

Finding suitable telerobotics solutions for space exploration:

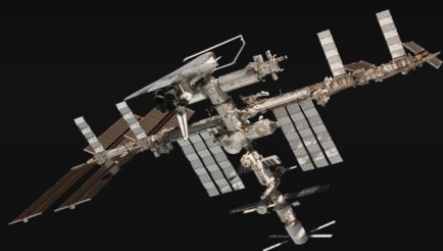
A look into Kontur-2 and Meteron Supvis-Justin

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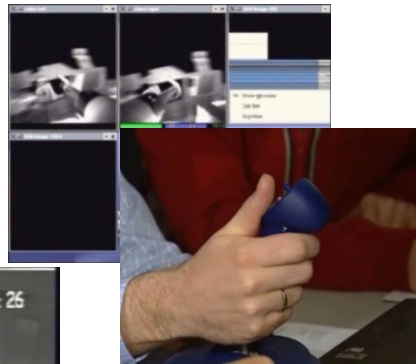
¹Institute of Robotics and Mechatronics
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Moon 2020-2030
December 16, 2015



<http://www.dlr.de/rmc/rm/kontur-2>
<http://meteron.dlr.de/>

From Rotex to Kontur-2 and Supvis-Justin

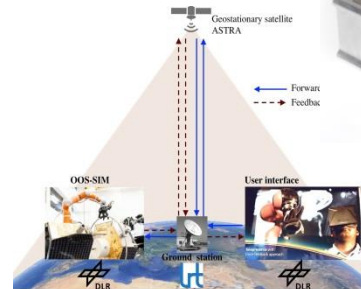
A time line of DLR's space telerobotics development



RokVISS (2004-2010)



Rotex (1993)



Artemis
(2008-2009)
Astra
(2014-2015)



Kontur-2
(2015-2016)



Supvis-Justin
(2016-)



Kontur-2: Telepresence in space

Robotics technology



DLR Kontur-2
Force Feedback Joystick



Joint and Cartesian
level trajectory
commands



DLR high dexterity
robot Justin

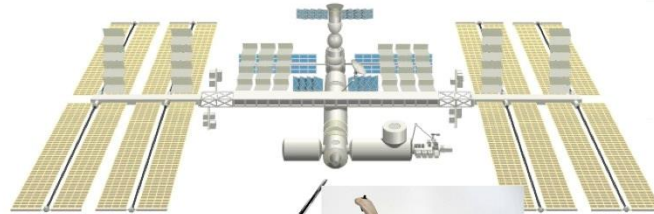


DLR RokVISS
2-DOF dexterous robot



Kontur-2: Telepresence in space

Communication S-Band



RJ0 (FM)

- Ground communication through
 - Dedicated line
 - Internet
- Direct ISS-Ground station link (when available)
- 256 kbit up/4 Mbit down

DLR – GSOC Ground station (Weilheim)



Standard UDP

INTERNET

GCTC (Moscow)

Access Gateway



RJ0 (QM)

On-Ground Computer

DLR - RMC (Oberpfaffenhofen)



ROKVISS



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Kontur-2: telepresence from space to ground

The multi-DOF experiments



Cosmonaut Oleg Kononenko @ ISS



ROSVISS 2-DOF robot @ ground

Kontur-2: telepresence from space to ground

Coming (real) soon... telehandshake (tomorrow at DLR!)



@ ISS (live training, November 2015)
Multi-DOF HMI

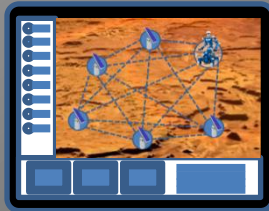
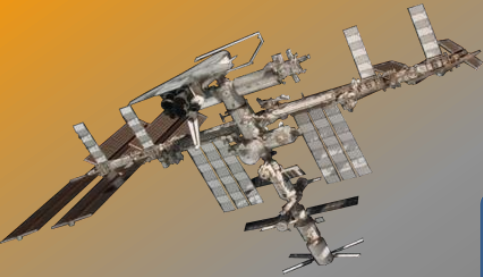


