

Sonification

Représentation sonore des données en salle de contrôle

visite du CNES CST le 17 et 18 février 2022

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Sonification

L'importance de la perception auditive







Évaluation du potentiel de sonification

Visite du CNES Toulouse

Alexander Mihalic (Alter Instruments) et Maxime Poret (SCRIME)

Visite le 17 et 18 février 2022

Remerciements à Sylvain Michel (CNES) et Daniel Galarreta (CNES)

Lieux



- *Cyber Sécurité* (Security Operations Center) - bâtiment GALOIS

- Caroline **FUENTES**, Jean **BAZERQUE**

- *Salles de contrôle principales MIP* (Mise à poste) – bâtiment FERMAT

- *Centres de contrôle Mini-Micro Satellites* - bâtiment FRESNEL

- Gérard **GALET**

- *InSight* - bâtiment DESCARTES

- Rémi **LAPEYRE**

- *CADMOS* - bâtiment FRESNEL

- Rémy **GOUZE**



Observations

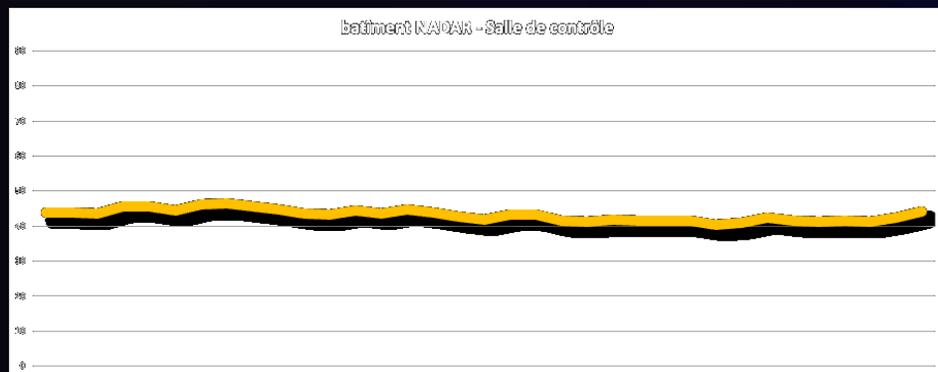
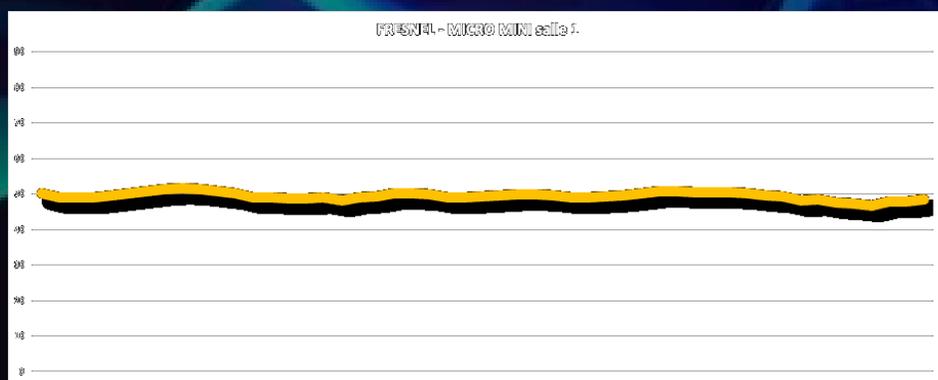
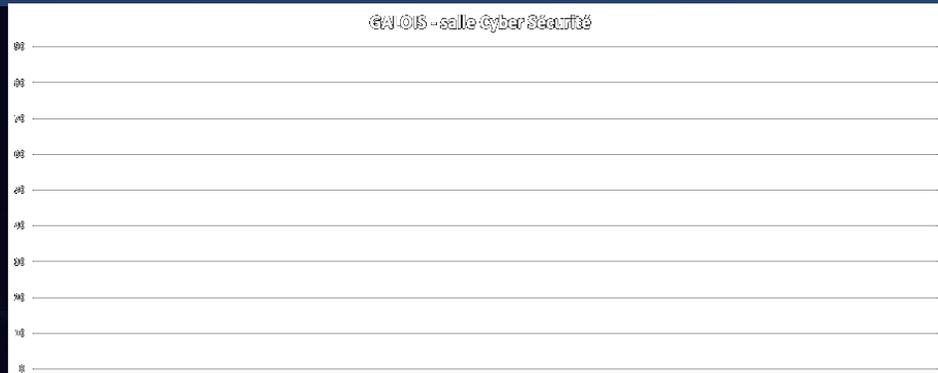
Salles type open space



