGS ARE GETTING REALLY SERIOUS. HUYGENS WILL WAKE UP FOR ITS THREE-HOUR MISSION BUT AFTER THAT ITS BATTERIES WILL BE EMPTY.

ON 14 JANUARY 2005, HUYGENS ENTERS TITAN'S ATMOSPHERE AT A HEIGHT OF 1200 KM AND AT MACH 25, MORE THAN 20,000 KM/H.

THAT'S CRAZY!  
HOW WILL I STOP?



WHAT ARE YOU SCARED OF? IT'S ONLY 150 TIMES FASTER THAN A CAR ON A MOTORWAY! SERIOUSLY, FIRST TITAN'S ATMOSPHERE STRONGLY CUTS HUYGENS' SPEED. THE FRONT SHIELD KEEPS IT SAFE FROM THE 10,000°C OF THE HIGH-SPEED ENTRY!

HUYGENS' SPEED IS ALREADY REDUCED TO 1500 KM/H ABOUT 150 KM ABOVE THE SURFACE AND THE FIRST PARACHUTE IS RELEASED.



WHAT'S HAPPENING?

HUYGENS IS LIKE A WALNUT, ITS SHIELD PROTECTS ALL THE FRAGILE INSTRUMENTS.

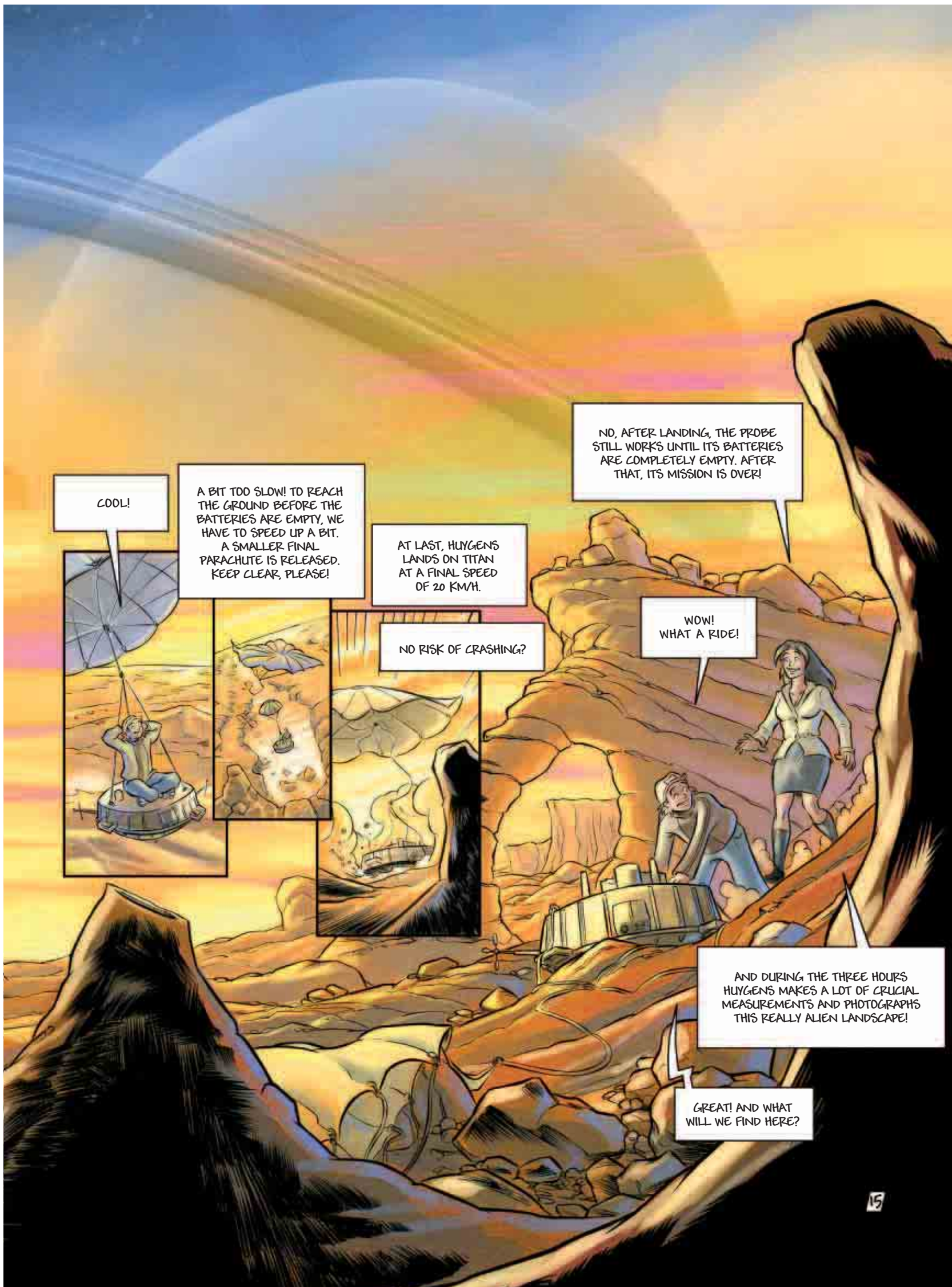


LESS THAN 3 SECONDS LATER, THE MAIN PARACHUTE SLOWS IT DOWN TO LESS THAN 150 KM/H.

THE SPEED AND TEMPERATURE ARE NOW LOW ENOUGH FOR HUYGENS' PROTECTIVE SHELL TO BE THROWN AWAY TO LET THE INSTRUMENTS DO THEIR WORK.







COOL!

