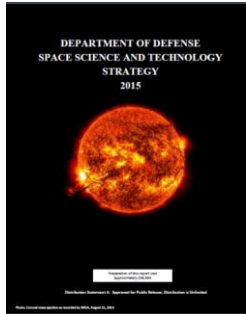




MÉTÉOROLOGIE : DE L'ATMOSPHÈRE À L'ESPACE (NANOSATELLITES)
LES ACTEURS DU NEWSPACE EN OBSERVATION DE LA
TERRE

MICHEL FAUP CNES/DIA/IP (RESTITUTION ÉQUIPE ANTICIPATION)



<= Red Dragon en vue de la conquête de Mars

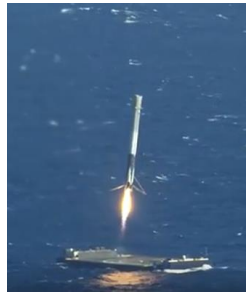
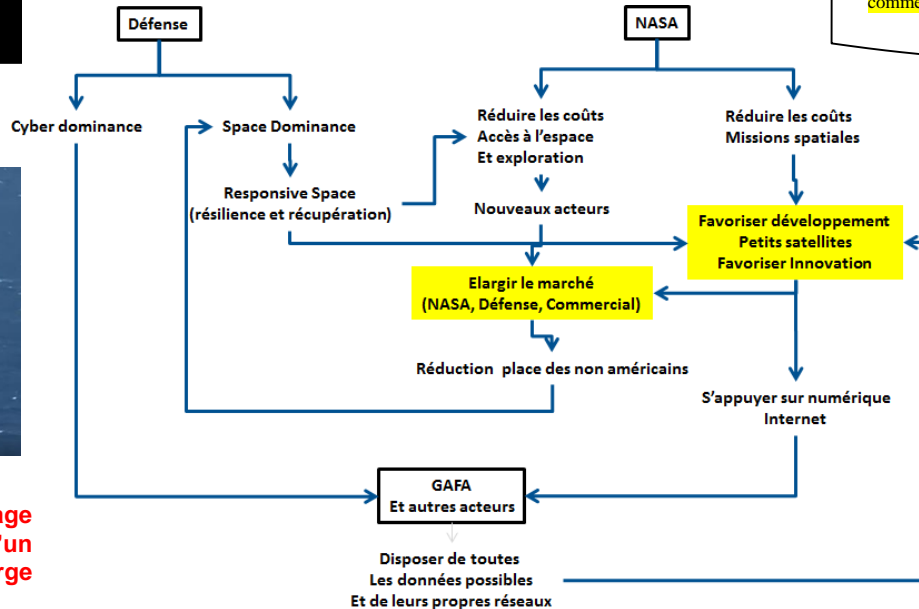
Capsule équipage de New Shepard en vue du tourisme spatial =>



The National Aeronautics and Space Act
 Pub. L. No. 111-314
 124 Stat. 3328 (Dec. 18, 2010)

CONGRESSIONAL DECLARATION OF POLICY AND PURPOSE

Sec. 20102. Congressional declaration of policy and purpose
 (...)
 (c) Commercial Use of Space.— Congress declares that the general welfare of the United States requires that the Administration **seek and encourage, to the maximum extent possible, the fullest commercial use of space.**



10/04/16 : Atterrissage réussi du 1^{er} étage d'un Falcon 9 sur une barge (SpaceX)

23/11/15 : Atterrissage réussi du module de propulsion de New Shepard (Blueorigin)

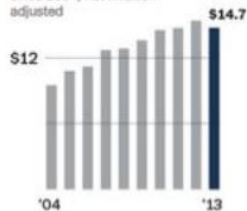
The top five agencies, by spending



Central Intelligence Agency

Collect, analyze, evaluate, disseminate foreign intelligence and conduct covert operations.

Agency fiscal year budget since 2004, not inflation-adjusted

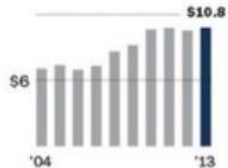


Approximate percentage growth from 2004 to 2013



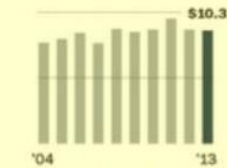
National Security Agency

Protect the government's information systems and intercept foreign signals intelligence information.



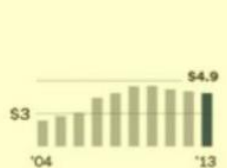
National Reconnaissance Office

Design, build, and operate the nation's signals and imagery reconnaissance satellites.



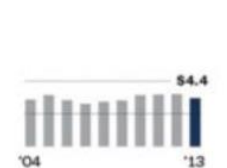
National Geospatial-Intelligence Program

Generate and provide imagery and map-based intelligence, which is used for national security, U.S. military operations, navigation and humanitarian aid efforts.