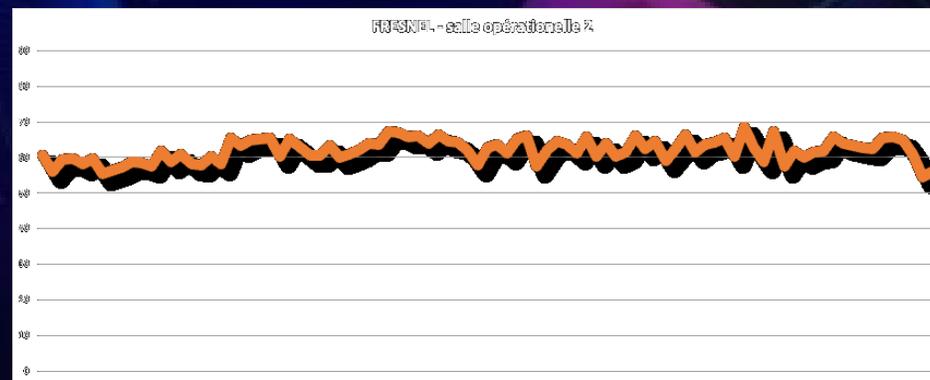
Présence d'écrans - pas / peu d'audio



Salles vides ou peu de personnel

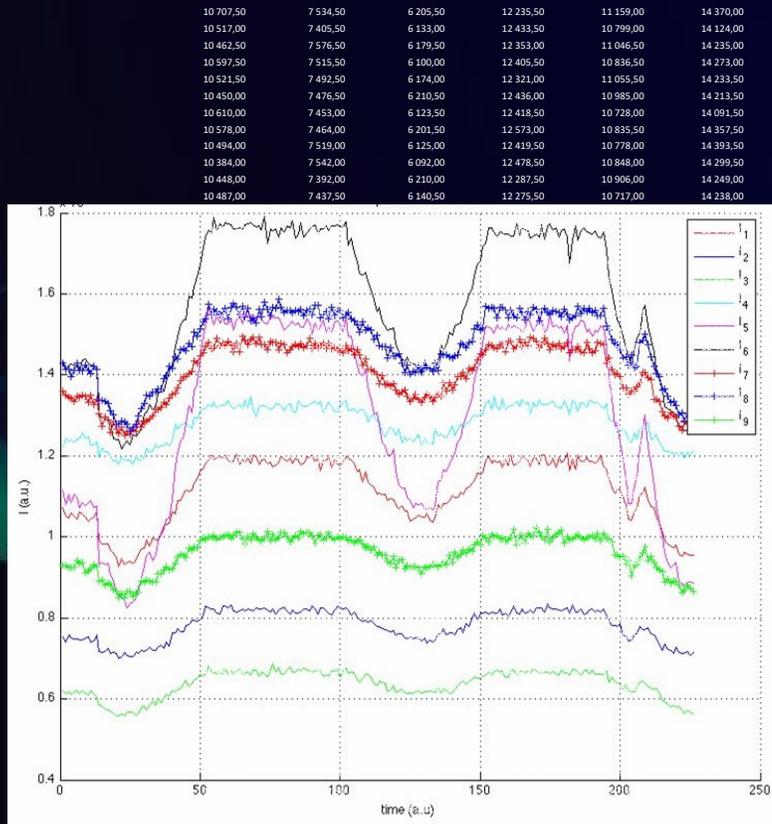


Salles pleines avec les équipes en travail



Analyser des dizaines de milliers de courbes

Réagir en temps réel aux données / alarmes



9 333,50	7 172,50	5 937,00	11 388,00	9 311,50	13 079,50	13 029,50	13 382,50	8 913,50
9 832,00	7 146,00	5 812,00	12 204,50	9 358,00	12 938,00	12 723,00	13 364,00	8 941,50
9 817,00	7 164,50	5 754,00	12 085,00	9 308,50	13 000,50	12 972,00	13 344,50	8 801,00
9 831,00	7 244,00	5 722,50	12 099,00	9 333,50	12 885,50	12 876,00	13 290,50	8 865,00
9 665,50	7 133,50	5 700,50	11 991,00	9 068,50	12 843,00	12 590,50	13 126,50	8 843,50
9 585,00	7 160,50	5 657,50	11 877,00	8 937,00	12 430,50	12 831,00	13 013,50	8 703,00
9 489,00	7 118,00	5 567,00	11 880,50	8 599,00	12 393,00	12 649,50	12 794,00	8 658,00
9 256,50	6 989,00	5 599,50	11 797,50	8 606,00	12 407,00	12 546,00	12 781,50	8 494,50
9 464,00	7 051,00	5 625,00	11 966,50	8 473,00	12 169,00	12 716,00	12 850,50	8 600,00
9 326,00	7 141,00	5 584,00	11 822,00	8 461,00	12 293,00	12 510,00	12 826,00	8 502,50
9 355,50	7 062,00	5 679,00	11 886,50	8 251,50	12 380,00	12 618,00	12 796,50	8 658,50
