



Defence

Space

Telecoms

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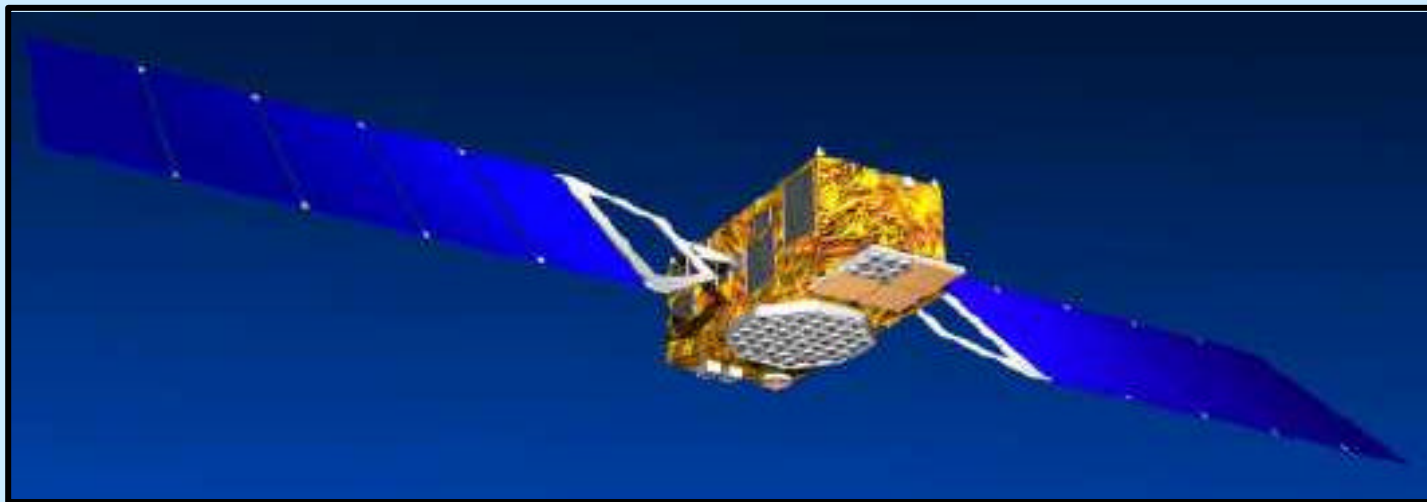
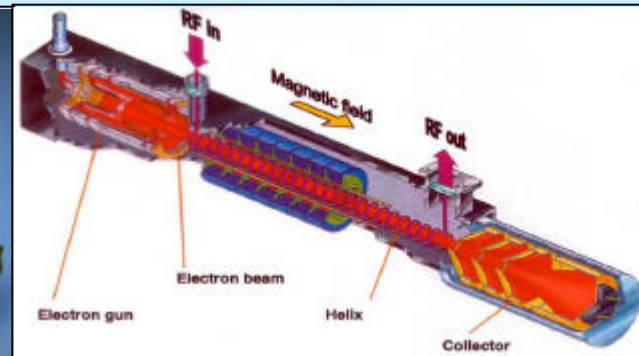
2.Raumfahrt-Technologie-Tage 2003

**L-Band Wanderfeldröhre für
Satellitennavigation**

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5. Nov 2003

L-Band TWT für Satellitennavigation



- /// Einleitung / Motivation / Anforderung**
- /// Erfahrung /Heritage**
- /// Entwicklungsschritte**
- /// Tests & Ergebnisse**
- /// Vorteile L - Band TWT/ TWTA für Satellitennavigation-
damit auch für Galileo**
- /// Zusammenfassung / Ausblick**

Motivation L-Band Verstärker für Navigation



Gute Heritage von TEDG bei L-und S-Band Verstärkern

Deutlich gesteigerte Leistungsdaten bei der S-Band Röhre,
Übertragung auf L-Band TWT ist in Bearbeitung

sehr hohe Zuverlässigkeit (fit rate)

Wachsender Markt für die Navigationsanwendung

Kritische Parameter für ein Navigationssystem



Wirkungsgrad: maximal, damit **Gesamtleistung** bei Kleinsatelliten ausreicht



Ausgangsleistung: von 60 W bis weit über 100 Watt



Bandbreite: große Bandbreite über das ganze Navigationsband ermöglicht flexiblen Einsatz



Signalstabilität: geringe Variation bei äußeren Einflüssen (Temperatur ,
Spannungvariationen)

Wie verhält sich ein Wanderfeldröhrenverstärker gegenüber diesen Anforderungen?

