

The JWST mission: status and overview









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Cesa

MIRI



NIRSpec



FGS/NIRISS



NIRCam

European Space Agency





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 - Thanks for giving me the opportunity to give this seminar on JWST.

- All along this presentation you will see the results of work conducted by a large number of teams in Europe, USA and Canada.
- Many elements of this presentation are based on existing presentations prepared by other members of the JWST project, the instrument teams and STScI.

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 - Orbit, field-of-regard and visibility constraints.
- JWST Science & timeline for scientific operation.
 - Where to find presentations, white papers...
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- Conclusion.

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The James Webb Space Telescope (JWST) The mission in a nutshell





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JWST will be one of the "great observatories" of the next decade.

- Often presented as the next step after the Hubble Space Telescope (HST)
- Joint mission between NASA, ESA and CSA.
 - High-priority endeavor for the associated astrophysical communities.
- Setup similar to the HST one.
 - Over the duration of the mission, > 15% of the total JWST observing time goes to ESA member states applicants.
- To be launched at the end of 2018 for a minimum mission duration of 5 years (10-year goal).





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Ground segment



Science and operation center (STScI)

15 ESA staff members

Common systems (deep space network)

Provided by CSA

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- The end of the dark ages: first light and reionization.
- The assembly of galaxies: the formation and evolution of galaxies.
- The birth of stars and proto-planetary systems.

• Planetary systems (including our solar system and exoplanets) and the origin of life.

And a wealth of other scientific programs as JWST will be a general observatory.







segmented primary mirror (18 hexagonal mirrors of 1.32m flat-to-flat; collecting surface > 25m²)



(4 optical elements, only 2 visible here)

secondary mirror (0.74m diameter)

the sunshield

5 membranes of Kapton foil allowing **passive cooling of the telescope and the instruments down to ~40K** the size of a tennis court



Note that a cryogenic cooler is used to cool JWST's mid-infrared instrument (MIRI) down to 6-7K.

the spacecraft bus and solar panels

payload module

and their

the 4 instruments

electronic boxes

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NIRSPEC

MIRI = Mid-InfraRed Instrument

50/50 partnership between a nationally funded consortium of European institutes (MIRI EC) under the auspices of ESA and NASA/JPL.

PIs: G. Wright and G. Rieke

NIRSpec = Near-infrared Spectrograph

FGS = Fine Guidance Sensor

Provided by the European Space Agency. Built by an industrial consortium led by Airbus Defence and Space.



ASTRIUM NIRSPEC



NIRISS = Near-infrared Imager and Slit-less Spectrograph

FGS = Fine Guidance Sensor

Provided by the Canadian Space Agency.

PIs: R. Doyon & C. Willott





NIRCam = Near-InfraRed Camera

Developed under the responsibility of the University of Arizona.

PI: M. Rieke

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JWST's instruments



http://jwst.nasa.gov/videos_deploy.html

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JWST imaging capabilities

nstrument	Wavelength (in microns)	Pixel scale (in mas/pixel)	Field of view (arcmin x arcmin)
NIRCam	0.6-2.3	32	2.2' x 4.4'
NIRCam	2.4-5.0	65	2.2' x 4.4'
NIRISS	0.9-5.0	65	2.2' x 2.2'
MIRI	5.0-28	110	1.3' x 1.7'





NIRCam: Simultaneous imaging of the same field of view in the `blue' and `red' channels.

- More than one order of magnitude sensitivity improvement in some bands.
- Extremely powerful observatory, a lot of discovery space.

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JWST imaging capabilities Mapping of the focal plane



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JWST imaging capabilities

NIRISS (2.2' x 2.2')





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Not to scale.

NIRCam (4.4' x 2.2')





Seminar Cambridge - 26 January 2016

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- Take-home message: in JWST, spectroscopy comes in many different flavors...
 - Can address many different scientific needs.
 - Unique combination of sensitivity & spatial resolution.