A BIT TOO SLOW! TO REACH THE GROUND BEFORE THE BATTERIES ARE EMPTY, WE HAVE TO SPEED UP A BIT. A SMALLER FINAL PARACHUTE IS RELEASED. KEEP CLEAR, PLEASE!

AT LAST, HUYGENS LANDS ON TITAN AT A FINAL SPEED OF 20 KM/H.

NO RISK OF CRASHING?

NO, AFTER LANDING, THE PROBE STILL WORKS UNTIL ITS BATTERIES ARE COMPLETELY EMPTY. AFTER THAT, ITS MISSION IS OVER!

WOW!  
WHAT A RIDE!

AND DURING THE THREE HOURS HUYGENS MAKES A LOT OF CRUCIAL MEASUREMENTS AND PHOTOGRAPHS THIS REALLY ALIEN LANDSCAPE!

GREAT! AND WHAT WILL WE FIND HERE?





THAT'S WHAT WE ALL  
WANT TO KNOW!



WHAT IS HIDING UNDER  
TITAN'S ORANGE HAZE?



THE PROBE MUST WITHSTAND  
THUNDERBOLTS AND WINDS  
GUSTING TO MORE THAN 400 KM/H.



WILL HUYGENS COME DOWN  
ON SOLID LAND IN THE MIDDLE  
OF METHANE GEYSERS?



OR SPLASH INTO AN  
ETHANE OCEAN?

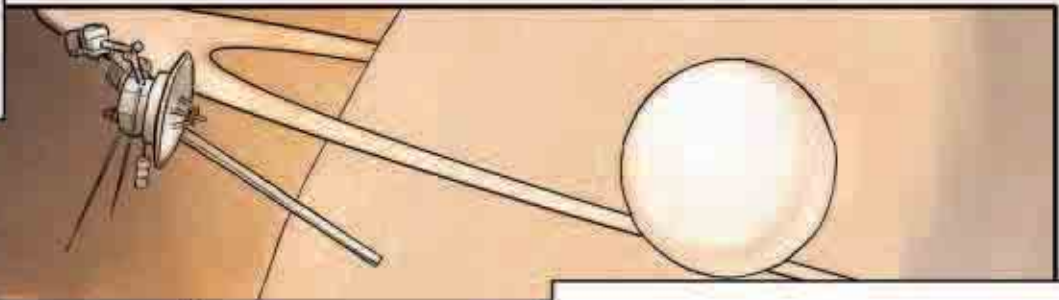


OR LAND AMONG AMMONIA  
VOLCANOES AND END UP  
FROZEN SOLID AT  $-200^{\circ}\text{C}$ ?

SO WHY GO THEN, IF  
NO ONE KNOWS WHAT  
WE'LL FIND THERE?



IT ALL BEGINS IN 1980,  
WHEN THE VOYAGER  
PROBE PASSES BY TITAN.

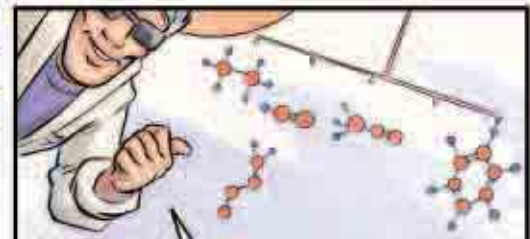


UNFORTUNATELY, ORANGE  
SMOG SURROUNDS TITAN  
LIKE A BLANKET!

AND THE PICTURES  
ARE BLURRED ...

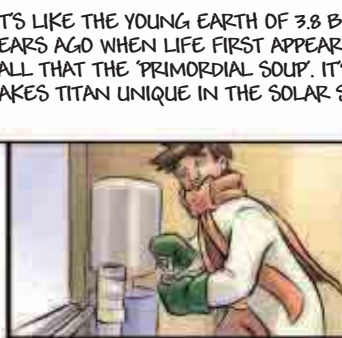
BUT WE FIND THERE IS  
NITROGEN AND METHANE  
IN TITAN'S ATMOSPHERE!

WE KNOW THAT SUNLIGHT BREAKS UP  
METHANE AND NITROGEN INTO ETHANE. SO  
FINDING LOTS OF METHANE MEANS THERE  
ARE HUGE QUANTITIES OF THIS GAS ON TITAN.



NITROGEN AND METHANE CAN COMBINE  
INTO COMPLEX MOLECULES THAT ACT AS  
BUILDING BLOCKS OF LIVING CELLS.

IT'S LIKE THE YOUNG EARTH OF 3.8 BILLION  
YEARS AGO WHEN LIFE FIRST APPEARED. WE  
CALL THAT THE 'PRIMORDIAL SOUP'. IT'S WHAT  
MAKES TITAN UNIQUE IN THE SOLAR SYSTEM.



NO, IT'S MUCH TOO  
COLD THERE!

AND THERE'S NO  
WATER AT ALL!

APART FROM THE  
COLD AND NO  
WATER, WE HAVE  
ALL THE CONDITIONS  
FOR LIFE!

TITAN IS LIKE A FROZEN EARTH JUST BEFORE LIFE APPEARED!



WE DON'T KNOW YET. BUT  
I CAN SHOW YOU HOW THE  
UNIVERSE FORMED ...



?

IT ALL STARTED WITH THE BIG BANG, A GIGANTIC EXPLOSION, ABOUT 13 BILLION YEARS AGO. THE UNIVERSE WAS THEN CONCENTRATED IN A SINGLE POINT AT BILLIONS AND BILLIONS OF DEGREES.



AS THE UNIVERSE EXPANDED, IT COOLED DOWN ENOUGH FOR ATOMS TO FORM.



AFTER THE FIRST CHEMICAL ELEMENTS FORMED FROM THOSE ATOMS, GRAVITY COLLECTED THEM TO BUILD GALAXIES.



