



MORABA
Mobile Launch and Range Infrastructure





Title and all Photos: © Credit: DLR CC BY-SA 3.0 IGO

MORABA Mobile Launch and Range Infrastructure

The Mobile Rocket Base (MORABA) at DLR Space Operations carries out sounding rocket and balloon missions for scientific research. It provides efficient and unique research possibilities in the fields of atmospheric physics, microgravity, hypersonic research, technology testing and education. MORABA integrates all necessary key technologies like electronics, radio, flight dynamics and mechanics in one department. This experience and competence is valued and sought after by national and international facilities, industry and institutions of higher education.

MORABA has developed a unique mobile infrastructure and hardware for the planning, preparation and implementation of sounding rocket projects. In principle, it can be used to launch a rocket from anywhere on Earth within a short space of time.

A detailed overview of MORABA's Mobile Telemetry Station, Mobile Range Instrumentation Radar and the MAN 2 Mobile Launcher is presented hereinafter.

More information about MORABA services can be found in the Portfolio Module „[MORABA Sounding Rocket Flight Experiments](#)“.

Highlights

- High mobility, flexibility and adaptability
- Worldwide operation
- Minimal requirements on site
- Operation in extreme environmental conditions
- Reliable tracking of highly dynamic vehicles

Point of Contact

German Aerospace Center (DLR)
Mobile Rocket Base
Münchener Str. 20, 82234 Weßling

Telemetry Station:

Andreas Kimpe, Phone: +49 (0) 8153 28 2780 / E-Mail: Andreas.Kimpe@dlr.de

Radar Station:

Dietmar Kail, Phone / +49 (0) 8153 28 2600 / E-Mail: Dietmar.Kail@dlr.de

MAN 2 Launcher:

Frank Scheuerpflug, Phone +49 (0) 8153 28 3649 / E-Mail: Frank.Scheuerpflug@dlr.de

DLR.de/RB



Table of Contents

1.	MORABA Mobile Launch and Range Infrastructure.....	1
2.	Mobile Telemetry Station	
2.1	Principal constituents	3
2.2	Main Features.....	4
2.3	Field of operation	4
3.	Mobile Range Instrumentation Radar	
3.1	Tracking Radar RIR-774C	7
3.2	General Characteristics Tracking Radar RIR-774C	8
4.	MAN 2 Mobile Launcher	
4.1	General characteristics	12
4.2	Electrical Specification.....	12
4.3	Transportation	13
4.4	Current positioning.....	13

Publisher

German Aerospace Center (DLR)
Spacecraft Operations and Astronaut Training
Münchener Straße 20, 82234 Weßling

Photos

@ DLR CC-BY-3.0



2. Mobile Telemetry Station

MORABA maintains and operates a mobile telemetry, tracking and telecommand station in the S-band frequency spectrum. The station is composed of CSC standard ISO containers and as such can be set up around the globe with minimal requirements on the site. The 1.5m Secondary Antenna can be stored in boxes and used as aiding antenna together with the 5m Primary Antenna or as independent highly flexible receiving station. The Antenna Pedestals are designed for high angular velocities and accelerations to maintain a reliable tracking even for highly dynamic vehicles. The control station is equipped to simultaneously receive, record and support several Telemetry and TV streams with various modulation schemes. It is self-contained and adaptable to a variety of configurations.