9 383,50	7 052,50	5 678,50	11 882,00	8 349,50	12 377,00	12 517,50	12 606,50	8 663,00
9 341,50	7 042,50	5 661,50	11 788,50	8 394,50	12 526,00	12 655,00	12 714,50	8 528,00
9 440,50	7 143,00	5 594,50	12 017,00	8 510,00	12 489,50	12 610,50	12 782,00	8 623,00
9 563,00	7 127,00	5 645,50	11 905,00	8 759,00	12 562,50	12 849,00	12 979,00	8 616,00
9 695,50	7 201,50	5 801,50	11 891,50	8 958,50	12 702,50	12 715,00	13 172,00	8 905,00
9 720,00	7 182,00	5 824,50	11 983,50	9 295,00	13 045,00	12 841,50	13 295,50	8 894,00
9 918,00	7 212,50	5 729,50	12 201,50	9 535,00	13 072,50	12 858,50	13 509,00	8 932,00
9 770,00	7 277,50	5 856,50	12 104,50	9 624,50	13 280,50	13 920,00	13 472,50	8 901,50
9 992,00	7 189,50	5 938,50	12 130,50	9 412,00	13 140,00	12 990,00	13 574,00	8 873,00
9 921,50	7 197,50	5 861,00	12 308,00	9 554,00	13 232,50	13 150,50	13 588,00	8 886,00
9 940,50	7 289,00	6 019,00	12 205,50	9 886,00	13 557,50	13 140,50	13 649,50	9 097,50



An abstract graphic featuring a large, glowing wave that transitions in color from green on the left to blue in the center, and then to purple and red on the right. The wave has a soft, ethereal glow and is set against a dark, starry background. Several thin, faint white lines also trace wave-like paths across the scene.