General Defense Intelligence Program

Provide assessments of foreign military intentions and capabilities to policymakers and military commanders. Conduct human and technical intelligence collection, document and media management.



Une « fuite » d'un document sur les budgets secrets des organisations de renseignement de 2013 a révélé que leur total était alors de 52,6 G\$ dont les organisations spécifiquement spatiales (NRO et NGA) représentaient 15,2 G\$ soit 28,9 % du total.

GEOINT Reinvented

Digital
Production

Object-Based
Production

Persistent
GEOINT



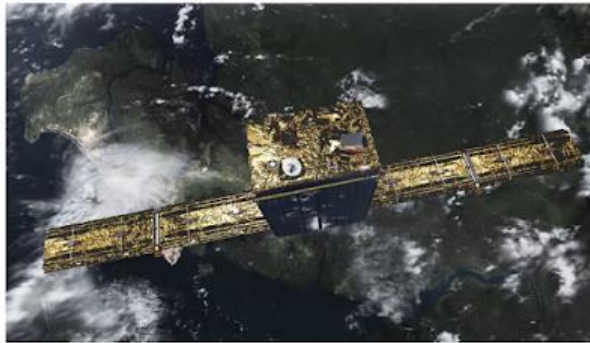
Age of Content → Age of Context



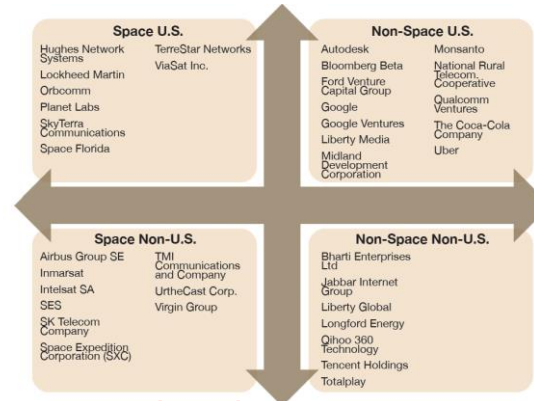
NGA
NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

@ GEOINT 2015



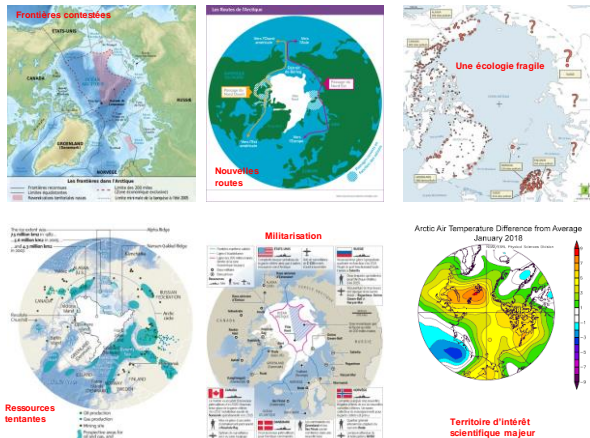


ICEYE's first proof-of-concept satellite, ICEYE-X1



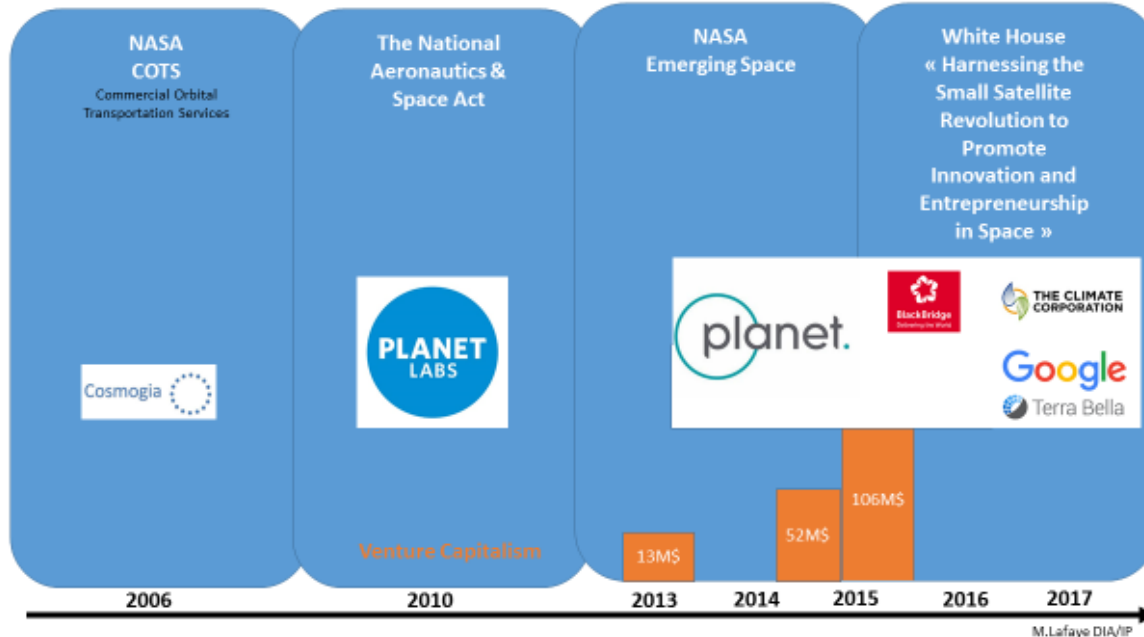
Les entités privées qui investissent dans l'espace ont plus couramment leur siège aux USA et proviennent plus souvent de secteurs non spatiaux