+	Ausgangsleistung:	keine Limitierung, bis 150 W, qualifiziert, bis 250 W entwickelt
+	Bandbreite:	bis 400 MHz erlaubt flexiblen Einsatz, auch Mehrträgerbetrieb möglich
+	Wirkungsgrad:	abhängig von der Bandbreite bis 64 % (Röhre) als Verstärker bis 58 %
+	Signalstabilität:	sehr geringer Einfluß, übertrifft die Anforderung bei weitem
—	Gewicht/Größe	bedingt durch die Frequenz -schwerer als SSPA

WORLDSTAR Project TL 2140 L- Band TWT

- 2 satellites operational in orbit, 1 satellite ready for launch
($\Sigma > 72$ tubes),m TWTA: TWT Thales EPC: Tesat
- Output power:150 W; Frequency band: 1.452 GHz to 1.492 GHz
Efficiency: 55%, mass 2200 g

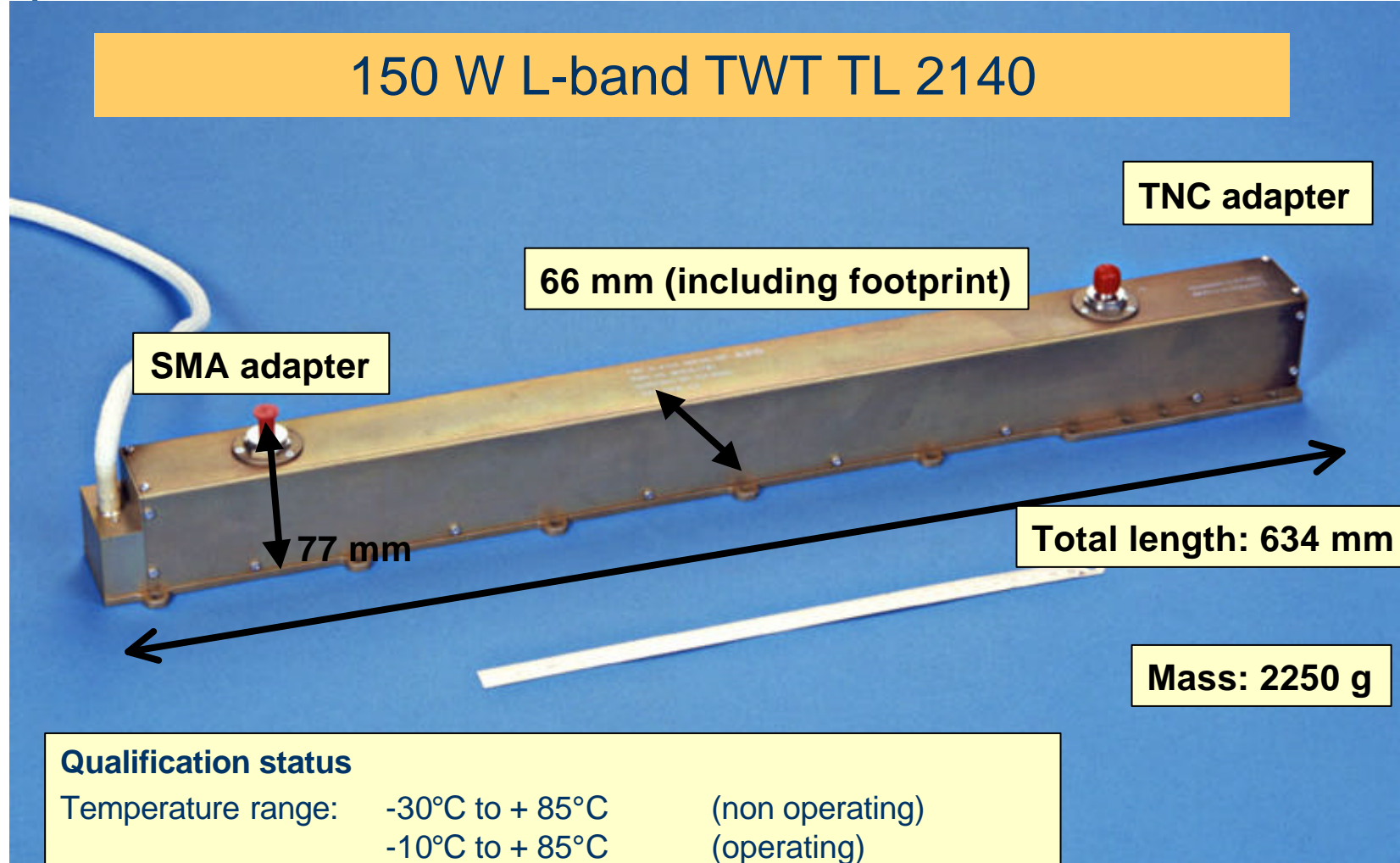
XM-Radio Project TL 2210 S- Band TWT

- 2 satellites operational in orbit, 1 satellite ready for launch
($\Sigma > 130$ tubes delivered) EPC: Tesat
- Output power:220 W, Frequency band: 2.332 to 2.345 GHz
Efficiency: 58.5%, mass 1450 g

Insat-Radio Project TL 2090 S- Band TWT

- 1 satellites operational in orbit, 1 satellite ready for launch
($\Sigma > 16$ tubes delivered), EPC: Tesat
- Output power:70W, Frequency band: 2.48 to 2.655 GHz
Efficiency: 58.5%, mass 1450 g