Pistes pour la sonification

Temps différé – post-traitement des données



0.65	148054	102022	0.21	0.45	0.80	1.44	2.24	3.27	4.50	5.93	7.54	9.21	10.91	12.61	14.31	16.01	17.71	19.41	21.11	22.81	24.51	26.21	27.91	29.61	31.31	33.01	34.71	36.41	38.11	39.81	41.51	43.21	44.91	46.61	48.31	50.01	51.71	53.41	55.11	56.81	58.51	60.21	61.91	63.61	65.31	67.01	68.71	70.41	72.11	73.81	75.51	77.21	78.91	80.61	82.31	84.01	85.71	87.41	89.11	90.81	92.51	94.21	95.91	97.61	99.31	101.01	102.71	104.41	106.11	107.81	109.51	111.21	112.91	114.61	116.31	118.01	119.71	121.41	123.11	124.81	126.51	128.21	129.91	131.61	133.31	135.01	136.71	138.41	140.11	141.81	143.51	145.21	146.91	148.61	150.31	152.01	153.71	155.41	157.11	158.81	160.51	162.21	163.91	165.61	167.31	169.01	170.71	172.41	174.11	175.81	177.51	179.21	180.91	182.61	184.31	186.01	187.71	189.41	191.11	192.81	194.51	196.21	197.91	199.61	201.31	203.01	204.71	206.41	208.11	209.81	211.51	213.21	214.91	216.61	218.31	220.01	221.71	223.41	225.11	226.81	228.51	230.21	231.91	233.61	235.31	237.01	238.71	240.41	242.11	243.81	245.51	247.21	248.91	250.61	252.31	254.01	255.71	257.41	259.11	260.81	262.51	264.21	265.91	267.61	269.31	271.01	272.71	274.41	276.11	277.81	279.51	281.21	282.91	284.61	286.31	288.01	289.71	291.41	293.11	294.81	296.51	298.21	299.91	301.61	303.31	305.01	306.71	308.41	310.11	311.81	313.51	315.21	316.91	318.61	320.31	322.01	323.71	325.41	327.11	328.81	330.51	332.21	333.91	335.61	337.31	339.01	340.71	342.41	344.11	345.81	347.51	349.21	350.91	352.61	354.31	356.01	357.71	359.41	361.11	362.81	364.51	366.21	367.91	369.61	371.31	373.01	374.71	376.41	378.11	379.81	381.51	383.21	384.91	386.61	388.31	390.01	391.71	393.41	395.11	396.81	398.51	400.21	401.91	403.61	405.31	407.01	408.71	410.41	412.11	413.81	415.51	417.21	418.91	420.61	422.31	424.01	425.71	427.41	429.11	430.81	432.51	434.21	435.91	437.61	439.31	441.01	442.71	444.41	446.11	447.81	449.51	451.21	452.91	454.61	456.31	458.01	459.71	461.41	463.11	464.81	466.51	468.21	469.91	471.61	473.31	475.01	476.71	478.41	480.11	481.81	483.51	485.21	486.91	488.61	490.31	492.01	493.71	495.41	497.11	498.81	500.51	502.21	503.91	505.61	507.31	509.01	510.71	512.41	514.11	515.81	517.51	519.21	520.91	522.61	524.31	526.01	527.71	529.41	531.11	532.81	534.51	536.21	537.91	539.61	541.31	543.01	544.71	546.41	548.11	549.81	551.51	553.21	554.91	556.61	558.31	560.01	561.71	563.41	565.11	566.81	568.51	570.21	571.91	573.61	575.31	577.01	578.71	580.41	582.11	583.81	585.51	587.21	588.91	590.61	592.31	594.01	595.71	597.41	599.11	600.81	602.51	604.21	605.91	607.61	609.31	611.01	612.71	614.41	616.11	617.81	619.51	621.21	622.91	624.61	626.31	628.01	629.71	631.41	633.11	634.81	636.51	638.21	639.91	641.61	643.31	