- Créer les conditions de déstabilisation des concurrents internationaux
- Avoir une offre qui fait la différence - compétitivité : performance, coût, service, ...
- Soutenir son marché national – commande institutionnelle (science, Défense, ...)
- Faciliter l'export ou la prise de participation dans des projets internationaux
 - IceEYE, financement US
 - GOMSpace, idem
- Profiter/Créer les conditions de « rachat par la dette »
- Identifier les phases de développement – Levées de fonds pour changer d'échelle
 - Planet – Skybridge – TerraBella
 - UrtheCast – DEIMOS
 - IceEYE (US), DAURIA (Chine), Satellogic (Chine)



Les enjeux arctiques

Un soutien de bout en bout pour qu'un grand groupe entre au tour de table...MONSANTO via Climate Corp



M.Lafaye DIA/IP

Les grandes manœuvres ont commencé

2017 :

- Planet deale avec Google et récupère les Skysat de TerraBella



- Accord Planet – Farmer’s Edge (octobre) et Human Rights Watch

- UrTheCast-Deimos et SpaceEye signent un accord de partenariat

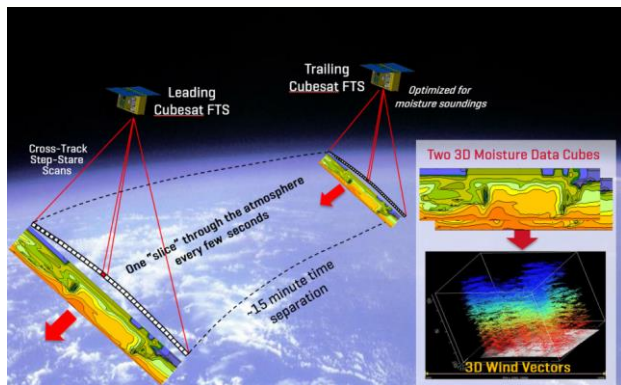
- Planet annonce « Mission 1 completed ! » => 1 Terre en 1 jour

- TAS + SpaceFlight fabriqueront les satellites de BlackSky Global

- Hera systems change de management <= anciens de BOEING

- Rachat MDA DigitalGlobe

- Acquisition de Orbital ATK par Northrop Grumman



Le concept Hypercube de mesure des vents en 3D



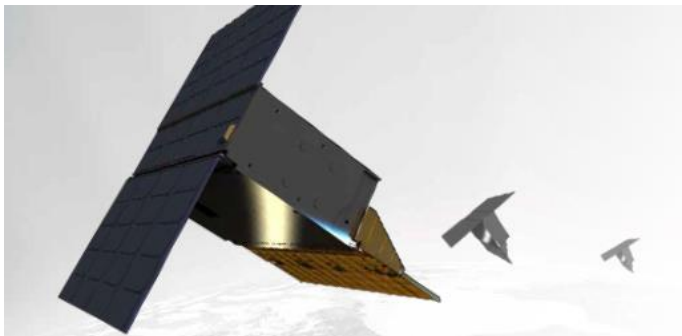
Prototype de satellite hypercube

Caractéristiques Hypercube :

Spectral Range: 5.7 – 8.3 μm
Spectral Resolution: 1 cm^{-1}
Swath: 2000 km
Instrument Mass: 5 kg
Pointing Accuracy: 0.02°
Downlink Capability: 2 Mbps
Power: 40 W

<https://www.harris.com/solution/hypercube-3d-wind-measurement>

- Entreprise fondée en 1895 (Cleveland) pour commercialiser un chargeur automatique de papier pour impression
- A partir de 1957 s'intéresse au spatial à travers les télécommunications
- Aujourd'hui, un revenu annuel de 8G\$ et une offre centrée sur les systèmes de télécommunications, les systèmes d'intelligence et spatiaux et les systèmes électroniques
- Harris annonce pour 2019 un service de données vent sur la base de sa constellation de 12 satellites
- Satellites fournis par Space Dynamics (un laboratoire de Utah State University)
- Instrument améliorant la technologie du CrIS de la NOAA (JPSS-1)
- La géométrie de la constellation permet une séparation temporelle de 15 min et une revisite de 2 fois par jour à l'équateur



HYPERCUBE™ 3D WIND MEASUREMENT

Weather forecasting models depend on detailed observations of the atmosphere to produce accurate forecasts. Satellites have significantly increased the amount of temperature and moisture data collected, but the availability of wind data at multiple levels of the atmosphere has lagged behind. Harris developed the HyperCube™ three-dimensional sounding instrument to bridge that gap.