2.1 Principal constituents



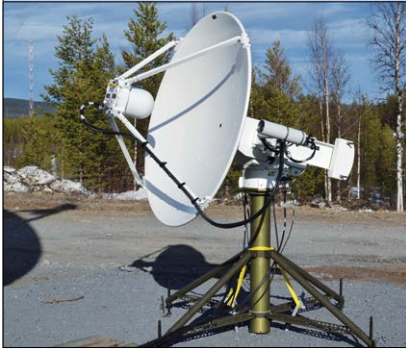
Control Station	
	<ul style="list-style-type: none"> • Two side expandable, isolated 20' ISO-Container • Redundant external power supply with automatic selection • Internal UPS for ~30 min • Dual air condition for equipment and operating room for outdoor temperatures from -40°C to +50°C • Telemetry instruments mounted in five vibration damped 19" Racks <ul style="list-style-type: none"> – AL-4000 Orbit Antenna Control Unit – 6 Cortex RTR Dual Receiver – 4 Intus TV Dual Receiver – 2 Wideband digital Recorder – Spectrum Analyzer, Oscilloscopes • Separated office and workshop area
Primary Antenna	
	<ul style="list-style-type: none"> • 5m parabolic reflector, segment able • Main Feed: <ul style="list-style-type: none"> – S-Band 5 Element E-Scan Tracking Feed – RHC/LHC simultan – S-Band Uplink • Acquisition Feed: <ul style="list-style-type: none"> – S-Band 4 Element SCM Tracking Feed – RHC/LHC simultaneous • Orbit AL-4034D Pedestal, EL over AZ, Dual drive • Verification camera • Operable on ISO-Flat Rack • Transportable on ISO-Flat rack with cover
Secondary Antenna	
	<ul style="list-style-type: none"> • 1,5m parabolic reflector • Feed: <ul style="list-style-type: none"> – S-Band 5 Element E-Scan Tracking Feed – RHC/LHC simultaneous • Orbit AL-4012S Pedestal, EL over AZ • Verification camera • Independent or cooperative operation possible • Transportable in boxes • Possibility to use custom feeds for example: <ul style="list-style-type: none"> – UHF TX – C-Band RX – X-Band RX





Fig. 2-1 Mobile Telemetry Station at Esrange Space Center, Sweden

2.2 Main Features

- High mobility, easy transportation of the standardized ISO Container via Truck, Train or Ship
- Low requirements on Site infrastructure
- Easy installation of the station with few personnel
- Designed for adverse environmental conditions, like extreme temperatures in arctic or tropic regions, strong winds, saline air in coastal areas
- Flexibility and adaptability

2.3 Field of operation

- Sounding rockets and balloons
- Supersonic and re-entry missions
- Airplane and Drone test
- Satellite missions, First acquisition





Station Specifications		
Power Supply	Mains	3 Phase 400V or 200V 63A
	Backup	3 Phase 400V 63A IT-Net
Power Redundancy	Automatic switching between Mains/Backup	
	UPS for switching and ~30min autonomous operation	
Air Condition	2 separate A/C circuits for rack equipment and personnel	
Antenna Control Units	2 Orbit AL-4000 ACUs	
Receiving Equipment	6 Cortex RTR dual channel TM receivers	
	4 Intus dual channel TV receivers	
Recording	2 Wideband DRS3000	

Main Antenna Specifications		
Pedestal Motion Type	Elevation over azimuth	
Drive Type	Dual servo drives	
Movement Range	Azimuth	unlimited
	Elevation	-3° to 183°
Max. Velocity	25°/s	
Max. Acceleration	25°/s²	
Pointing Accuracy	< 0.05°	
Tracking Accuracy	< 0.5°	
Tracking Velocity	25°/s (stable tracking)	
Dish Diameter	5m parabolic	
3 dB Beam width	1.8°	
Gain	38 dBi	@ 2.3 GHz
Feed Type	Main	5 element prime focus
	Acquisition	4 cavity backed elements
Tracking Type	Main	E-Scan
	Acquisition	Single Channel Monopulse
Scan Rate	500 Hz	
Receive Characteristics	Polarity	LHCP and RHCP simultaneously
	Frequency Range	S-band: 2200 - 2400 MHz
		System is prepared for optional upgrade to C-band
	G/T	> 14 dB
	Dynamic Range	96 dB
Response	ripples over whole frequency range < 2 dB/K	
Transmit Characteristics	Polarity	LHCP or RHCP, simultaneous with reception
	Frequency Range	S-band: 2000 - 2100 MHz
	Output Power	2 redundant 100 W power amplifier
	Max. EIRP	52 dBW

Environmental Specifications	
Temperature:	-40°C to +50°C operational
Wind:	80 km/h operational
	180 km/h stowed
Precipitation:	Rain, Snow, Icing