645.01	646.71	648.41	650.11	651.81	653.51	655.21	656.91	658.61	660.31	662.01	663.71	665.41	667.11	668.81	670.51	672.21	673.91	675.61	677.31	679.01	680.71	682.41	684.11	685.81	687.51	689.21	690.91	692.61	694.31	696.01	697.71	699.41	701.11	702.81	704.51	706.21	707.91	709.61	711.31	713.01	714.71	716.41	718.11	719.81	721.51	723.21	724.91	726.61	728.31	730.01	731.71	733.41	735.11	736.81	738.51	740.21	741.91	743.61	745.31	747.01	748.71	750.41	752.11	753.81	755.51	757.21	758.91	760.61	762.31	764.01	765.71	767.41	769.11	770.81	772.51	774.21	775.91	777.61	779.31	781.01	782.71	784.41	786.11	787.81	789.51	791.21	792.91	794.61	796.31	798.01	799.71	801.41	803.11	804.81	806.51	808.21	809.91	811.61	813.31	815.01	816.71	818.41	820.11	821.81	823.51	825.21	826.91	828.61	830.31	832.01	833.71	835.41	837.11	838.81	840.51	842.21	843.91	845.61	847.31	849.01	850.71	852.41	854.11	855.81	857.51	859.21	860.91	862.61	864.31	866.01	867.71	869.41	871.11	872.81	874.51	876.21	877.91	879.61	881.31	883.01	884.71	886.41	888.11	889.81	891.51	893.21	894.91	896.61	898.31	900.01	901.71	903.41	905.11	906.81	908.51	910.21	911.91	913.61	915.31	917.01	918.71	920.41	922.11	923.81	925.51	927.21	928.91	930.61	932.31	934.01	935.71	937.41	939.11	940.81	942.51	944.21	945.91	947.61	949.31	951.01	952.71	954.41	956.11	957.81	959.51	961.21	962.91	964.61	966.31	968.01	969.71	971.41	973.11	974.81	976.51	978.21	979.91	981.61	983.31	985.01	986.71	988.41	990.11	991.81	993.51	995.21	996.91	998.61	1000.31	1002.01	1003.71	1005.41	1007.11	1008.81	1010.51	1012.21	1013.91	1015.61	1017.31	1019.01	1020.71	1022.41	1024.11	1025.81	1027.51	1029.21	1030.91	1032.61	1034.31	1036.01	1037.71	1039.41	1041.11	1042.81	1044.51	1046.21	1047.91	1049.61	1051.31	1053.01	1054.71	1056.41	1058.11	1059.81	1061.51	1063.21	1064.91	1066.61	1068.31	1070.01	1071.71	1073.41	1075.11	1076.81	1078.51	1080.21	1081.91	1083.61	1085.31	1087.01	1088.71	1090.41	1092.11	1093.81	1095.51	1097.21	1098.91	1100.61	1102.31	1104.01	1105.71	1107.41	1109.11	1110.81	1112.51	1114.21	1115.91	1117.61	1119.31	1121.01	1122.71	1124.41	1126.11	1127.81	1129.51	1131.21	1132.91	1134.61	1136.31	1138.01	1139.71	1141.41	1143.11	1144.81	1146.51	1148.21	1149.91	1151.61	1153.31	1155.01	1156.71	1158.41	1160.11	1161.81	1163.51	1165.21	1166.91	1168.61	1170.31	1172.01	1173.71	1175.41	1177.11	1178.81	1180.51	1182.21	1183.91	1185.61	1187.31	1189.01	1190.71	1192.41	1194.11	1195.81	1197.51	1199.21	1200.91	1202.61	1204.31	1206.01	1207.71	1209.41	1211.11	1212.81	1214.51	1216.21	1217.91	1219.61	1221.31	1223.01	1224.71	1226.41	1228.11	1229.81	1231.51	1233.21	1234.91	1236.61	1238.31	1240.01	1241.71	1243.41	1245.11	1246.81	1248.51	1250.21	1251.91	1253.61	1255.31	1257.01	1258.71	1260.41	