HYPERCUBE™ FEATURES

Constellation: 12 HyperCubes—overlapping ground tracks separated by 15 minutes
Channels: 637 (1600-2250 cm^{-1} at 1.26 cm^{-1} spectral resolution)
Ground sample size: 5 km
Focal Plane Array: 25x25 MWIR
Thermal: 2 stage passive cooler (95K at FPA)
Mass: 12 kg (full satellite)
Volume: 6U-12U
Power: 13 W (Instrument), 21 W total
NEΔN: 0.1-0.2 $\text{mW/m}^2\text{sr}\text{cm}^{-1}$
Radiometric Accuracy: 0.5K

WIND VECTOR CHARACTERISTICS

Accuracy: 2-3 m/sec
Density: 30+ vertical layers
Frequency: Every 6 hours

More detailed wind information has been identified as a top priority to improving weather forecasting models. Harris provides HyperCube™, a high-performance, cost-effective solution.

HyperCube™ is designed to measure vertical profiles of temperature and moisture, and the speed, direction, and elevation of winds in the atmosphere. Being a Fourier transform spectrometer, the HyperCube™ is much smaller, less expensive, and easier to implement than complex LiDAR wind measurement programs.

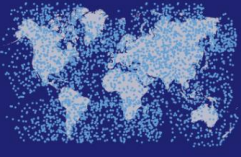
Enabled by the proven sounding technology of Harris, HyperCube™ uses more than 600 hyperspectral infrared channels to provide wind measurements at more than 30 layers of the atmosphere, at a fraction of the size of previous instruments.

Data accuracy is maintained using an onboard calibration target capable of precise, absolute calibration. HyperCube™ also offers collection time flexibility, allowing for more mission coverage than alternative technologies.

Revolutionizing our understanding of Earth's atmosphere with the highest-quality, most cost-effective data for weather forecasting and climate monitoring.

GLOBAL

Over 8 million observations per day



POWERFUL

Penetrates through clouds & storms down to the Earth's surface (where weather matters most)

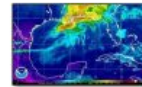
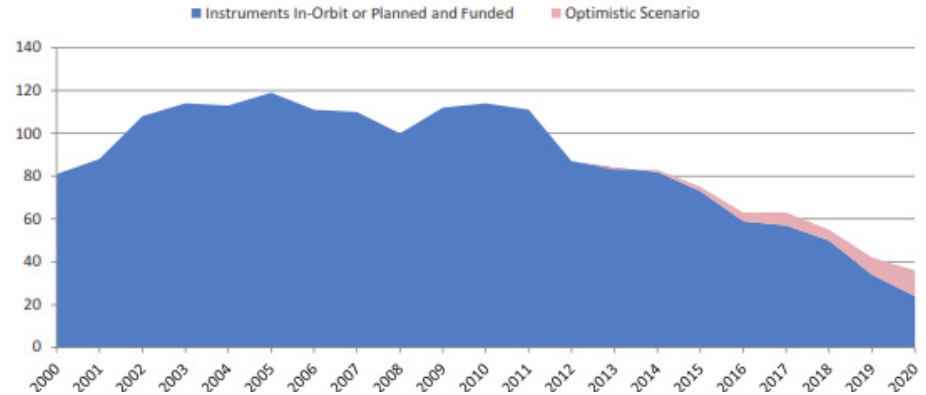


PRECISE

The most accurate global measure of temperature



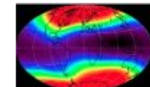
PlanetIQ will launch the first commercial constellation exclusively focused on weather, climate and space weather, with 12 microsattellites on orbit by early 2018.



Weather

Vertical atmosphere profiles:

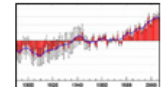
- Refractivity
- Pressure
- Temperature
- Density



Space Weather

Ionosphere measurements:

- Total Electron Content
- Scintillations
- Local Energetic Particles
- F-Region



Climate

Vertical atmosphere profiles of:

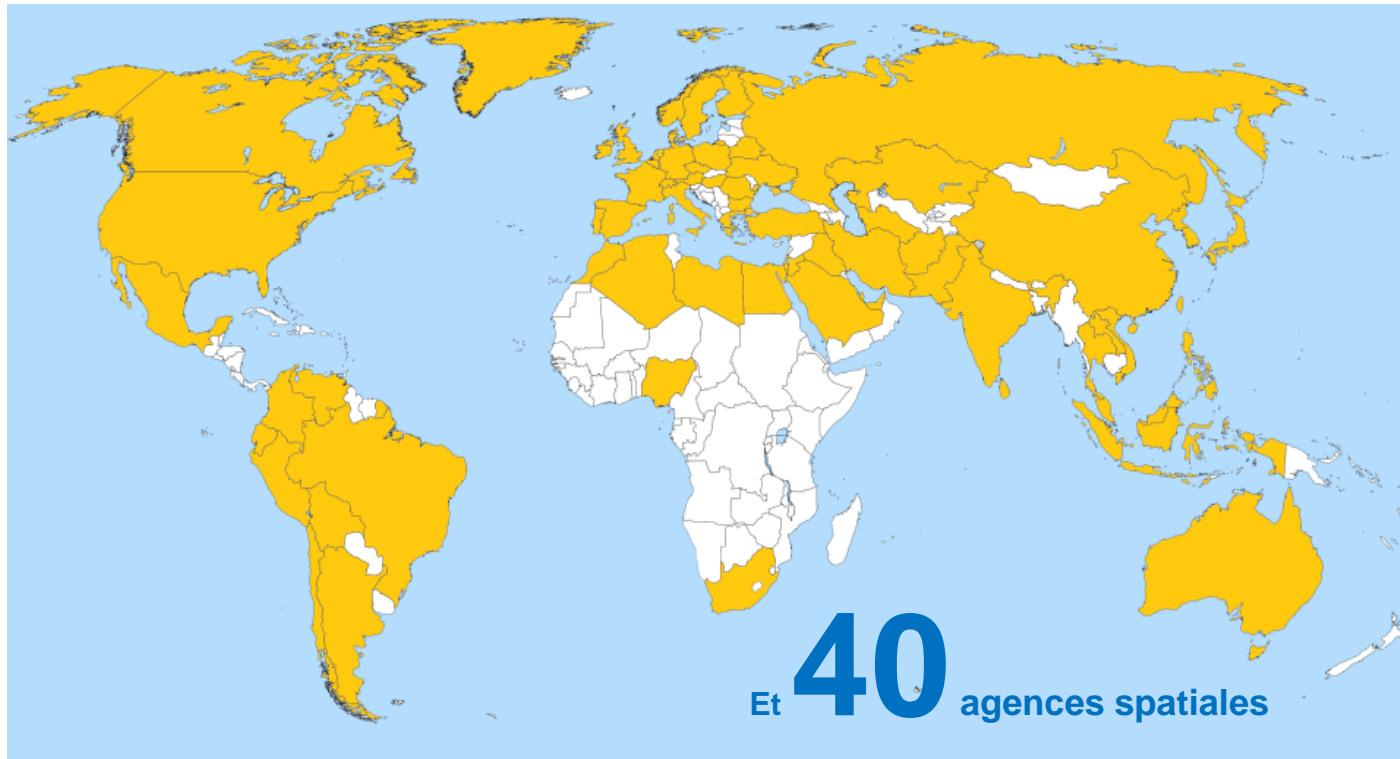
- Refractivity
- Pressure
- Temperature
- Density

- **Entreprise fondée en 2012 (Boulder)**
- **PlanetIQ représente un modèle nouveau de coopération public-privé : lever des fonds privés pour augmenter les systèmes gouvernementaux par des données commerciales**