A GALAXY HAS BILLIONS OF STARS - GIANT BALLS OF HOT GAS. AS GRAVITY SQUEEZES THE BALL, IT GETS HOTTER AND HOTTER UNTIL THE STAR LIGHTS UP.



AT THE END OF THEIR LIVES, SOME STARS EXPAND ENORMOUSLY TO BECOME RED GIANTS. ONE DAY, BILLIONS OF YEARS FROM NOW, OUR SUN WILL INFLATE LIKE A BALLOON AND SWALLOW OUR PLANET!

SEVERAL GENERATIONS OF STARS HAVE COME AND GONE BEFORE THE SUN AND ITS PLANETS FORMED.

DID LIFE START RIGHT AWAY?





OH NO, JUST AFTER ITS FORMATION 4.5 BILLION YEARS AGO, OUR EARTH WAS A SCARY PLACE. THE ATMOSPHERE WAS SCORCHING AND UNBREATHABLE. VOLCANOES ERUPTED EVERYWHERE AND ASTEROIDS FELL FROM THE SKY.



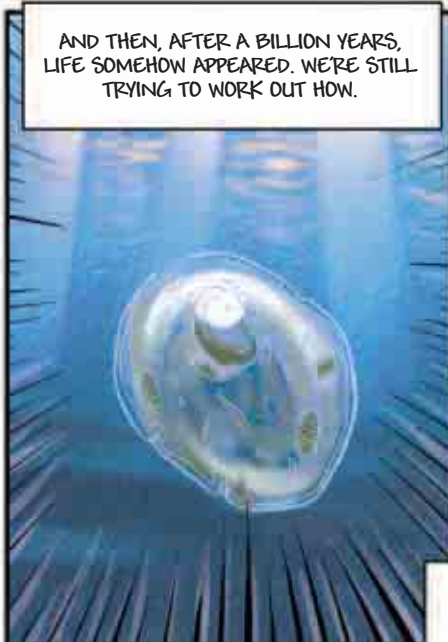
IN THIS CHAOS, BASIC CHEMICAL MOLECULES FORMED AND GREW.



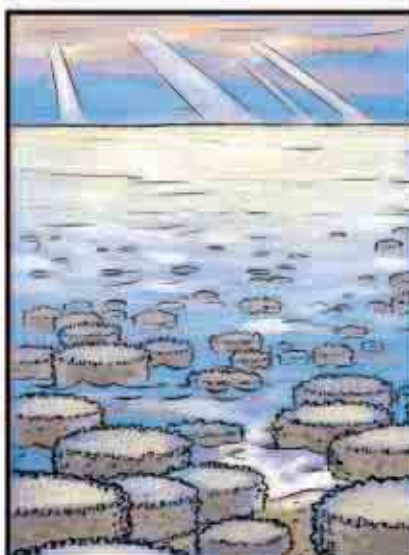
THE EARTH COOLED DOWN AND OCEANS COVERED MOST OF THE SURFACE. NUCLEIC ACIDS, PROTEINS AND LIPIDS FORMED.



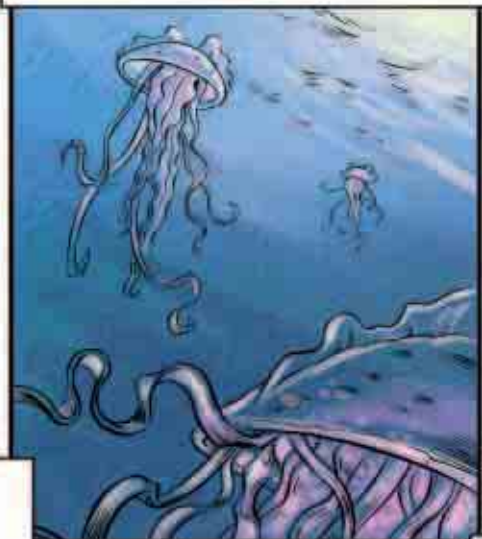
AND THEN, AFTER A BILLION YEARS, LIFE SOMEHOW APPEARED. WE'RE STILL TRYING TO WORK OUT HOW.



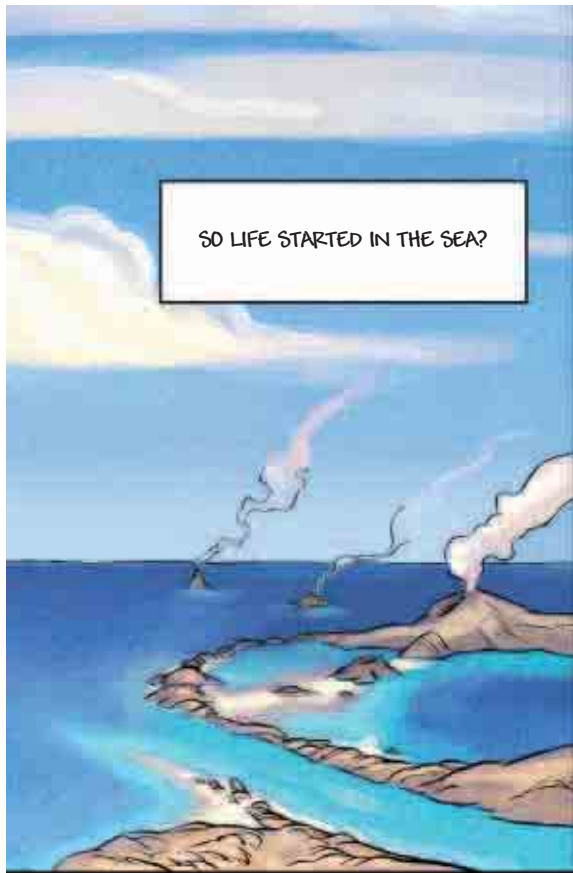
THEY GREW TOGETHER IN COLONIES AND EVOLVED OVER THE NEXT 3 BILLION YEARS INTO THE FIRST SEA INVERTEBRATES. THIS HAPPENED 'ONLY' 500 MILLION YEARS AGO.