1262.11	1263.81	1265.51	1267.21	1268.91	1270.61	1272.31	1274.01	1275.71	1277.41	1279.11	1280.81	1282.51	1284.21	1285.91	1287.61	1289.31	1291.01	1292.71	1294.41	1296.11	1297.81	1299.51	1301.21	1302.91	1304.61	1306.31	1308.01	1309.71	1311.41	1313.11	1314.81	1316.51	1318.21	1319.91	1321.61	1323.31	1325.01	1326.71	1328.41	1330.11	1331.81	1333.51	1335.21	1336.91	1338.61	1340.31	1342.01	1343.71	1345.41	1347.11	1348.81	1350.51	1352.21	1353.91	1355.61	1357.31	1359.01	1360.71	1362.41	1364.11	1365.81	1367.51	1369.21	1370.91	1372.61	1374.31	1376.01	1377.71	1379.41	1381.11	1382.81	1384.51	1386.21	1387.91	1389.61	1391.31	1393.01	1394.71	1396.41	1398.11	1399.81	1401.51	1403.21	1404.91	1406.61	1408.31	1410.01	1411.71	1413.41	1415.11	1416.81	1418.51	1420.21	1421.91	1423.61	1425.31	1427.01	1428.71	1430.41	1432.11	1433.81	1435.51	1437.21	1438.91	1440.61	1442.31	1444.01	1445.71	1447.41	1449.11	1450.81	1452.51	1454.21	1455.91	1457.61	1459.31	1461.01	1462.71	1464.41	1466.11	1467.81	1469.51	1471.21	1472.91	1474.61	1476.31	1478.01	1479.71	1481.41	1483.11	1484.81	1486.51	1488.21	1489.91	1491.61	1493.31	1495.01	1496.71	1498.41	1500.11	1501.81	1503.51	1505.21	1506.91	1508.61	1510.31	1512.01	1513.71	1515.41	1517.11	1518.81	1520.51	1522.21	1523.91	1525.61	1527.31	1529.01	1530.71	1532.41	1534.11	1535.81	1537.51	1539.21	1540.91	1542.61	1544.31	1546.01	1547.71	1549.41	1551.11	1552.81	1554.51	1556.21	1557.91	1559.61	1561.31	1563.01	1564.71	1566.41	1568.11	1569.81	1571.51	1573.21	1574.91	1576.61	1578.31	1580.01	1581.71	1583.41	1585.11	1586.81	1588.51	1590.21	1591.91	1593.61	1595.31	1597.01	1598.71	1600.41	1602.11	1603.81	1605.51	1607.21	1608.91	1610.61	1612.31	1614.01	1615.71	1617.41	1619.11	1620.81	1622.51	1624.21	1625.91	1627.61	1629.31	1631.01	1632.71	1634.41	1636.11	1637.81	1639.51	1641.21	1642.91	1644.61	1646.31	1648.01	1649.71	1651.41	1653.11	1654.81	1656.51	1658.21	1659.91	1661.61	1663.31	1665.01	1666.71	1668.41	1670.11	1671.81	1673.51	1675.21	1676.91	1678.61	1680.31	1682.01	1683.71	1685.41	1687.11	1688.81	1690.51	1692.21	1693.91	1695.61	1697.31	1699.01	1700.71	1702.41	1704.11	1705.81	1707.51	1709.21	1710.91	1712.61	1714.31	1716.01	1717.71	1719.41	1721.11	1722.81	1724.51	1726.21	1727.91	1729.61	1731.31	1733.01	1734.71	1736.41	1738.11	1739.81	1741.51	1743.21	1744.91	1746.61	1748.31	1750.01	1751.71	1753.41	1755.11	1756.81	1758.51	1760.21	1761.91	1763.61	1765.31	1767.01	1768.71	1770.41	1772.11	1773.81	1775.51	1777.21	1778.91	1780.61	1782.31	1784.01	1785.71	1787.41	1789.11	1790.81	1792.51	1794.21	1795.91	1797.61	1799.31	1801.01	1802.71	1804.41	1806.11	1807.81	1809.51	1811.21	1812.91	181
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Temps réel – ajouter / enlever / modifier