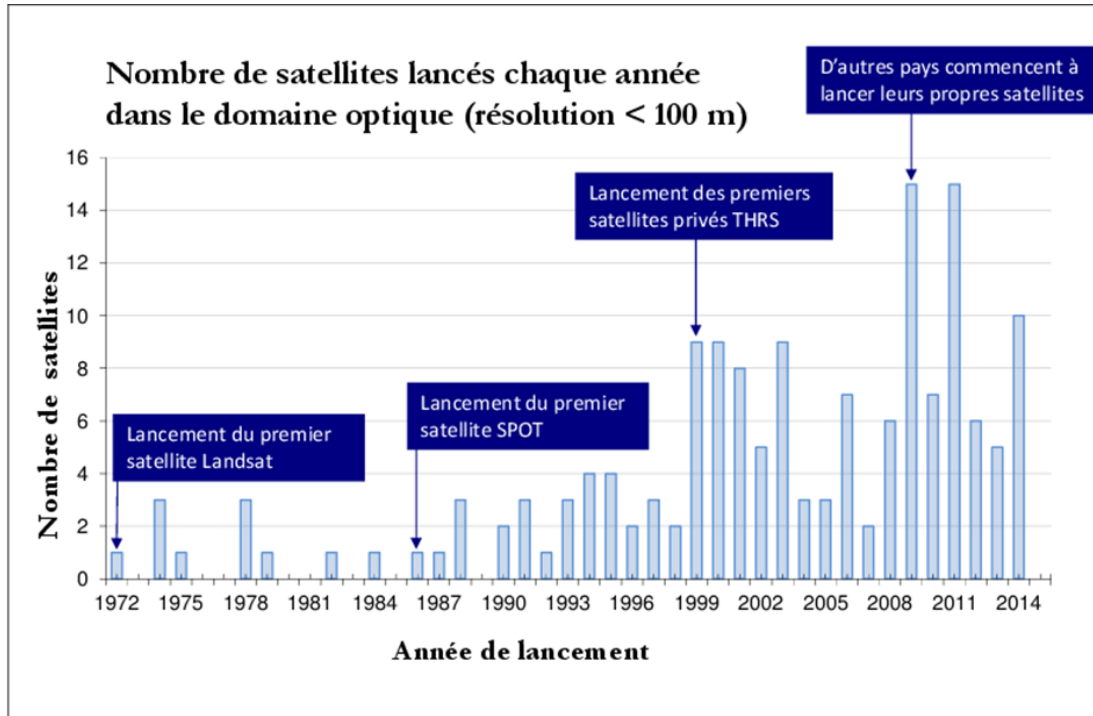
En 1966, il y en avait **4**

En 2017, il y en a **70**

Sources : UCSUSA (Union of Concerned Scientists USA)



Et **40** agences spatiales



60 agences (météorologie)

+ Satellites commerciaux (imagerie)

~400 satellites

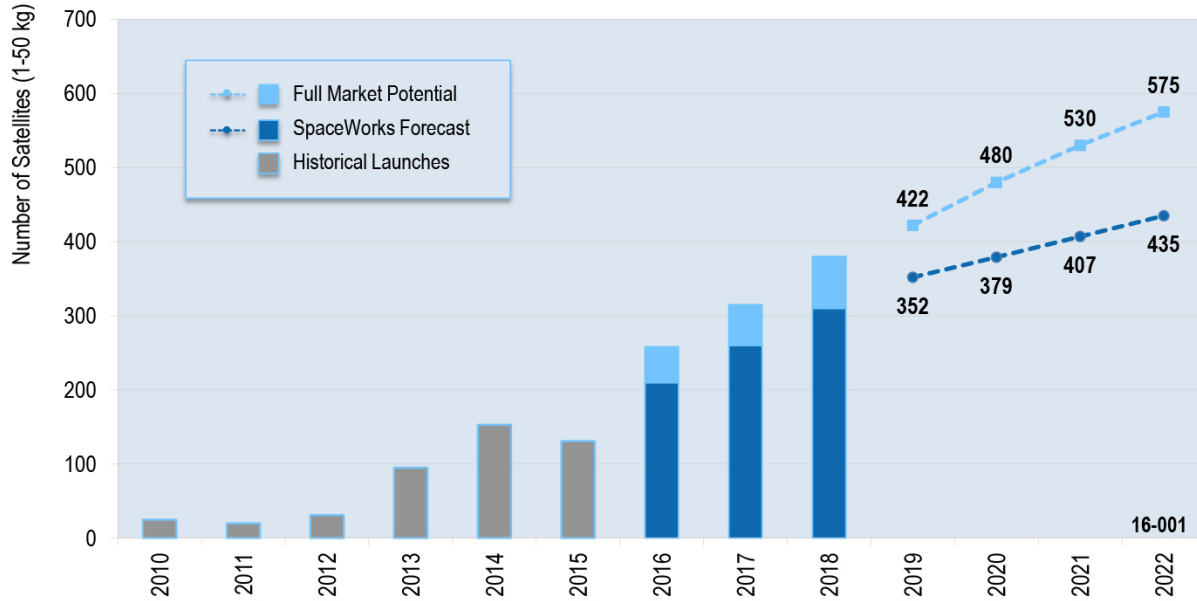
+ Satellites de Défense (optique & radar) ??

France (total)

**~25 satellites lancés
(4 Défense)**

**vers 2020
~34 satellites
(7 Défense)**

Projections based on announced and future plans of developers and programs indicate as many as 3,000 nano/microsatellites will require a launch from 2016 through 2022



The 2016 Full Market Potential dataset is a combination of publicly announced launch intentions, market research, and qualitative/quantitative assessments to account for future activities and programs.
The 2016 SpaceWorks Forecast dataset reflects SpaceWorks' expert value judgment on the likely market outcome.