THE FIRST SINGLE-CELL ORGANISMS APPEARED: BLUE ALGAE. FOR 2 BILLION YEARS, THEY PUMPED OXYGEN INTO THE ATMOSPHERE, GIVING THE SKY ITS BLUE COLOUR. THE FIRST ANIMALS APPEARED: SPONGES.







SO LIFE STARTED IN THE SEA?

EXACTLY. IN THE HEART OF THE OCEAN, LIFE DEVELOPED DIFFERENT FORMS STARTING FROM THE BASIC ORGANISMS.

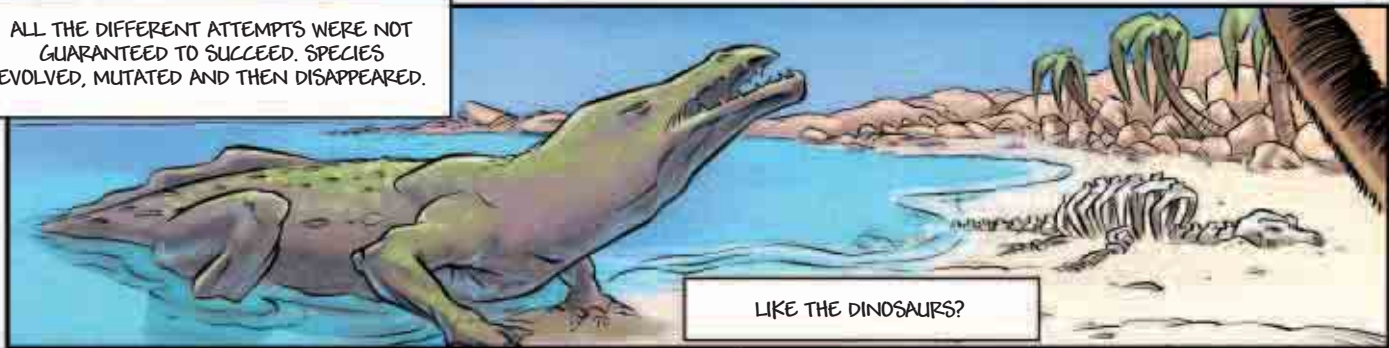


LIFE TRIED ALL POSSIBLE COMBINATIONS.

OH YES! THESE FISH LOOK WEIRD!



ALL THE DIFFERENT ATTEMPTS WERE NOT GUARANTEED TO SUCCEED. SPECIES EVOLVED, MUTATED AND THEN DISAPPEARED.



LIKE THE DINOSAURS?



BUT ALL SPECIES HAVE THE SAME ORIGIN. WE KNOW THAT BECAUSE ALL LIVING THINGS ON EARTH CARRY SOME OF THE SAME DNA MOLECULES IN THEIR CELLS.



INCLUDING HUMANITY, AND ITS EVOLUTION UP TO YOU, LUCAS!



YOU SEE, WE ALREADY KNOW A LOT OF THINGS, BUT YOU CAN SEE NOW WHY IT'S SO IMPORTANT TO DISCOVER HOW LIFE APPEARED. IT'S ONE OF THE LAST BIG MYSTERIES IN THE UNIVERSE! SO LET'S HAVE A LOOK AT THE EXPLORERS, HUYGENS' PASSENGERS!



EXACTLY! ACCORDING TO CHARLES DARWIN'S THEORY OF EVOLUTION, ONLY THE SPECIES BEST ADAPTED TO THEIR SURROUNDINGS WILL SURVIVE.

GOSH! I DIDN'T KNOW I WAS SO IMPORTANT!



TO GET THE INFORMATION WE NEED, HUYGENS IS A SPACE LABORATORY CARRYING ALL ITS VITAL SYSTEMS AND SIX SCIENTIFIC INSTRUMENTS, EACH WITH ITS OWN SPECIAL JOB.



LIKE THIS BOX?



YES. THIS INSTRUMENT IS HASI, THE HUYGENS ATMOSPHERIC STRUCTURE INSTRUMENT. IT WAS BUILT BY THE UNIVERSITY OF PADUA IN ITALY.



WHAT IS IT FOR EXACTLY?



AMONG OTHER THINGS, IT MEASURES DECELERATION, PRESSURE, TEMPERATURE AND LIGHTNING FLASHES.

ARE THE FLASHES IMPORTANT?



THEY MIGHT BE THE SPARK OF LIFE!

NOW LOOK AT THIS CYLINDER. IT'S THE GCMS, THE GAS CHROMATOGRAPH & MASS SPECTROMETER, BUILT BY NASA'S GODDARD SPACE FLIGHT CENTER IN AMERICA.



WHAT A STRANGE NAME!

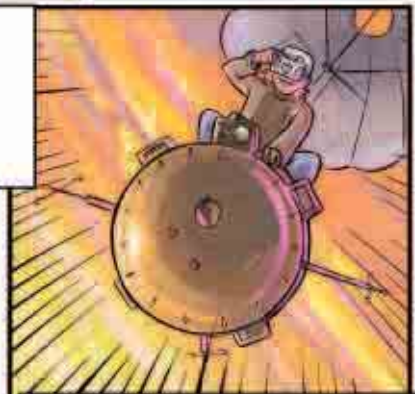
THERE ARE TWO MAIN THEORIES FOR THE ORIGIN OF LIFE. MAYBE THE BUILDING BLOCKS OF LIFE FORMED WHEN SUNLIGHT AND LIGHTNING REACTED WITH THE BASIC CHEMICAL ELEMENTS OF THE PRIMORDIAL EARTH. OR PERHAPS THESE BLOCKS WERE BROUGHT BY A COMET TO EARTH.