Site Requirements		
Power Supply	3 Phase 400V or 200V, 63A, IEC 60309 3L+N+PE	
	Either via mains supply or electric generator (400V)	
Required space:	Control Station:	min. 8m x 8m, flat area
	Main Antenna:	min. 8m x 4m, flat area, undistorted view to mission area
		Maximum distance to Control Station 20m to 30m (depending on orientation)
	Secondary Ant:	min. 4m x 4m, flat area, undistorted view to mission area
		Maximum distance to Control Station 20m to 30m (depending on orientation)
	Antenna Cover:	min. 8m x 4m, flat area to place Antenna cover
Transport Container:	min. 8m x 4m, flat area	
Required Ground:	Asphalt, concrete or solid gravel	
Main Antenna:	Concrete or stripe foundation with fixing points required, if wind loads >80 km/h possible	

Secondary Antenna Specifications	
Pedestal Motion Type:	Elevation over azimuth
Max. Velocity:	30°/s
Max. Acceleration:	30°/s ²
Tracking Velocity:	30°/s (stable tracking)
Dish Diameter:	1.5m parabolic
3 dB Beam width:	5°
Gain:	28 dBi @ 2,3 GHz
Feed Type:	5 element prime focus
Tracking Type:	E-Scan
Scan Rate:	500 Hz
Receive Polarity:	LHCP and RHCP simultaneously
Frequency Range:	S-band: 2200 - 2400 MHz
G/T:	3 dB

Truck and lifting device accessibility required to place Control Station Container (10t), Antenna Flat Rack Container (10t) and for installation of the Antenna.

Communications (Internet, Ethernet, Telephone, Intercom ...) required depending on Mission configuration.



3. Mobile Range Instrumentation Radar

3.1 Tracking Radar RIR-774C

DLR-MORABA's tracking radar RIR-774C is a highly mobile and highly accurate C-Band (5.4-5.9 GHz), Monopulse, single target tracking radar.

The station is composed of 4 CSC standard ISO containers and as such can be set up around the globe with minimal requirements on the site. The 8 foot Antenna can be stored inside the Pedestal-Container for transport. The Antenna-Pedestal-System is designed for high angular velocities and accelerations to maintain a reliable tracking even for highly dynamic vehicles. The Radar can track in Skin- (passive reflection) or Beacon-Mode (active transponder on-board).

A solid ground platform is needed for the containers (5 to 13 tons of weight).

The internal analog intercom system (4-wire) for communication can be adapted to other intercom systems. To synchronize the time code generator a external IRIG-B signal or the internal GPS clock can be used.

Tracking data will be recorded on the radar computer internal (hard disk) or external (USB device) in 100 Hz. Online tracking data (target position data only in 10 Hz) and the antenna camera video can be sent externally by an Ethernet link.

Further technical specifications of the radar, such as pedestal, antenna, transmitter, receiver, optics, etc., are listed in the attached spec-sheets from the manufacturer of the radar.

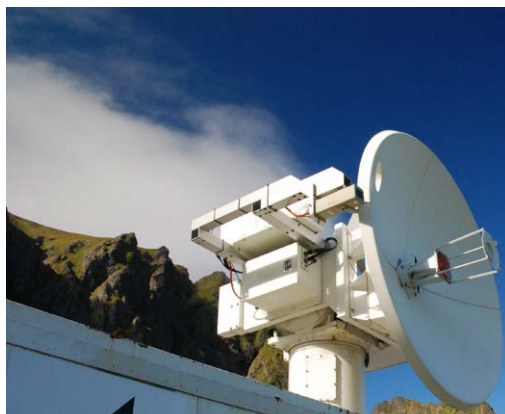


Fig. 3-1 Impressions of the Mobile Tracking Radar at Andøya Space Center, Norway.



3.2 General Characteristics Tracking Radar RIR-774C

Characteristic	Specification
Type	RIR-774C, Transportable C-Band Radar
Tracking Accuracy	0.015° (0.247 Mils) RMS with 10 dB SNR, Angles +/- 5 meters RMS with 10 dB SNR, Range
Data Precision	19-bit, angle 32-bit, range
Digital Data Output	RS232
Operating Modes	TV and RF (skin, beacon, mixed, designate)
Acquisition Aids	Range-Hit Processor (Auto Acquisition for full PRT or 3k yard segment) Angles-Local Designate (Optical Director), Computer GEN. scans Angles and Range-Remote Designate (via data link)
Shelter	
a) Type	4 each standard ISO containers (CFE)
b) Dimensions (LxWxH)	20' (3 expandable to 28') X 8' X 8'6"
c) Designations	1 ea Pedestal Cont., 1 ea Electronics Cont., 1 ea Lab Cont. and 1 ea Transport Cont.
Weight	
a) Pedestal Container	Approximately 13 tons
b) Electronic Container	Approximately 9 tons
c) Lab Container	Approximately 7 tons
d) Transport Container	Approximately 5 tons
Calibration Equipment	a) TV/Optics (STARCAL Program) b) Precision Level Meter