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10 707,50 7 534,50 6 205,50 12 235,50 11 159,00 14 370,00 13 612,00 14 295,50 9 283,00
10 517,00 7 405,50 6 133,00 12 433,50 10 799,00 14 124,00 13 498,50 14 146,00 9 303,50
10 462,50 7 576,50 6 179,50 12 355,00 11 046,50 14 235,00 13 451,50 14 133,00 9 234,00
10 597,50 7 515,50 6 100,00 12 405,50 10 836,50 14 273,00 13 421,50 13 958,00 9 221,00
10 521,50 7 492,50 6 174,00 12 321,00 11 055,50 14 233,50 13 345,00 14 101,50 9 246,00
10 450,00 7 476,50 6 210,50 12 436,00 10 985,00 14 213,50 13 464,00 14 299,00 9 424,50
10 610,00 7 453,00 6 123,50 12 418,50 10 728,00 14 091,50 13 446,50 14 112,00 9 342,50
10 578,00 7 464,00 6 201,50 12 573,00 10 835,50 14 357,50 13 509,00 14 120,00 9 358,50
10 494,00 7 519,00 6 125,00 12 419,50 10 778,00 14 393,50 13 468,00 14 239,00 9 118,00
10 384,00 7 542,00 6 092,00 12 478,50 10 848,00 14 899,50 13 320,00 14 114,50 9 171,00
10 448,00 7 392,00 6 210,00 12 287,50 10 906,00 14 249,00 13 497,00 14 039,50 9 220,50
10 487,00 7 437,50 6 140,50 12 275,50 10 717,00 14 238,00 13 271,00 14 224,00 9 312,00
10 640,00 7 585,00 6 047,00 12 354,00 10 767,00 14 180,50 13 392,00 14 129,00 9 262,00
9 933,50 7 172,00 5 837,00 11 980,00 9 311,50 13 049,00 13 029,50 13 382,50 8 913,50
9 832,00 7 146,00 5 812,00 12 204,50 9 338,00 12 938,00 12 723,00 13 364,00 8 941,50
9 837,00 7 164,50 5 754,00 12 085,00 9 308,50 13 900,50 12 972,00 13 344,50 8 801,00
8 931,00 7 214,00 5 732,00 12 099,00 9 333,50 12 885,50 12 876,00 13 390,50 8 865,00
9 911,00 7 214,00 5 732,00 12 099,00 9 911,00 9 068,50 12 843,00 12 590,50 8 843,50
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8 805,50 8 599,00 12 430,50 12 590,50 8 805,50 8 599,00 12 430,50 12 590,50 8 805,50
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8 394,50 12 526,00 12 655,00 12 714,50 8 528,00 8 394,50 12 526,00 12 655,00 12 714,50
8 17,00 8 510,00 12 489,50 12 610,50 12 782,00 8 623,00 8 17,00 8 510,00 12 489,50 12 610,50 12 782,00 8 623,00
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Sonification



Conditions d'écoute – qualité du signal

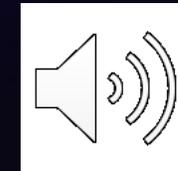
Information visuelle - écrans

- Multiplication des écrans
- Agrandissement de taille
- Amélioration constante de qualité



Information auditive – casques

- Casques rares
- Pas de stéréophonie
- Qualité basique



Trois postes pilotes pour la sonification

Temps différé

- Post-traitement des données
- Une partie des données vers les données auditives

- KINEIS
- 25 nano-satellites

Temps réel

- Action immédiate
- Faciliter la prise de décision
- Enlever le stress visuel

- SWOT
- MIP (Mise à poste)

Communication

- Action immédiate / différée
- Améliorer et enrichir le signal audio
- Alarmes non binaires

- CADMOS
- Communication avec ISS

Conclusions

- Supervision multisensorielle – rendre l'opérateur plus performant

- En fonction de l'environnement
- Ne pas rajouter d'informations visuelles
- Prévenir la fatigue visuelle et auditive

- Plus d'efficacité
- Faciliter la prise de décision
- Améliorer les conditions de travail

Alter Instruments

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