WE KNOW THAT ARGON GAS IS VERY IMPORTANT FOR THE ORIGIN OF LIFE, SO THE GCMS WILL MEASURE THE EXACT AMOUNT IN TITAN'S ATMOSPHERE. IF IT FINDS VERY LITTLE, THEN THE ARGON PROBABLY FORMED LOCALLY ON TITAN. BUT FINDING HUGE QUANTITIES PROBABLY MEANS IT RAINED DOWN ON COMETS.



GREAT! AND THIS ONE, WHAT IS IT FOR?

BUT HOW CAN WE DECIDE?



CAREFUL, DON'T TOUCH IT! THIS IS THE DISR, THE DESCENT IMAGER/SPECTRAL RADIOMETER, BY THE UNIVERSITY OF ARIZONA IN AMERICA TO STUDY THE COMPOSITION OF TITAN'S SURFACE.



JUST BEFORE LANDING, A LAMP WILL LIGHT UP THE SURFACE TO SEE WHAT'S THERE.

WHERE ARE THE OTHER INSTRUMENTS?

IT MAKES EXTREMELY SENSITIVE MEASUREMENTS OF HUYGENS' SPEED AND DIRECTION, REVEALING THE WINDS PUSHING THE PROBE AROUND AS IT FLOATS UNDER THE PARACHUTES. IT WAS BUILT BY THE UNIVERSITY OF BONN IN GERMANY.

LOOK! HERE'S THE DWE, THE DOPPLER WIND EXPERIMENT.

WHAT ELSE IS ON THE CAPSULE?

YOU WILL SEE THE ACP, THE AEROSOL COLLECTOR AND PYROLYSER.

IT WAS BUILT BY THE INSTITUT D'AÉRONOMIE IN VERRIÈRES IN FRANCE TO ANALYSE TITAN'S ATMOSPHERE.

ON THIS SIDE YOU CAN FIND THE BATTERIES, HUYGENS' COMPUTERS AND RADIO TRANSMITTER. BUT IF YOU LOOK BELOW ...

IT HEATS UP SAMPLES OF THE ATMOSPHERE IN SMALL OVENS TO BREAK THE MOLECULES APART, AND FEEDS THEM TO THE GCMS FOR IDENTIFICATION. IT WORKS LIKE A TINY KITCHEN OVEN.

AND THIS LAST ONE IS THE SURFACE SCIENCE PACKAGE. IT REVEALS THE SURFACE AND COMPOSITION OF THE LANDING SITE.

AND WHAT IF HUYGENS SPLASHES INTO AN OCEAN?

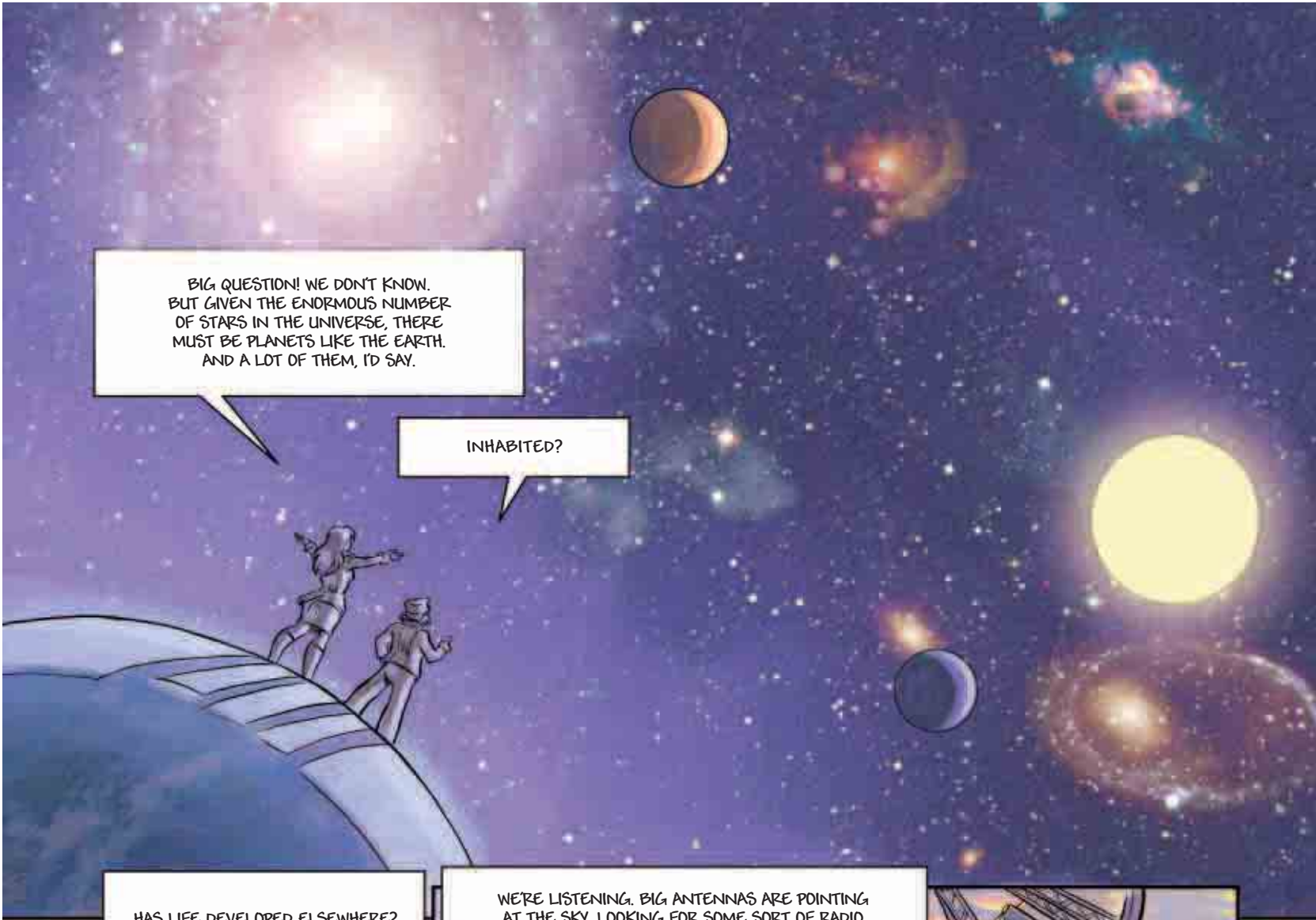
IT CHECKS FOR WAVES, THE DEPTH AND IF THEY'RE LIQUID ETHANE OR SOMETHING SIMILAR.