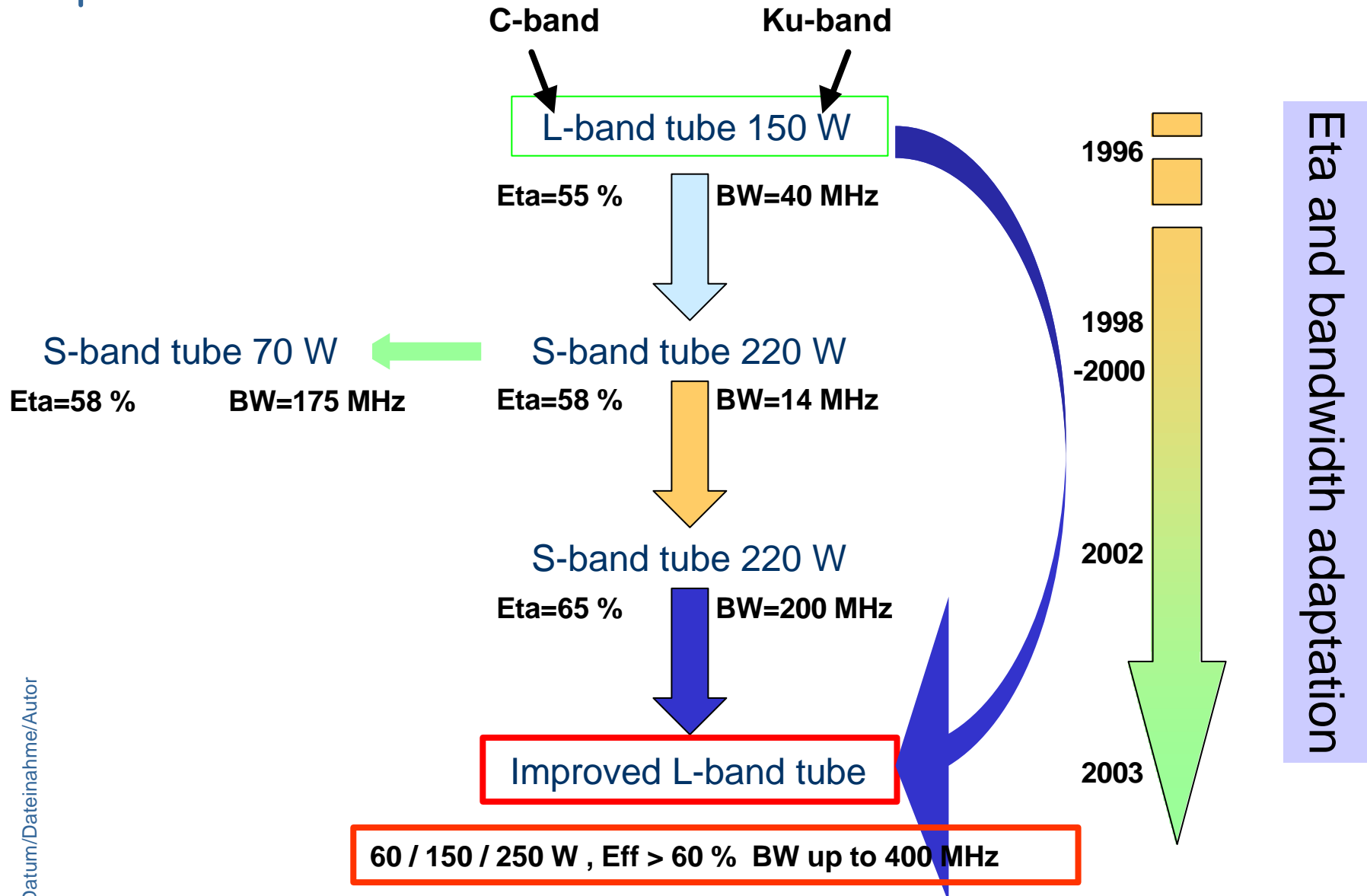
150 W L-band TWT TL 2140



Qualification status		
Temperature range:	-30°C to + 85°C	(non operating)
	-10°C to + 85°C	(operating)
Vibration:	18 grms (random, perpendicular)	
Shock:	480 g (limitation by test equipment)	