Table 3-1 Overall System Characteristics

Characteristic	Specification
Input Voltage, Pedestal Container	220/380 V AC, +/- 10% of nominal, WYE 3-phase, 4-wire, 50 Hz +/- 3 Hz
Transmitter Output Power (Peak)	650 kW measured at magnetron output flange
Transmitter Output Power (Average)	650 W measured at magnetron output flange
Transmitter Output Frequency	5.4 – 5.9 GHz (C-Band)

Table 3-2 Power Specifications

Characteristic	Specification
Equipment Outside ISO Containers	
Temperature, Operating	-40° C (-35° C for Pedestal) to +50° C
Temperature, Non-Operating	-40° C to +60° C with antenna/pedestal in stowed position
Relative Humidity	0 to 100 %
Winds, Operating	80 km/h (22 m/s)
Winds, Non-Operating	180 km/h (50 m/s) with antenna/pedestal in stowed position
Precipitation, Non-Operating	10 cm/h
Equipment Inside ISO Containers	
Operating Temperature Range	18° C to 30° C with operation up to 50° C for not more than 10 minutes
Operating Humidity Range	20 to 80 % relative

Table 3-3 Environmental Specifications



Characteristic	Specification
Type	Cassegrain, 5.4 to 5.9 GHz
Antenna Feed	8-Horn, 3-Channel Monopulse with common aperture feed
Diameter	8 Feet, effective
Side Lobes	17 dB (minimum) below reference peak
Antenna Polarization	Vertical – Linear
Power Gain (at waveguide interface)	39.0 dBi Minimum
Design	Allow assembly/disassembly by two men without the use of cranes, etc.

Table 3-4 Antenna Specifications

Characteristic	Specification
Type	Kintec Model 24100
Azimuth Travel	Continuous
Elevation Travel	
a) Mechanical Limits	-7° to +187°
b) Electrical Limits	-5° to +185°
c) Electrical Rate Limit	+5° to +175°
Maximum Velocity	≥ 30°/s (533 Mils/s), both axes
Angular Acceleration	≥ 30°/s (533 Mils/s), both axes
Power Requirements	220 V AC, 3-phase, 50 Hz
Electronic Level Sensor	VLS-767 Level Sensor with an output range of +/- 100 arcseconds

Table 3-5 Pedestal Specifications

Characteristic	Specification
RF Source	Varian SDF-313B tunable coaxial Magnetron
Tunable Range	5.4 to 5.9 GHz
Power Output	650 kW peak (minimum)
Output Pulse Widths	0.25 μs +/- 0.10 0.50 μs +/- 0.10 1.00 μs +/- 0.10
Nominal Magnetron Input	25 kV at 18 A Peak
Pulse Coding	Two pulse code groups; code spacing in increments of 3 ns (within max. duty cycle); spaced 3 to 10 μs (adjustable in 3 ns increments) from leading edge to leading edge at 3 dB points; pulse code ON/OFF console selectable
Pulse Frequency Variation	< 200 kHz rms between pulses
PRFs	160, 320, 640 and 1280 pps (console selectable)
Power Programmer	Variable up to 25 dB manually and computer controlled

Table 3-6 Transmitter Specifications

Characteristic	Specification
Type	Three-Channel Solid State Monopulse
RF Amplifiers	Three C-Band amplifiers with 25 dB gain each
RF Mixers	Three low noise mixers with image rejection
Local Oscillators	Two YIG-tuned local oscillators, independently tunable from 5.43 to 5.93 GHz
Frequency Control	Automatic and Manual for each local oscillator
AGC/MGC Dynamic Range	≥ 80 dB