NOW YOU'VE SEEN ALL OUR TOOLS TO PROBE THE MYSTERY OF THE ORIGIN OF LIFE. DID YOU ENJOY IT?

YES! IT'S FASCINATING! BUT DO YOU THINK WE ARE ALL ALONE IN THE UNIVERSE?

THE TEAM AT THE OPEN UNIVERSITY OF MILTON KEYNES IN THE UNITED KINGDOM HAVE THOUGHT OF EVERYTHING!





BIG QUESTION! WE DON'T KNOW.  
BUT GIVEN THE ENORMOUS NUMBER  
OF STARS IN THE UNIVERSE, THERE  
MUST BE PLANETS LIKE THE EARTH.  
AND A LOT OF THEM, I'D SAY.

INHABITED?

HAS LIFE DEVELOPED ELSEWHERE?  
WE DON'T KNOW YET, BUT IT'S LIKELY!

WE'RE LISTENING. BIG ANTENNAS ARE POINTING  
AT THE SKY, LOOKING FOR SOME SORT OF RADIO  
SIGNAL SENT BY ALIEN CIVILISATIONS.

HAVE YOU HEARD  
ANYTHING YET?

BUT HOW CAN WE  
MAKE SURE?

NOT YET! BUT SATELLITES WILL BE  
LAUNCHED SHORTLY TO LOOK FOR  
PLANETS AROUND OTHER STARS.

THAT'S NOT SO EASY!  
REMEMBER, WE NEEDED  
SEVEN YEARS TO GET TO  
SATURN, WHILE THE NEAREST  
STAR FROM EARTH, PROXIMA  
CENTAURI, IS 38,000 TIMES  
FARTHER. AT THAT SPEED, IT  
WOULD TAKE 266,000 YEARS!

THEORETICALLY, IT IS POSSIBLE TO  
HAVE A SPACESHIP MAKE A RETURN  
TRIP TO A DISTANT STAR.

WHY NOT SEND A  
SPACE PROBE ALL THE  
WAY OUT THERE TO  
LOOK CLOSER-UP?

BUT OUR TECHNOLOGY ISN'T  
READY - A LOT OF WORK  
REMAINS TO BE DONE.

BUT THERE MUST  
BE A WAY!



WHAT DO YOU MEAN?

ANOTHER TIME - IT'S RATHER COMPLICATED. I HAVE TO GET YOU BACK TO THE BUS!

OH NO! NOT YET!

DON'T FORGET THE ARRIVAL OF HUYGENS ON TITAN IN JANUARY 2005.

HOW CAN I GET MORE INFO ON WHAT WILL HAPPEN?

THE CENTRE WILL CLOSE IN A FEW MINUTES. PLEASE PROCEED TO THE GATE. THANK YOU!

YOU CAN LISTEN TO THE TV NEWS, IT WILL BE A WORLDWIDE EVENT!

YOU CAN ALSO CHECK THE ESA WEBSITE AT [WWW.ESA.INT](http://WWW.ESA.INT), WHERE THERE'S LOTS OF GREAT STUFF!

ALL RIGHT! BUT IF I WANT TO KNOW MORE?

THE INTERNATIONAL COOPERATION ON THE CASSINI/HUYGENS MISSION HAS ALREADY MADE A SUCCESS OF THIS DARING PROGRAMME.

EVERYTHING STARTED ALMOST 20 YEARS AGO, HUNDREDS OF PEOPLE ARE INVOLVED IN THIS FASCINATING PROJECT, AND THOUSANDS MORE WILL ANALYSE THE INFORMATION SENT BACK FROM THIS FARAWAY MOON.

ME TOO! I WANT TO BE PART OF THIS STUFF WHEN I GROW UP!

WHEN YOU'VE FINISHED SCHOOL AND UNIVERSITY, THERE ARE LOTS OF JOBS IN THE SPACE SECTOR: AT ESA, AT NATIONAL SPACE AGENCIES, RESEARCH LABORATORIES, UNIVERSITIES AND INDUSTRY. YOU CAN CHOOSE - THEY ALL CONTRIBUTE TO SPACE PROJECTS.

THAT'S A MARVELLOUS PROJECT, LUCAS!

YOU KNOW WHAT, AUNTY ANN? I'M GOING TO INVENT SATELLITES TO COMMUNICATE WITH ALIENS ON OTHER PLANETS!



DO YOU WANT TO  
KNOW MORE?



YES!!