Tube in life test:	no critical event for 45000 hours	

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The way to improve L-Band TWTs



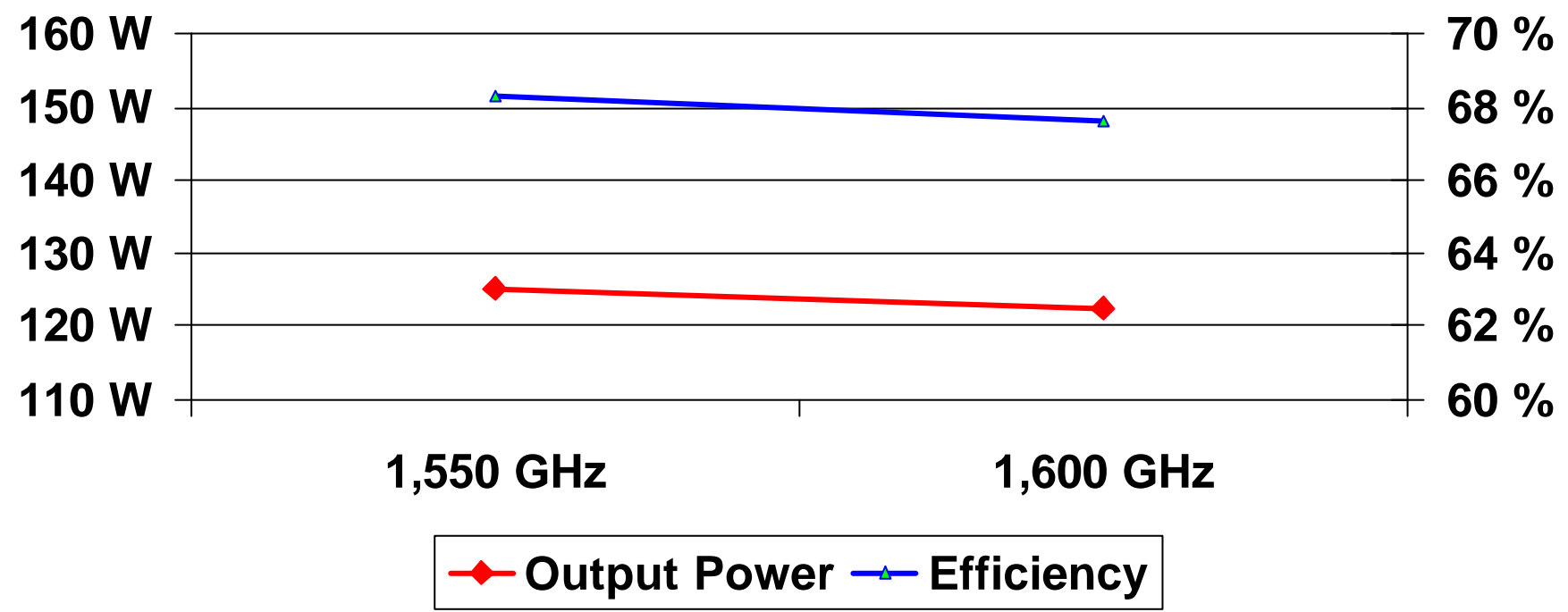
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Results of the improved L-Band Tubes