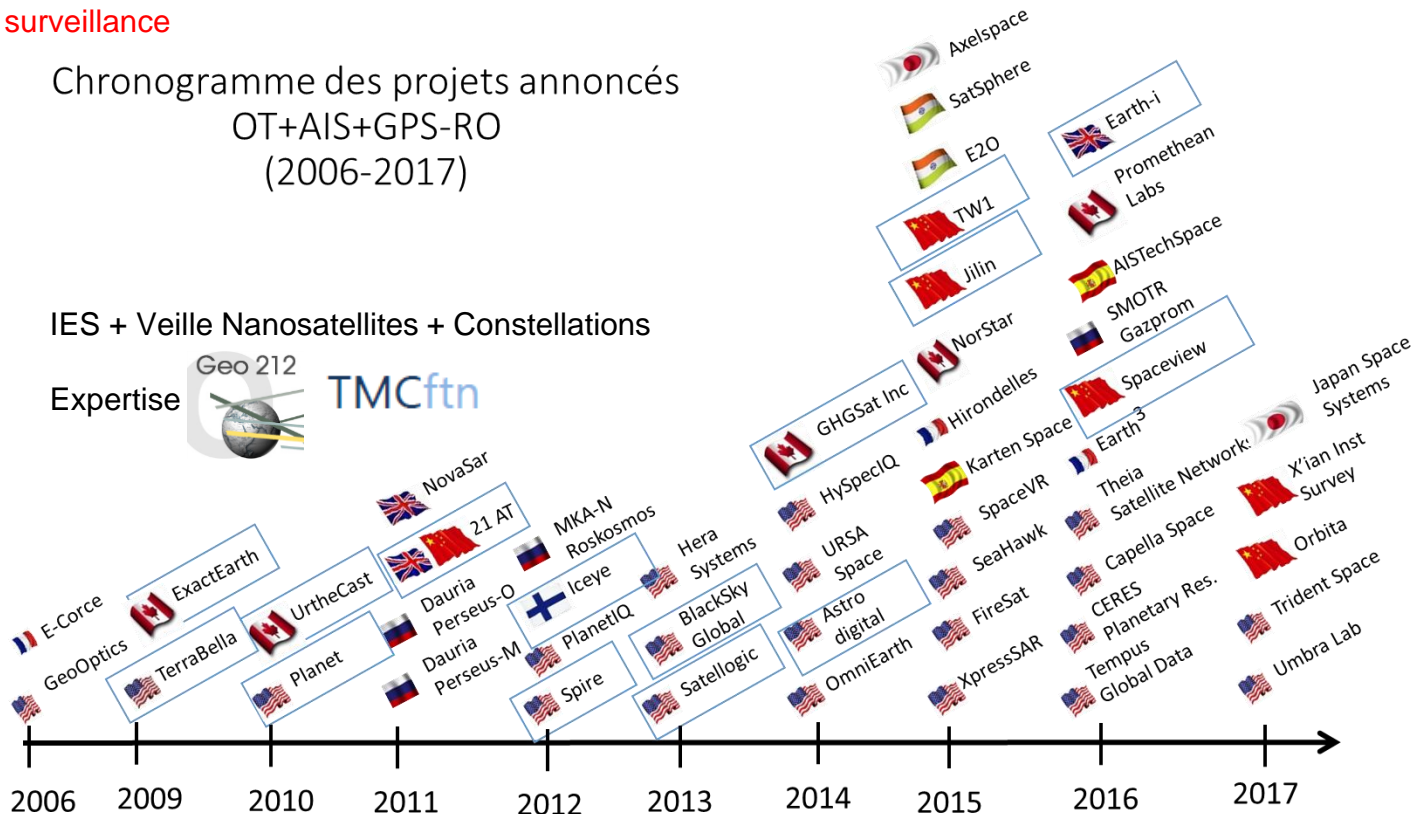
...et de + en + d'universités bénéficiant de transfert de technos Défense

74 sous surveillance

Chronogramme des projets annoncés
OT+AIS+GPS-RO
(2006-2017)

IES + Veille Nanosatellites + Constellations

Expertise TMCftn



Projet ayant des satellites en orbite (fin 2016)

Source CNES, DIA/IP – M.Lafaye

Resilient Space: landscape in 2020?

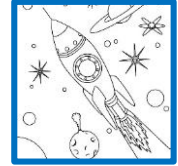


New Space

COTS
Miniaturizing
Capital risk
Venture Capital
Digital
New actors
Business 360
Verticalizing
...

Planet (Skysat)	Worldview-Scout	PléiadesNéo	
Blacksky Global	EIAST		
Hera System	KARI-Cas500	CGST-Jilin	
Theia	Earth-i		Optique THR 1m
Satellite Networks			
Planet (RapidEye)	Axelspace	SpaceView	Earth ³
		21AT-DMCi	Optique HR 2 à 5m
		SMOTR-Gazprom	
Planet-cubesat		Orbita	Earth2Orbit
		Xi'an Inst.Survey&MappingSilkRoad	Optique MR 6m et +
		Dauria Perseus-O	
		MKA-N Roskosmos	
Capella Space	UrtheCast	Iceye	Satsphere
	(Deimos+OptiSAR)	Satellogic	SaudiSat
Umbra lab	NorStar	NovaSar	
		Trident Space (Magna Parva)	SAR et hyperspectral
Blink Astro	ExactEarth	Kleos Space (Magna Parva)	UnSeenLabs
Terran Orbital	Kepler	Sky and space Global	Magnitude Space
HawkEye360	Communications	Norsat	ISIS – Innov.Data Services
Spire Global	Helios Wire	AISTech	Aerial and Maritime (GOMSpace)
AIREON (Iridium Next)	FleetSpace	Karten Space	Astrocast (ELSE)
			AIS, DVS-B, ROEM