Instrument	Туре	Wavelength (microns)	Spectral resolution	Field of view
NIRISS	slitless	1.0-2.5	~150	2.2' x 2.2'
NIRCam	slitless	2.4-5.0	~2000	2.2' x 2.2'
NIRSpec	MOS	0.6-5.3	100/1000/[2700]	9 square arcmin.
NIRSpec	IFU	0.6-5.3	100/1000/2700	3" x 3"
MIRI	IFU	5.0-28.8	2000-3500	>3" x >3.9"
NIRSpec	SLIT	0.6-5.0	100/1000/2700	Single object
MIRI	SLIT	5.0-10.0	60-140	Single object
NIRSpec	Aperture	0.6-5.3	100/1000/2700	Single object
NIRISS	Aperture	0.6-2.5	700	Single object



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JWST spectroscopic capabilities Spectral resolution



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JWST coronagraphic and aperture masking interferometry capabilities

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 Like for spectroscopy a variety of modes are available, spread over the wavelength range covered by JWST.

Instrum ent	Wavelength (in microns)	Pixel scale (in mas/pixel)	Field of view	Туре
NIRCam	0.6-2.3	32	20" x 20"	Lyot
NIRCam	2.4-5.0	65	20" x 20"	Lyot
NIRISS	3.8-4.8	65	0.1-0.5″	Aperture masking interferometry
MIRI	10.65	110	24" x 24"	4QPM
MIRI	11.4	110	24" x 24"	4QPM
MIRI	15.5	110	24" x 24"	4QPM
MIRI	23	110	30" x 30"	Lyot

QPM = four-quadrant phase masks

 Since the "replan" that took place on the US side around 2010-2011, the development of the JWST mission has been progressing steadily.

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- Within cost and within schedule for a *launch in October 2018*.
- > 8 months of funded schedule contingencies available along the critical path (40 months before launch)

→ we are on track.

- Does this mean that we do not encounter any problem? Of course not.
 - But we have the necessary schedule and funding contingencies.

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• We are well into the assembly, integration and testing phase.



Integrated payload module with all four instruments in flight configuration



Family picture! All JWST mirrors.

> Testing the deployment of the sunshield while manufacturing the flight membranes



Primary mirror backplane structure Secondary mirror support structure



Slide #17

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JWST – From now to launch

Behind the Webb – videos and podcasts



- Series of short videos showing various moments in the development of JWST
- <u>http://</u> webbtelescope.org/ webb_telescope/ behind_the_webb/
- Oriented toward a fairly wide audience.

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JWST – From now to launch.





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Now: Final payload module testing at the Goddard Space Flight Center.



Now: integration of the telescope.





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JWST – From now to launch.





JWST – From now to launch.

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And now... [webcam from this morning]



http:// jwst.nasa.gov/ webcam.html

JWST – From now to launch.











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2017-2018: final integration and testing of the spacecraft and...

... LAUNCH!

But this will only be the beginning of the story for the scientific life of JWST!



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- **Event-driven mode of operation.**
 - Observation plan uploaded on a weekly basis.
 - contact of 4h every 12h; plan up to 10-day long.
 - Unless an observation is time critical, the observation plan does not consist in an association of activities and time but rather a sequence of activities.
- But JWST will be able to accommodate observations with a fairly strict "timing" requirement.
- Turn-around time for targets for opportunities will be less than 48 hours.
 - Requirement value. Actual time likely a little bit shorter.
- Turn-around time for the data will be < 5 days.
 - Between the moment when the observations are taken and the moment when data is made available to the users.
- Note: moving target capability available.
 - Up to 30 mas per second.

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JWST - Orbit and field-of-regard



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L2 "halo" orbit. Keeping the Sun, the Earth and the Moon on the same side of the sunshield.





Halo orbit period is ~ 6 months

Final details on the orbit depend on launch window

JWST - Orbit and field-of-regard

How mobile is the telescope given that it needs to remain constantly in the shade?