@ DLR, Oberpfaffenhofen, Germany
(live training, November 2015)
Multi-DOF Robot

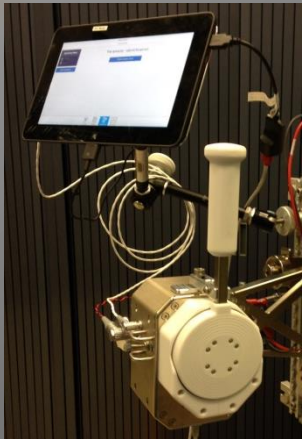


Meteron Supvis-Justin: supervised autonomy for space

Robotics technology



Abstract task level
robot commands



Tablet PC with
Intuitive GUI

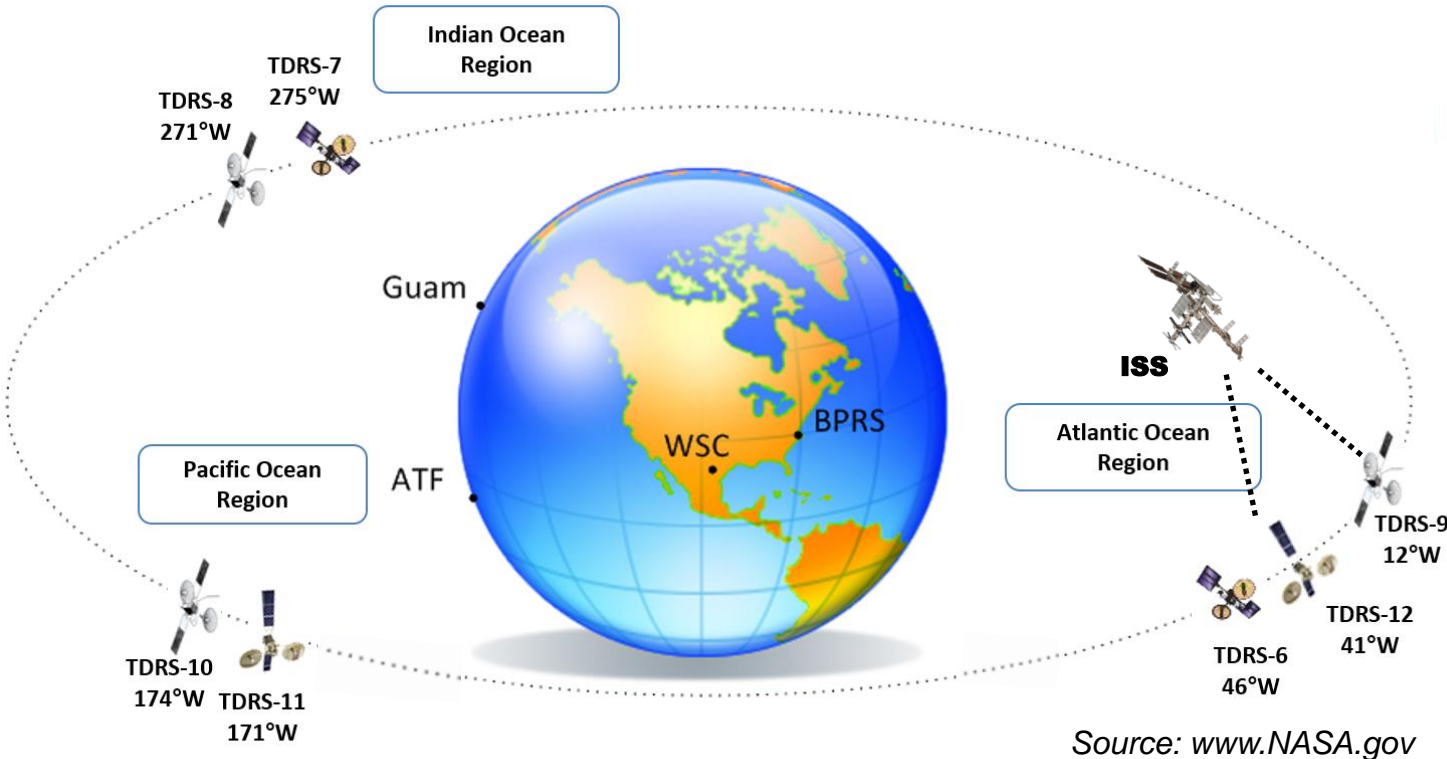


Justin and the Solex
environment



Meteron Supvis-Justin: supervised autonomy for space

Communication: K_u band forward link



- Ground communication through Internet
- Ground station through HOSC
- 24/7 availability (nearly)
- 10 Mbit up/down (max)