# BIOGRAPHIES

The orbiter spacecraft is named after the French/Italian astronomer Giovanni Domenico Cassini, the probe is named after the Dutch astronomer Christiaan Huygens. Here's some information about these two scientists.



## Christiaan Huygens

Born in the Netherlands in 1629, Christiaan Huygens studied law and mathematics and conducted experiments in mechanics and optics, especially telescopes. In 1655, he pointed his telescope towards Saturn to study its rings. He was surprised to see that, besides the rings, the planet also had a large moon. This moon is now known as Titan.

He invented the pendulum clock and became one of the founding members of the French Academy of Sciences in 1666. He stayed in Paris from 1666 to 1681 with only occasional visits to Holland. In 1673 he published his famous book "Horologium Oscillatorium". In 1689 Huygens met Sir Isaac Newton in London, but because they disagreed over their different scientific theories the two did not get on very well.

Huygens died in 1695. The scientist was not really recognised in his time, but his contributions to science are now considered to be of fundamental importance.

## Jean-Dominique Cassini

Cassini was born Giovanni Domenico Cassini in Perinaldo, Imperia, Italy, on 8 June 1625. He became a French citizen in 1673, changing his first name to Jean-Dominique.

Cassini was Director of the Observatoire de Paris and spent much of his time observing Saturn, its moons and rings. Cassini discovered four moons of Saturn: Iapetus, Rhea, Tethys and Dione. He also discovered what is known today as the 'Cassini Division', the narrow gap separating Saturn's main rings, and that the rings were in fact swarms of tiny moonlets too small to be seen individually.



He died in Paris in 1712, after starting the long and distinguished dynasty of French astronomers working at the Observatoire de Paris. Cassini was a traditionalist by nature and, although he accepted some theories, he also dismissed others that have since proved to be true. Nevertheless, he stands among the most important scientists of the 17th and 18th centuries.



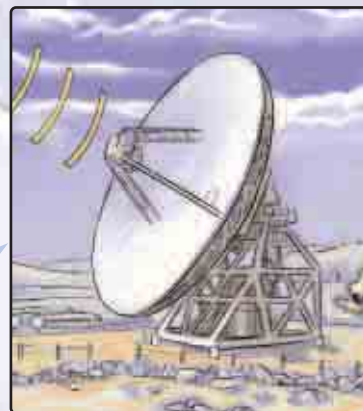
# GLOSSARY

**Aerosol:** Mixture of particles (liquid or solid) in a gas. A cloud is an aerosol.

**Ammonia:** Compound (or molecule) with the chemical formula  $\text{NH}_3$  (one nitrogen atom and three hydrogen atoms).

**Antenna:** Electricity-conducting device used to radiate and/or receive electromagnetic waves such as radio waves.

**Argon:** Inert, colourless and odourless gas (belonging to the group of noble gases). The atmosphere of Titan is thought to have only a few percent of argon.



**Asteroid:** Small planet with no atmosphere, less than 1000 kilometres in diameter. There is an asteroid belt between Mars and Jupiter.

**Atmosphere:** Layer of gases surrounding a planet or moon. On Earth, the atmosphere (about 100 km thick) enables us to breathe. Titan's atmosphere has a thickness of 1200 km.

**Big Bang:** The event that created the Universe as we know it. Scientists think it was a gigantic explosion that caused particles to form and led to the formation and subsequent collection of all known elements.

**DNA/RNA:** DNA stands for deoxyribonucleic acid. It is the essential constituent of chromosomes, that part of a cell that carries the genes. RNA stands for ribonucleic acid.

**Envisat:** An ESA satellite that is making environmental measurements of the Earth. It was launched in 2002 into an orbit that passes over the poles at a height of 800 km. It weighs 8 tonnes and contains 10 different instruments.

**ESA - European Space Agency:** Europe's organisation responsible for space research and development. Fifteen countries are members now, with another two by the end of 2005.

**Ethane:** Compound with the chemical formula  $\text{C}_2\text{H}_6$  (two carbon atoms and six hydrogen atoms), which is a constituent of organic compounds on Titan and of its atmosphere (having formed from methane ( $\text{CH}_4$ ) because of the Sun's ultraviolet rays) as well as of the liquids on its surface.

**Fuel:** When mixed with an oxidiser, fuel burns in an engine. Petrol is a fuel.

**Galaxy:** A group of stars. Our Solar System – the Sun and its planets – are in the galaxy we call the Milky Way.





**Geostationary:** A satellite that orbits the Earth above the equator, at a height of about 36000 km. Like this, it remains constantly above the same spot on Earth and is ideal for communications or weather observation.

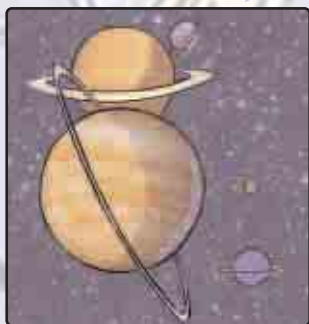
**Giotto:** ESA probe that flew close to Halley's comet in 1986.

**Gravity assist:** Using a planet's gravity to accelerate and alter the course of a space probe as it passes close to the planet.

**Hydrocarbon:** Chemical compound containing only carbon and hydrogen, such as methane, ethane and petrol.

**Lipids:** Fatty compounds. They are the main constituent of butter and cooking oil, but are also essential building blocks of any living organism.

**Methane:** A chemical compound of one carbon atom and four hydrogen atoms ( $\text{CH}_4$ ). It is a constituent of organic compounds on Titan, its atmosphere and probably of any liquids on its surface.