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The James Webb Space Telescope (JWST) Orbit and field-of-regard

At any time during the year, JWST will be able to observe an "annulus" corresponding to 35-40% of the sky.



http://www.stsci.edu/jwst/overview/design/field-of-regard

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The James Webb Space Telescope (JWST) Orbit and field-of-regard

Periods of visibility / orientation of the field of view

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Visibilities and orientation during a 1-year cycle

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Visibilities and orientation during a **1-year cycle**



Along the ecliptic: restricted range of orientations, 2 windows per year, long time with the same orientation (~50 days).



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JWST – Science & timeline for scientific operation

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- JWST is a general observatory, so as I have said earlier in the presentation it will be up to you the users to shape the science that will be done.
 - The scientific operation center for JWST is the Space Telescope Science Institute (STScI) like for HST.
- In the next few slides, I will give you pointers to places where you can find information, presentations and white papers showing which type of science can be conducted with JWST.
 - The flashy images are in the presentations!



JWST – Science & timeline for scientific operation



Category	# of Programs	Total Time [days]	Percentage of Total Time
Solar System	8	51.3	7.9%

- The Science Operations Design Reference Mission (a.k.a. SODRM)
- <u>http://</u> <u>www.stsci.edu/jwst/</u> <u>science/sodrm/</u>
- Exercise aiming at simulating what could be one year of JWST observations.

• From 2012.

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JWST – Science & timeline for scientific operation



ESA/ESTEC

October 12-16

2015

"Exploring the Universe with JWST" 49th ESLAB symposium

An international conference dedicated to the presentation

and discussion of future scientific research that will be

REGISTRATION AND ABSTRACT SUBMISSION EXTENDED TILL 22 JUNE 2015

http://congrexprojects.com/15a02

enabled by the James Webb Space Telescope.



The presentations are available on the web. Follow the instructions in the conference web site.

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Sessions covering a broad range of scientific topics.

From end 2015.

http://www.cosmos.esa.int/web/jwst/ conferences/jwst2015



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JWST – Science & timeline for scientific operation



- JWST science corner site maintained by STScI
- http://www.stsci.edu/jwst/jwst-science-corner/#jwstscience-corner/

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JWST Science Corner	Newsletter Articles	Flyers	White Papers
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- Repository for JWST's white papers.
 - Recent ones: exoplanets, solar system.
- Useful information.



Science Instruments





Exposure Time Calculator



JWST – Science & timeline for scientific operation

Recent JWST Science Highlights



Example from the JWST science highlights section:

Water Clouds in Y Dwarfs and Exoplanets, Morley et al., 2014



- Highlights on science with JWST.
- <u>http://</u>

www.stsci.edu/jwst/
jwst-science-corner/
#jwst-sciencecorner/

 There you can also submit your own paper if you think it could appear in the JWST science highlights section.





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- NASA JWST site
- jwst.nasa.gov
- In the "FOR SCIENTISTS" section, you can register to receive the JWST newsletter, "The Webb update".





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JWST – Science & timeline for scientific operation

- Yearly call for proposal set up by the scientific operation center (STScI; similar to HST).
 - Selection by a time allocation committee (which will include European representatives).
 - ~15% of the time for European principal investigators.
 - Not implemented as a strict quota (scientific merit comes first) but so far it has been working well for HST.
 - Proprietary period of 1 year for GO and GTO programs.



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JWST – Science & timeline for scientific operation



Classes of Program

- Guest Observer (GO programs)
 - Open access for the community
 - ~80% of time in Cycles 1 through 5
- Guaranteed Time Observer (GTO) programs
 - 4020 hours allocated over first 30 months (i.e. Cycles 1 through 3)
 - NASA policy constraints on time/cycle
- Director's Discretionary Time (DD) programs
 - Up to 10%/cycle i.e. ≤877 hours
 - Rapid response observations & targeted science programs

Extracted from a presentation by N. Reid during the JWST2015 conference at ESA/ESTEC.