Table 3-7 Receiver Specifications



Characteristic	Specification
Reference Oscillator	41,965,704.28 Hz crystal-controlled lock, adjustable +/- 20 Hz
	Stable to +/- 1 part in 108 per 24 hours
Range Data Out	23 bits
System Granularity	1m LSB
Range Designate	20 bits; 4 yard granularity
Range Capability	< 500 m to 2000 km, N'th time around
Tracking Accuracy	< +/- 5 m rms at 10 dB SNR
Beacon Delay	Two beacon delays; both adjustable from 1.5 to 10 μ s, in 3 ns steps
Range Track Velocity	\geq 10,000 meters/s
Range Track Acceleration	\geq 10,000 meters/s ²
Range Slew Rate	\geq 50,000 meters/s (selectable)

Table 3-8 Digital Range Tracker Specifications

Characteristic	Specification
Camera	
Type	
a) BW	RCA TC1005/N1
b) Colour	Plettac Electronics Model FAC 836
Lens for a)	
Type	Davro Model DOS180RA-M6
Aperture	7 in. (180 mm)
Focal Length	40 in. (1015 mm)
Lens Speed	f/5.6
Recording Device	Samsung 8-Channel Digital Recorder Model SRD-870DC

Table 3-9 Optics System Specifications

Characteristic	Specification
VME Computer	
Type	Custom Build VME Chassis Model 8008372-10
Power	220 VAC, 50 Hz
Opcom PC	
Type	EI Industrial Computers Model SCD8008269 Rack Mount PC
Power	220 VAC, 50 Hz
Display	
Type	Viewsonic Model TD2230 Touch Screen Monitor 22"
Power	220 VAC, 50 Hz
Data Handling	
Data Recording Rate	100 Hz
Data Recording Location	On Opcom PC a) Internal hard disk drive or b) External USB device
Data Output Rate	10 Hz data link on RS232 connection

Table 3-10 Computer and Peripherals Specifications



4. MAN 2 Mobile Launcher

The MAN Mobile Launcher N° 2 was built by Maschinenfabrik Augsburg-Nürnberg AG (MAN) in 1976 on behalf of DLR (formerly DFVLR). It was designed for DLR Mobile Rocket Base as an universal sounding rocket launcher with remote control and is capable of being easily dismantled and shipped to a distant range. By mounting different launch rails on the launcher beam, various types of rockets can be launched. The launcher is designed for a maximum rocket launch weight of approximately 4 metric tons.

In principle every Sounding Rocket vehicle used by MORABA can be launched from the MAN 2 Launcher.

The largest Sounding Rockets launched successfully from MAN 2 Mobile Launcher are:

- 4-stage Javelin
- Black Brant X
- Skylark 12

Fig. 4-1 MAN 2 Mobile Launcher during relocation at Esrange Space Center, Sweden



4.1 General characteristics

Operational temperature limits	-40°C - + 60°C
Useable length of the launch beam	12,35 m
Total weight	app. 19 metric tons
Load Capacity	Total Moment 600.000 Nm Usable Moment 370.000 Nm