Different Power classes from

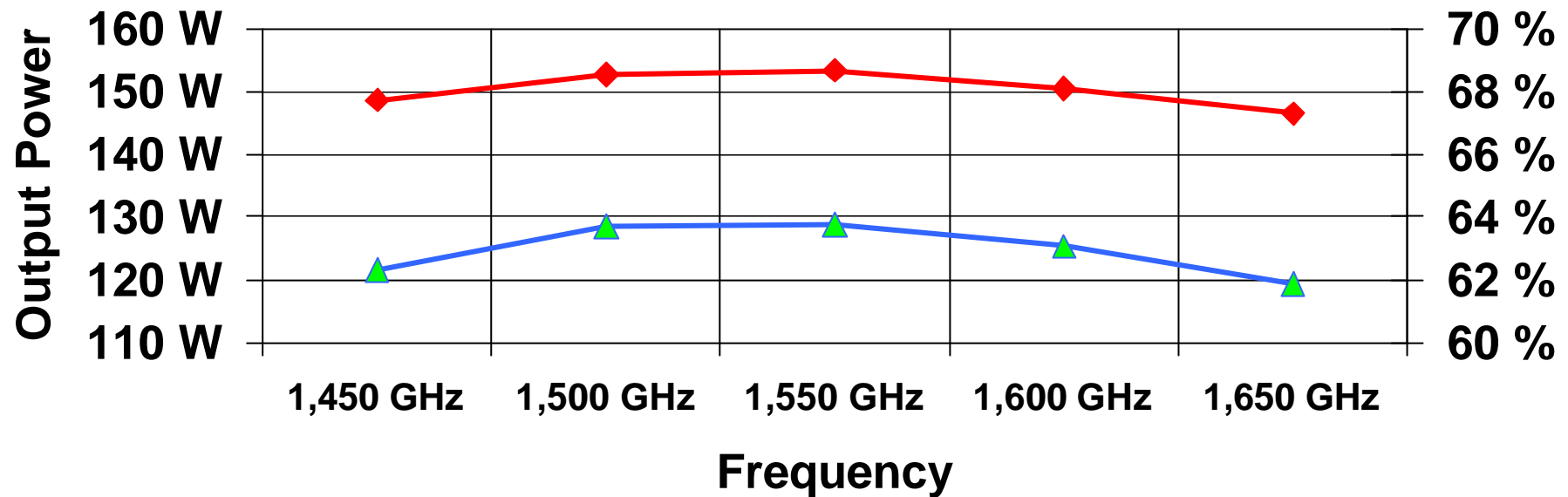
- 60-80 Watt** optimised for Broad Band
(total navigation band 1.1 to 1.6 GHz)
- 120-150 Watt** optimised for 1.4 to 1.6 GHz
(high power band for Galileo)
- 250 Watt** as a high power tube