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JWST – Science & timeline for scientific operation



How much GO time in Cycle 1?

- 8766 hours available to schedule
- Up to 10% of total time as DD time
 - ~870 hours \rightarrow ~7900 hours for GO+GTO
- NASA policy requires that GTO programs account for between 25% and 49% of the time available to GO and GTO programs in Cycle 1
 - Assume ~2200 hours for GTO time
- GO programs would constitute ~5700 hours in Cycle 1
- Hubble has ~3500 science orbits/year
 - ~5200 hours (with overheads)
- JWST Cycle 1 will offer more GO time than a typical Hubble Cycle
- GO allocation increases in Cycle 2 & 3 as GTO time decreases

Extracted from a presentation by N. Reid during the JWST2015 conference at ESA/ESTEC.

JWST – Scientific timeline



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An Early Release Science program

A science program of the community chosen by the community for the community

- JWST is an incredibly powerful machine with broad scientific reach and complex instrumentation
 - Exploiting that power requires an informed community
 - Providing early access to data from representative science programs is crucial to understanding JWST's capabilities and enabling the community to maximise the science return.

Extracted from a presentation by N. Reid during the JWST2015 conference at ESA/ESTEC.



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JWST – Science & timeline for scientific operation

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Cycle 2 proposal schedule

- JWST science observations start in April 2019
 - Cycle 2 proposal deadline in early December 2019, ~7.5 months into Cycle 1
- The general community will have very limited access to nonproprietary observations to aid preparations for Cycle 2 programs



Extracted from a presentation by N. Reid during the JWST2015 conference at ESA/ESTEC.



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JWST – Science & timeline for scientific operation



An Early Release Science Program

- The JSTAC has recommended implementation of an Early Release Science Program
 - "..to obtain images and spectra that would be used to demonstrate key modes of the JWST instruments. ...the First-Look data be released both in raw form and with any initial calibrations as soon as possible; the key aspect is speed." [JSTAC letter, 21/6/2010]
- The primary goal is to maximise the science impact of JWST by
 - Educating the community on JWST's instrumental capabilities
 - Ensuring rapid data availability
 - Engaging the community now in planning the program
 - To achieve those goals, the program should
 - Provide a wide range of scientifically interesting datasets
 - Exercise a wide range of the instrument modes for a range of science topics
 - Execute very early in the first cycle
 - Plan the program based on proposals from community members [JSTAC letter 26/3/2014]

Concept: A suite of science-driven observing programs, designed by the community and selected through proposal peer review

Extracted from a presentation by N. Reid during the JWST2015 conference at ESA/ ESTEC.

For more details: http://www.stsci.edu/jwst/science/ers

Seminar Cambridge - 26 January 2016

JSTAC = advisory committee to the STScI director



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JWST – Science & timeline for scientific operation

STScI's timeline for the preparation of scientific operation.



Presentation J. Kalirai (STScI) – Dec. 2014



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- There will be dedicated activities in Europe supported by ESA.
 - Will be harmonised with those of STScI and initiatives in individual countries.

http://www.cosmos.esa.int/web/jwst/esac2016



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JWST – Science & timeline for scientific operation

Also:

- JWST@ROE in Edinburgh
- http://www.roe.ac.uk/workshop/jwst/ index.html
- Update on JWST status + workshop on the potential of JWST to investigate key outstanding problems in galaxy formation and evolution at all redshifts

JWST@ROE

4th-7th July 2016

Royal Observatory Edinburgh EH9 3HJ

- HST & JWST joint conference in March 2017 in Venice.
 - Announcement to come.

Slide #46



JWST is on track for a launch in October 2018 and for a start of scientific operation in the first half of 2019!

Unique capabilities for the characterisation of exoplanets and the follow-up of candidates provided by other missions / facilities JWST dates you want to put in your calendar:

• 26-28 September 2016 – JWST workshop

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- November 2017 First call for proposals!
- Spring 2019 Start of scientific operation!

Thanks for your attention.