Fast Space



Fast production
Factory 4.0

Fast deployment
Small Launcher

Fast reconfiguration
Servicing
Recycling Stations
Energy
Robotics & AI

Fast service delivery
AI & Analytics



Source : étude pour le CNES TMCftrn GEOINT CATALYST SINCE 1066



Des partenariats bienvenus : SpaceEye devient l'élément de crédibilité clé de la constellation PanGeo dirigée par UrTheCast pour lutter contre les 3 gros



Taihe Palace of the Forbidden City | 31 May 2017



Une 2ème chance pour Satellogic : Investissement Tencent ; supply chain partiellement en Chine ; business focalisé Chine

- Les acteurs chinois dévoilent des initiatives dans toutes les composantes de l'observation de la Terre
- Le marché intérieur est suffisant à justifier les investissements dans des constellations
- Le développement de l'intelligence artificielle est très actif (du fait de la moindre réticence de la société chinoise à son usage)
- Les fonds chinois permettent de jouer à l'échelle internationale à travers des partenariats occidentaux

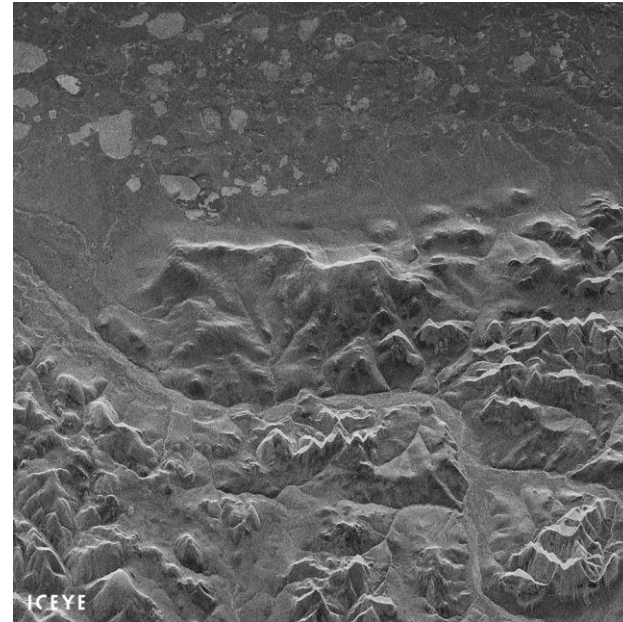
Les projets radar se portent bien

2018 Q1 :

- Lancement du POC IceEye (12/01/2018)
- Lancement ASNARO-2 (17/01/2018)
- Lancement PAZ (2018/02/22)

2018 Q2

- Lancement du POC Capella : Juin
- Lancement du POC NovaSAR-S ?
- Lancement SAOCOM 1A en Juin ?
- Lancement Radarsat Constellation ?





Agriculture

Gestion des ressources

Suivi environnemental

Planet	Geosys
Norstar	CLS-SIRS
Omni Earth	Airbus DS Geo-Farmstar
AstroDigital	TPZ
BlackskyGlobal	Terranis
Satellogic	Earth3
CGST	OpenForest
SpaceView	LK Spatialist
Dauria Perseus	Pixstart
UrtheCast	SnapPlanet
GHGSat	Agreenculture
SeaHawk	



Défense & Risques

Gestion des infrastructures

Planet	Airbus DS Geo
Hera Systems	TPZ
BlackskyGlobal	Magellium
Satellogic	CLS-SIRS
Urthecast	SERTIT
DMC3-21AT	PREDICT Services
CGST	Earth3
SpaceView	Gaiddon Software
SMOTR-Gazprom	
MKA-N Roskosmos	



Surveillance maritime

Spire	Airbus DS Geo
Planet	TPZ
Hera Systems	CLS
BlackskyGlobal	ACRI
Satellogic	Mercator
UrtheCast	SmartnGo
CGST	
SpaceView	
Iceye	



Analyses financières

Tous +	Airbus DS Geo
Descartes Lab	TPZ
URSA Space	Geosys
	Planet Observer
	TempusGlobalData
	SteadySun



Météorologie

Spire	Météo France
PlanetIQ	HD Rain
GeoOptics	
Planet Observer	
TempusGlobalData	



Media & jeux

UrtheCast	Planet Observer
Planet	
Space VR	

Source M.Lafaye CNES, DIA-IP