120 to 150 Watt Tube



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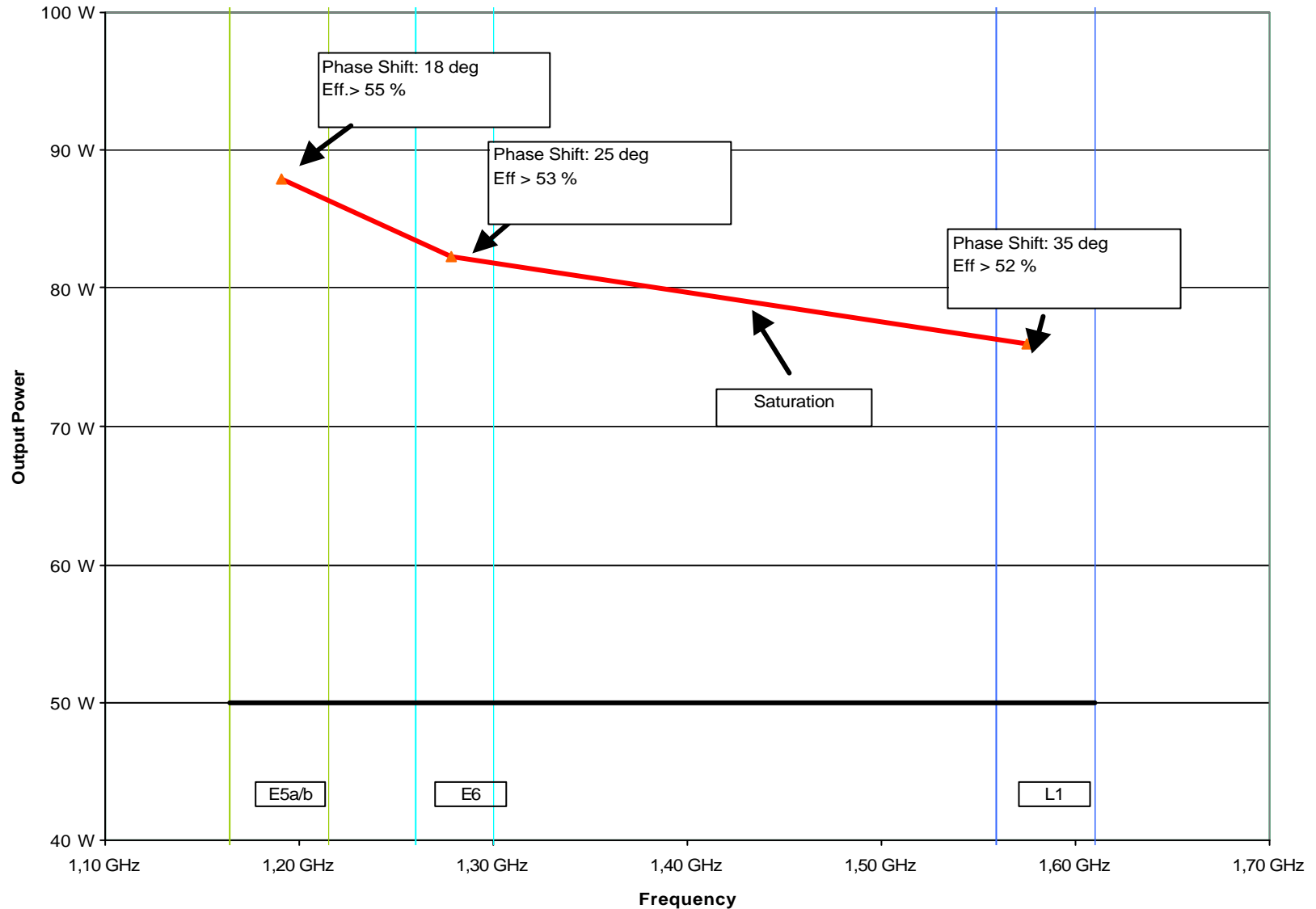
120 to 150 Watt Tube



◆ Output Power ▲ Efficiency

Phase shift:	< 45 deg
AM/PM conversion coefficient:	< 3 deg/dB
Gain in Saturation up to	50 dB