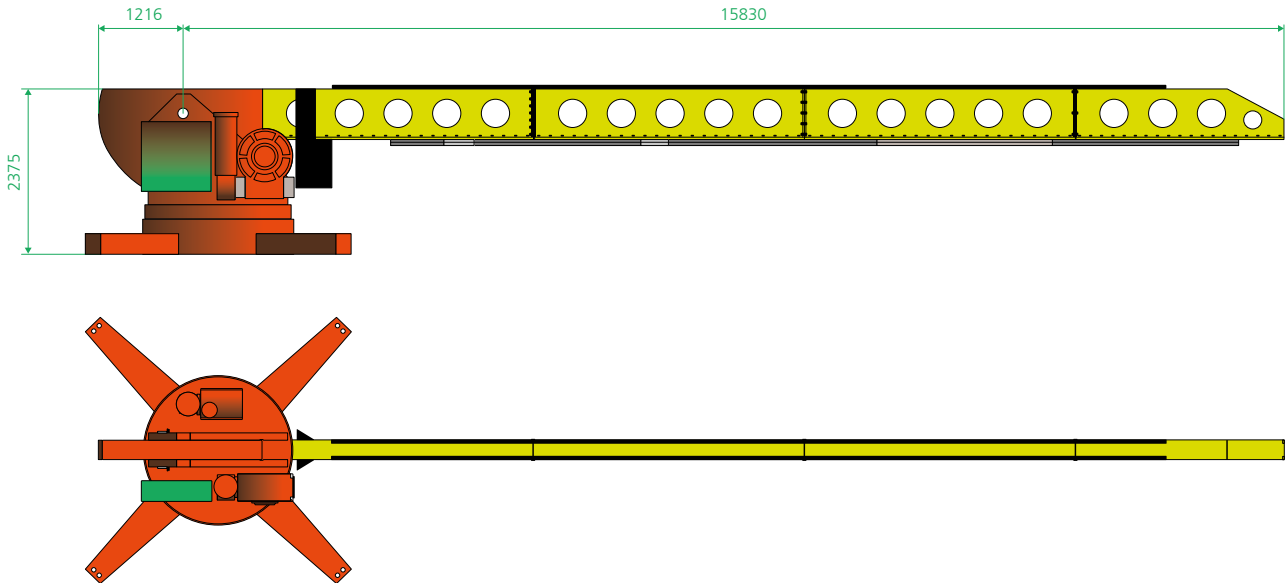


Fig. 4-2 MAN 2 Mobile Launcher overall dimensions

4.2 Electrical Specification

The beam is either elevated or lowered by an electric motor, which increases the current while simultaneously adjusting the load continuously. Built-in motor operated brakes are released or applied automatically on both elevation and azimuth systems. Limit switches prevent movement in azimuth and elevation beyond their respective range limits.

Elevation Range	-5° to + 90°
Resetting speed	0.55 deg/sec or at 0.28 deg/sec
Another 3-phase motor and transmission gear drive the launcher in azimuth on a slewing ring track through approximately 340 degrees.	
Azimuth resetting speed	0.28 deg/sec (above 80 degrees elevation this speed can be doubled to 0.5 deg/sec)

The MAN 2 Mobile Launcher requires a 3-phase 220/380V 50 Hz, 63 AC current with a power capacity of 40 kVA for:

- Launcher azimuth- and elevation motors
- Lights at the launcher pad
- Supply for launch control container
- Different tools



4.3 Transportation

The MAN 2 Mobile Launcher can be moved to principally every launch site allowing fully independent launch operations at remote locations. For weather and wind protection during the preparation phase, the launcher can be covered by a tent which is movable on railway tracks.



Fig. 4-3 MAN 2 Mobile Launcher with movable tent for preparation phase

The complete launcher including movable tent can be transported in three 20 ft. ISO-Containers as well as an open-top container for the main part.

Access roads to the launcher site shall be all-weather roads with grades and side-slopes no more than 2%. The roadway shall be 3.5 m wide with 0.5 m stable shoulders. A roadway designed for a 23 metric tons truck, 8 tons on every axle, is considered satisfactory for this application. The radius of curves should not be less than 50 m.

4.4 Current positioning

The MAN-2 Launcher is currently installed in the Mobile Tower at Esrange Space Center, 30 m high and with 8 x 10 m floor area. The building is heated, and the temperature can be controlled, with deviations of approx. ± 2°C. An electrically operated gantry crane can be used over the entire floor area.

Four work platforms at 9.0 m, 11.4 m, 14.0 m, and 16.6 m respectively above the floor are accessible by means of an external staircase on the north side of the tower. The three top platforms are also accessible by elevator. Umbilicals are connected through a 15 m high mast with platforms for ground support equipment on levels 2-4.

Remotely operated power outlets are available on the top three platforms. Shortly before launch the house is rolled away from the launch pad and the launcher is set to launch position.

Gantry crane specifications	Hoist speeds	Elevator
Max. load: 15 000 kg	83 mm/sec and 5 mm/sec	Max. load: 300 kg or 3 persons.
	Max. height to the hook: 19.4 m	Elevator floor area: 950 x 630 mm

Payload cables terminate at the payload platform level. Depending on the requirements and campaign setup, different media converter (ethernet fiber, coax fiber) can be used. The cabling is connected to various connectors/cable clamps inside the Blockhouse Payload Control (see also Esrange User Handbook v.2).