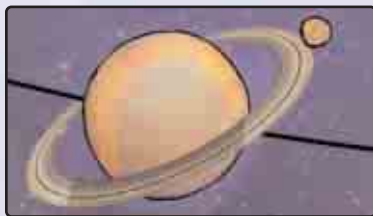
**Moon:** Body that orbits a planet. Almost all the planets in the Solar System have one or more moons - only Venus and Mercury have none.

**NASA:** National Aeronautics and Space Administration; the United States' space agency.

**Nitrogen:** Colourless, odourless gas. The atmospheres of Earth and Titan are mainly molecules of molecular nitrogen ( $\text{N}_2$ ).

**Nucleic acid:** Organic acid making up the nucleus of a cell. DNA and RNA are examples of nucleic acid.

**Oxidiser:** Compound which, when combined with another compound (fuel), leads to the latter's combustion. In the case of aircraft, oxygen from the air is the oxidiser. It is a constituent which must be flown aboard a launcher or satellite for propulsion in space where there is no oxygen in the atmosphere.



**Particle:** A very small part of matter, such as an electron, or of energy, such as a photon.

**Planet:** A large body orbiting a star. There are solid planets, like Earth, and gaseous planets, like Saturn. There are nine known planets in our Solar System, and they orbit our star, the Sun. Many gaseous giant planets have now been discovered orbiting other stars.

**Probe:** Machine launched to the Moon and planets.

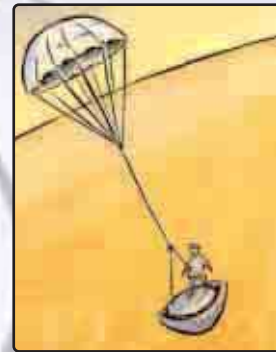




**Propulsion system:** The part of a satellite or probe used to change its path.

**Protein:** Complex molecule containing nitrogen – and one of the main constituents of living organisms.

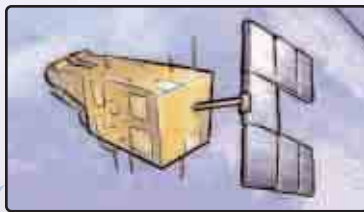
**Prototype:** First model of a satellite. With the help of the prototype, scientists and engineers check whether the satellite's design and operation are correct.



**Proxima Centauri:** Closest star to the Sun. It is just over four light years from us, which means that the light from this star takes four years to reach us at the speed of 300 000 km per second. The light from the Sun takes eight minutes to reach Earth and about 1 hour and 20 minutes to get to Saturn and Titan.

**Red Giant:** A star like the Sun will expand into a Red Giant when it becomes very old. A Red Giant is a very bright star with a large diameter (about 50 times that of the Sun).

**Rosetta:** ESA probe launched from Earth on 2 March 2004 and is heading for the comet Churyumov-Gerasimenko, which it will reach in 2014. Its 'Philae' lander will be the first thing to touch down on a comet.



**Satellite:** An object circling another. It may be a natural satellite such as the Moon or an artificial satellite such as Envisat, which are both orbiting the Earth. Likewise, the Earth is a satellite of the Sun.

**Satellite test chamber:** An enclosed space in which tests, such as noise, heat, cold, vacuum and radiation, can be carried out on satellites without putting people at risk.

**Solar panel:** Surface covered with solar cells that convert sunlight into electricity to power the equipment and instruments of a satellite or probe.

**Star:** Celestial body that produces energy through thermonuclear reactions. The Sun is a star.

**Trajectory:** Path taken by a satellite or probe in space.

**Ulysses:** ESA/NASA satellite orbiting the Sun's poles. It is the first satellite to leave the plane in which most planets (including the Earth) orbit the Sun and to fly over its poles. This was achieved by using a gravity assist from Jupiter. It was launched on 6 October 1990.



**Vibration:** Rapid shaking of a satellite during testing and lift-off.

**Voyager:** US probes (Voyager 1 and 2) that explored the Solar System, especially the giant planets, during 1977-89.





# LINKS

EUROPEAN SPACE AGENCY:

[www.esa.int](http://www.esa.int)

EUROPEAN SPACE AGENCY EDUCATION PAGES:

[www.esa.int/education](http://www.esa.int/education)

CASSINI/HUYGENS MISSION WEBPAGES:

[saturn.esa.int](http://saturn.esa.int)

INFORMATION AND EDUCATIONAL TOOLS ABOUT THIS COMIC:

[www.esa.int/education/huygens](http://www.esa.int/education/huygens)

## About ESA

The European Space Agency (ESA) is Europe's gateway to space. By the end of 2005 ESA will have 17 Member States. Many different people – scientists, engineers, politicians, lawyers and many more – from all these different countries work together to make sure that space continues to deliver benefits to the citizens of Europe. ESA can undertake programmes and activities that would be impossible to do for any single European country.

The Agency's projects are finding out more about the Earth, its immediate space environment, the Solar System and the Universe. ESA also works closely with space organisations outside Europe to share the benefits of space with the whole of mankind.

Cassini/Huygens is the result of cooperation between NASA (the US National Aeronautics and Space Administration), ESA and the Italian Space Agency (ASI).

## About Alcatel Space

Alcatel Space is one of the world's leading satellite builders. It does everything from telecommunications, navigation, environment to radar and optical observation, meteorological and scientific satellites.

Alcatel Space is active in projects undertaken by the European Commission, the European Space Agency, the French Space Agency CNES, Eumetsat (European Organisation for the Exploitation of Meteorological Satellites) and the French defence procurement agency DGA in programmes concerning oceanography, climatology, meteorology or environmental studies.

Alcatel Space also works on spacecraft that will try to answer some of the most fundamental questions of mankind: what happened at the Big Bang, for example, or whether there are planets like Earth somewhere in the Universe. The Alcatel Space plant in Cannes, France, is the prime contractor for the Huygens probe.