Output Power in Broad Band adjustment



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Additional Measurement performed on L-Band tube to prove the navigation requirements

- modulation tests**
- group delay measurements versus temperature and voltage** (typical EPC stability values used)
- noise measurements**
- Multi carrier measurements**
- Flexible Power setting only with anode voltage**

Conclusion after all Tests:

All performed tests

- all needed power levels covered by a highly efficient tube
- different modulation schemes
- non - linear behaviour sensitivity
- noise and multi carrier operation
- flexible power adjustment by anode voltage

confirm,

that the TWT test results are

excellent

(better than the known requirements)



**Advantage
to use a
Travelling Wave Tube
for
Navigation System
as
Galileo**



■ Output Power Flexibility

- No limitation in power: 150 W - or up to 250 W, if needed

■ Bandwidth

- The bandwidth of the L-Band TWT is 200 to 400 MHz.
- Fewer redundant amplifiers

■ Multi carrier operation

- 2 carrier operation is feasible and tested (for E5+ E6)
- less redundant tubes (5 TWTA compared to 8 SSPA)



■ **Group delay stability over temperature**

- Very low sensitivity - ideal for navigation systems
- has been tested under the critical conditions of temperature variation (up to 60 °C) and supply voltage stability.
- Group delay slope will be marginal (possible compensation)

■ **High power tubes**

- TED is manufacturing S- and Ku- Band tubes up to 220 Watt. The tubes are designed to operate without any degradation for more than 15 years.

■ **Qualified L-band TWT produced by TED**

- qualified up to 150 W output power.
- -10 to +85°C in operational conditions and the EPC from -10 to + 65 °C.
- Mechanical: random vibration up to 18 grms and pyro shock



■ Outstanding Heritage and Experience

- more than 30 years of experience for space TWTs (>5000 TWTs)
- TED has the experience to manage such an important and big project either as TWT or TWTA supplier (responsibility for the integration of TWT and EPC).

■ Proven Reliability

- accumulated operational time in orbit exceeds 3 Million hours.

■ Tube design

- all requirements and design goals according valued ESA PSS Space norms no change necessary

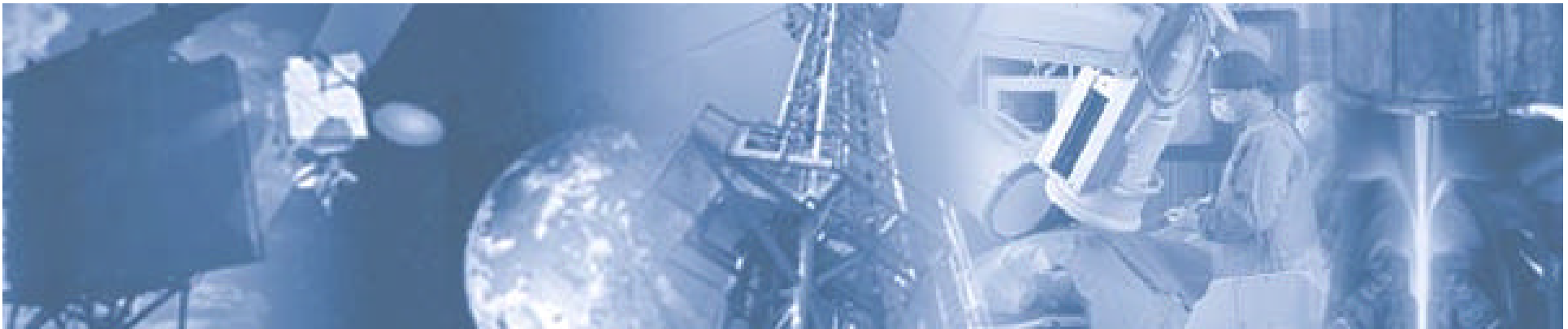
■ Advantage to use Dual EPC or with Lineariser + Champ

- additional mass reduction (redundancy plan)
- additional improvement for the linearity and therefore power consumption

THALES - TEDG
L-Band Travelling Wave
Tube Amplifiers
provide

an attractive solution for
Navigation System

Galileo



Thank you for your attention
Question / Answer