Source: www.nasa.gov

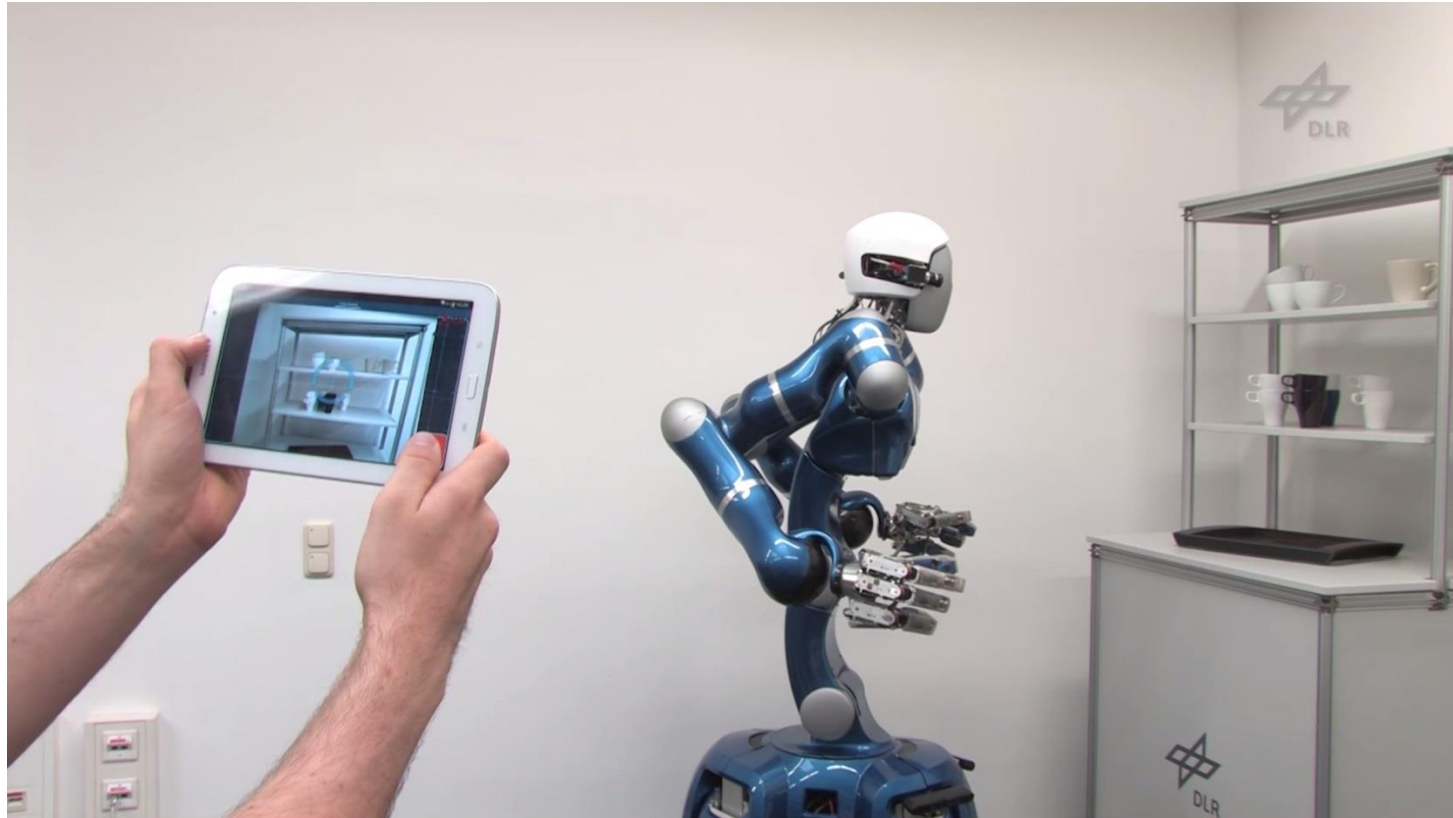
TDRS: tracking and data relay satellites
(currently 7 active)



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<http://meteron.dlr.de/>

Meteron SUPVIS-JUSTIN

On-going DLR development



*Courtesy P. Birkenkampf
Development of a human-robot interface for visualization of internal world states
and controlling potential manipulation capabilities of semi-autonomous robot
Technical University of Munich, 2013*



<http://www.dlr.de/rmc/rm/kontur-2>

<http://meteron.dlr.de/>

Supervise autonomy or telepresence?

Current performance comparison: communication



Kontur-2		Meteron Supvis-Justin
S-Band	Communication type	K _u band
256 kbit/sec	Uplink	10 Mbit/sec max; 1 Mbit nominal
4 mbit/sec	Downlink	10 Mbit/sec max; 1 Mbit nominal
50~80 msec	Latency	>800 msec
10 minutes per ISS orbit of 90 minutes (best case) ~12%	Availability	Theoretically continuous; ~90% nominal



<http://www.dlr.de/rmc/rm/kontur-2>

<http://meteron.dlr.de/>

Supervise autonomy or telepresence?

Current performance comparison: robotics technology



Kontur-2	Technology	Meteron Supvis-Justin
Justin, ROKVISS robots (Multi-DOF, human-in-the-loop agent)	On ground robotics	Rollin' Justin (High dexterity, local intelligence)
Multi-DOF force reflection joystick	Human-robot interface	Tablet PC with intuitive UI
Telepresence with latency tolerant control (up to 900 msec delay tested*)	Mode of operation	Supervised-autonomy with advanced robot reasoning Robot as a coworker

*A passive bilateral control scheme for a teleoperator with time-varying communication delay
Artigas, Ryu, Presuche, Mechatronics 2010



<http://www.dlr.de/rmc/rm/kontur-2>

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Supervise autonomy or telepresence?

Matching the right technology for the right application

Musings on the possibilities

- Telepresence
 - + Real-time performance
 - + Human in-the-loop capability
 - Limited by communication latency and distance
- Supervised autonomy
 - + Robot as a co-worker to assist the astronaut and cosmonaut
 - + Ease operator workload
 - + Highly scalable
 - Still limited, albeit improving, ability to cope with unforeseen events
- Hybrid approach
 - + Best of both worlds, if done right...
 - + Flexible use of resources:
communication bandwidth, astronaut workload
 - Distance limitation persists if telepresence is required



<http://www.dlr.de/rmc/rm/kontur-2>

<http://meteron.dlr.de/>

THANK YOU!



For Kontur-2,
visit us at:

<http://www.dlr.de/rmc/rm/kontur-2>



For Meteron SUPVIS-JUSTIN,
visit us at:

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